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Population Status, Distribution Pattern and Habitat Preference of Vulture Species in Bundelkhand Region, Central India

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Abstract

Scavenging vultures play a significant role in the ecosystem as scavengers, removing carcasses thereby preventing outbreaks of infectious diseases. In the last few decades there has been a massive population crash of vultures in the Indian subcontinent due to anthropogenic and environmental factors such as loss of habitat, declining food availability, poisoning, drugs used in veterinary medicine, and climate-related factors. The present study aims to assess the population status and distribution of vultures in Bundelkhand region of Central India. The relative abundance of species, habitat used, breeding features of the vultures in the settlings, and their correlation with several environmental parameters were analysed. The study included characteristic habits of vultures and their habitat preferences. The area was sampled using singular point count methodology with road transects. Population estimation was done through ightsightings; day to day season and census showed the data in direct observations while characteristics of habitat proved the nesting sites, types of vegetation, food availability and climatic conditions. The characteristic habit of vultures such as perches and birds' behaviour were also included in observations. Vultures especially nest at certain locations. When the rocky cliffs, edge of forests and open grassland patches as well as areas with adequate food resources are considered with variable habitat characteristics, somewhat greater numbers were always recorded. Human disturbances directly affect and modify the habits of vultus at such nearby localities globally were reflected in the population density at such locations. A strong climatic and habit-related effect was evident.

Keywords: Vultures, population status, habitat preference, species distribution, Bundelkhand region, conservation ecology, scavenger birds

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Introduction

Vulture, among the more ecologically important scavengers, make an important contribution to maintaining healthy ecosystems since they remove animal remains from the environment rapidly. Vultures of the family Accipitridae are specialized birds of prey well adapted to scavenging. They have a variety of unique characteristics including broad wings suitable for soaring flight, powerful hooked beaks well adapted to breaking up and tearing apart flesh, strong digestive systems adapted for destroying pathogens it is exposed to, and strong eyesight for finding carcasses from great distances (Houston, 1976). Birds that scavenge make an important function of turning over and cycling nutrients from dead animals and removing waste from the environment. Vultures are especially significant to the earth in the way they consume remains of animals and prevent accumulation of potentially disease harbouring carcasses that, if allowed to decay, could propagate disease and parasites. The acidic and toxic secretions of their digestive tract destroys a variety of microorganisms including anthrax spore and rabies germs and therefore interrupts the spread of a number of diseases and infection that might develop and pass wildlife to domesticated animals and to humans (Houston & Cooper, 1975). To mankind vultures also are indirectly helping to prevent plagues and pestilences. It appears that twenty-three species of vultures have been recognized worldwide, on the continents of Africa, Europe, Asia and the Americas. India also supports a diverse group of vultures, and once represented one of the principal stronghold for the vast majority of vultures in a subcontinent.The Indian sub-continent is home to Oriental White-backed Vultures (Gyps bengalensis), Indian Long-billed Vultures (*Gyps indicus*), Slender-billed Vultures (*Gyps tenuirostris*), Egyptian Vultures (*Neophron percnopterus*), Red-headed Vultures (*Sarcogyps calvus*), Himalayan Griffon Vultures (*Gyps himalayensis*), Indian Griffon Vultures (*Gyps fulvus*), Cinereous Vultures (*Aegypius monachus*), Bearded Vultures (*Gypaetus barbatus*). Not long ago vultures were one of the commonest groups of birds occurring over large areas in India and were common around forests, agriculture, in villages, grasslands and were also common birds of towns. However during the last few decades they have gone through catastrophic declines all over the Indian subcontinent. Population monitoring studies carried out in the 1990s found the first evidence that Gyps species were dramatically reducing in abundance (Prakash *et al*., 2003). Populations have fallen by more than 95-97% in a matter of years! Such rapid declines attracted worldwide scientific attention because of their importance in the ecosystem. Several factors have been identified as responsible for reducing numbers of these birds. Habitat destruction is a major threat even worldwide to vultures. Urban development, deforestation, modernized agriculture, mining and infrastructure

development reduce available habitat, decrease the nesting habitat of vultures, and generally lead to more isolated populations that are now less successful at breeding (Pain *et al*., 2003). As an extension of this is also reduced availability of food - vultures subsist mainly on the carcasses of wild and domestic animals.The availability of food is dependent on the management strategies practiced for livestock and the methods employed for the disposal of animal carcasses. Certain scavengers may thrive while others suffer as a result of the scarcity of carrion. The phenomenon of vultures declining or going extinct in certain regions of South Asia can probably be directly traced to deaths caused by poisoning via veterinary non-steroidal anti-inflammatory drugs, chiefly diclofenac. Diclofenac was used extensively for treating livestock afflicted with inflammatory diseases and other painful conditions. Residues of this drug were retained by the carcass when the animal died and vultures that fed upon those became poisoned, developing severe kidney failure and visceral gout. Work by Oaks *et al*. (2004); Green *et al*. (2006) identified diclofenac toxicity as the/one major cause of cataclysmic vulture declines in India, Pakistan and Nepal. These declines have further consequences on the availability of carrion, creating conditions unsuitable for other scavengers and resulting in increased populations of feral dogs and other pests; increased populations of feral dogs in turn has been linked to higher rates of rabies and other zoonotic diseases. The conservation of vultures has implications well beyond that of simple biodiversity and extends to the functioning of ecosystems as a whole as well as human welfare.

The entire Bundelkhand area of Central India is a diverse habitat shared between the states of Uttar Pradesh and Madhya Pradesh. The region is comprised of rocky hills, dry deciduous forests, open grassland, scrub, agricultural fields, rivers etc. Both the rocky cliffs and tall trees offer places where vultures (and other birds) may construct nests while in close proximity to food resources in the form of agricultural fields and that grazers bring to be fed upon by the vultures. Vultures as a group though differ in their habitat preferences in that they vary when it comes to their nesting and feeding ecology. Such considerations thus assist when seeking to understand vulture settlement patterns. Habitat preference has been found to help predict why vultures are more common in one locale compared to another, with a suite of factors sitting there - vegetation structure, competing scavengers for food resources, climatic and human disturbance.

The present study attempts to determine the population status, pattern of distribution and habitat preference of vultures in the Bundelkhand Region. Insights into environmental factors significant to their occurrence are also evaluated. Knowledge generated thus can prove valuable and relevant to conservation works planned in the future.

Review of Literature

Vulture populations have generated much scientific interest, not least of all because they play a key ecological role and have suffered widespread declines in recent decades. This has led many to study vultures' biology, population ecology, habitat management and conservation. The ecological role of vultures has been noted, particularly as scavengers and what they have meant to ecosystem health and biodiversity. Early ecology recognised vultures as a category of highly specialised scavengers capable of removing animal carcasses from ecosystems. David Houston remarked that vultures (Houston, 1973) have several physiological adaptions that equip them for their carrion diets. They have very acidic digestive tracts that destroy pathogenic micro-organisms and reduce the spread and persistence of infectious diseases in ecosystems. Houston declared that vultures "play a significant role in nutrient recycling and ecological sanitation" (Houston, 1973, p. 234). The ecological importance of vultures was further underscored by Houston & Cooper (1975). They investigated the physiology of vultures' digestion and its consequences for controlling disease. Their analysis revealed that decomposing carcasses are rich in harmful micro-organisms that the vultures' digestive tracts destroy. The authors conclude that vultures indirectly protect wildlife, domestic animals, and human populations from disease outbreaks. Population declines of vultures have been noted extensively in many parts of the world. The decline of Gyps species of South Asia attracted global scientific interest simply because of how great and quick the decline was. Gilbert *et al*. (2002) Examination of Oriental White-backed Vultures and the declines of breeding populations in Pakistan and surroundings shows that the authors reported of reproductive failure and increased mortality of adult birds. Prakash *et al*. (1999), after study of the whole of contents of several thousand pellets, conducted extensive studies on the population of vultures in Keoladeo National Park and reported of great declines in abundance. Because of the decline in numbers of vultures seen there, these authors inferred that Gyps populations had declined drastically, perhaps due to environmental events or human accidents. In their later study, Prakash *et al*. (2003) confirmed that the Indian vulture has suffered a decline of more than 95% in a short space of time. In some of the earliest reports of important vulture mortality cause was by oaks *et al*. (2004) who described the role of veterinary diclofenac residues in catastrophic population decline and for the associated development of renal failure and visceral gout in vultures feeding on treated carcasses. In the same ecological niche given by green *et al*. (2006) diclofenac toxicity pose a major danger to the existence of vultures within southern Asia. Shultz *et al*. (2004) also found strong support for the diclofenac theory through relatively more popular association with veterinary drug contamination in birds and the mortality factors based thereof on Gyps spp. Research into habitat and presence of vultures is scant but habitat structure poll has described vultures heavy predilection for habitats with such character that make them provide suitable nesting, food and least human disturbance. Brown (1983) showed the habitat selection effect among vultures described above is based on the availability of found food and the ability to roost on tall trees or rocky cliffs, while environmental factor helps in differencing habitations within. Jha (2015) studied the distribution patterns of vultures in uttar Pradesh and found a strong relation between occurrence of vultures and different habitat patterns. The areas with open regions and nesting habitat were abundantly present than cuddled environments with little preferred to make successful breeding. In the study, Kumar *et al*. (2017), Bundelkhand also is reported to be important breeding area Gyps. The authors concluded on the availability of rocky cliffs and good environmental habitat built from findings. Moreover, the study of population estimation of vultures by Munjpara *et al*. (2018) based in Gujarat, the vulture populations estimated in sights indicate systematic monitoring as valuable sources of information, especially in regard to how many of such

species might be in a region. In another study, Jha *et al*. (2020) reports of ecological considerations and population status of vultures in India. They cite that habitat degradation, reduced food stock, and human activities continue to remain threat factors to vultures found, habitats, and that habitat quality, food resources, climatic conditions highly affect vulture population status and distribution patterns among vultures.

Materials and Methods

Study Area-The present studies were undertaken in the Bundelkhand region of Central India, which is broadly distributed between southern Uttar Pradesh and northern Madhya Pradesh. The climate is semi-arid and bathing habitat to all kinds of Wild Life exists in form of dry deciduous forests, rocky cliffs, forested & non forested grassland regions, scrubland and agricultural habitats and riverine belt. Bundelkhand is ecologically important as several Wildlife including the vultures are recorded from the region. The area has potential core nesting and feeding resources of birds to study avian ecology. The area was preferred as Bundelkhand has been reported earlier as a probable breeding and habitat range of vultures, findings of which were correlates to our requirements.

Duration of Study- Field investigations were conducted over two breeding seasons for a total duration of nearly 18 months. Periodic survey over all seasons were undertaken to avoid as much as possible seasonal variations.

Selection of Study Sites- We selected five study sites in the Bundelkhand region that:

1) Supported populations of vultures, 2) Varied in habitats, 3) Were in proximity to potential nesting sites, 4) Had some reliable food resources, 5) Were easy to access in the field.

Each selected patches of land contained some combination of:

1) Rocky cliffs, 2) Open grasslands, 3) Agriculture, 4) Edge of forests, 5) Habitats near water bodies.

Field Survey Methodology-Field observations were performed using direct survey techniques including:

A. Point Count Method- Point count surveys were conducted at fixed locations where observers recorded:

•Number of individuals observed
•Species diversity
•Flight behavior
•Feeding activities
•Roosting behavior

Observation periods lasted approximately 20–30 minutes at each point.

Road Transect Method- Road transect surveys were conducted along predetermined routes within selected study areas.

Survey parameters included:

•Length of transect: 5–10 km
•Observation speed: 20–30 km/hr

Observation timing:

•Morning: 06:00–10:00 AM
•Evening: 04:00–06:30 PM

Individuals observed within visible distances from transects were recorded.

Population Estimation-Population estimation was performed through direct counting methods.

Population density was calculated using:

$$\text{Population Density} = \frac{Number\ of\ Individuals\ Observed}{Area\ Surveyed}$$

Species abundance and relative frequency were determined for each study site.

Habitat Assessment-Habitat characteristics were recorded simultaneously during field surveys.

The following parameters were assessed: Vegetation type, Tree density, Rocky habitat availability, Nesting structures, Food availability, Human disturbance levels, Water sources

Habitats were categorized as: Forest habitat, Grassland habitat, Rocky habitat, Agricultural habitat, mixed habitat

Behavioral Observations-Behavioral observations were conducted using focal animal sampling techniques.

Observed activities included: Feeding behavior, Roosting behavior, Flight activities, breeding activities, Nesting behavior, Intra- and interspecific interactions

Behavioral observations were recorded using binoculars and digital photography.

Climatic Variables-The following environmental parameters were recorded: Temperature (°C)**,** Relative humidity (%)**,** Rainfall (mm)**.** These parameters were used to examine relationships between environmental conditions and vulture distribution.

Statistical Analysis-Collected data were analyzed using: Arithmetic Mean, Standard Deviation (SD), Percentage analysis, Correlation analysis, One-way Analysis of Variance (ANOVA), Differences were considered statistically significant at: $p < 0.05$

Results

The present study estimated population status, distribution pattern and habitat preference of vultures in Bundelkhand Region, Central India. Population estimation and habitat surveys indicated variation in abundance of vulture and species occurrence among habitat types indicating habitat characteristics and environmental factors may play important role in distribution and population density of different species.

Table 1. Population density and species abundance at selected study sites

Study Site	Habitat Type	Number of Vultures Observed	Population Density (individuals/km²)
Site I	Rocky Habitat	68	6.8
Site II	Forest Edge	55	5.5
Site III	Grassland	43	4.3
Site IV	Agricultural Area	29	2.9
Site V	Mixed Habitat	51	5.1

The highest vulture abundance was recorded at rocky habitats (Site I), whereas agricultural habitats exhibited comparatively lower population density. Rocky habitats provided suitable nesting and roosting sites that supported greater species abundance.

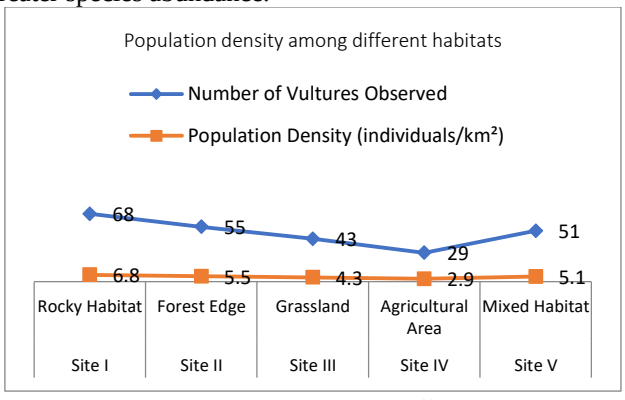

Figure 1. Population density among different habitats

Population density of vultures across different habitat types in Bundelkhand region. The graph indicates that rocky habitats supported the greatest population density, while agricultural habitats supported the lowest density.

Table 2. Habitat preference and breeding observations among vulture populations

Habitat Type	Nesting Sites Observed	Feeding Activity (%)	Breeding Success (%)
Rocky Habitat	18	82	78
Forest Edge	14	75	70
Grassland	10	68	63
Agricultural Habitat	6	49	45
Mixed Habitat	13	71	66

Rocky habitats showed the highest breeding success and feeding activity. Agricultural habitats exhibited relatively lower breeding success due to greater human disturbances and reduced nesting opportunities.

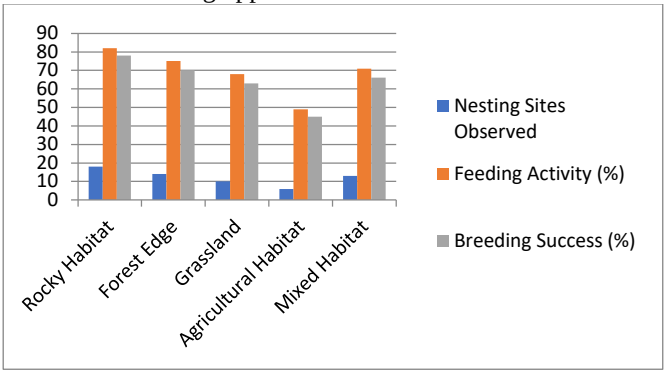

Figure 2. Breeding success in different habitat types

Breeding success was highest in rocky habitats because of appropriate nesting sites and lower disturbance rates. Reduced breeding performance in agricultural areas indicates that habitat modification is disadvantageous to vultures. Overall, habitat characteristics appear to play an important role in vulture population status and distribution patterns in Bundelkhand Region.

Discussion

The present study observed contrasting pattern in vulture abundance and population estimates across studied sites in Bundelkhand region of Central India for ecology, also varying with respect to habitat structure, nesting site availability, food sources and degree of human disturbances, as earlier ecological study (e. g. Shah *et al*., 2015) supported concepts of vulture population being affected by habitat structure. Compared to all, highest population densities were recorded in rocky habitats. Rocky cliffs and rocky elevated habitats are naturally preferred roost and nesting sites, being better suited for successful survival and breeding of vultures. Ecological study also reveal that bundelkhand being an region of importance for breeding Gyps species. Rocky area and their associated habitats play a great role also in successful nesting and impacting population persistence (Kumar *et al*., 2017). Lower abundance of vultures in the agricultural landscape are attributed to modification and extension of human interference as agriculture intensification disturb the areas (including application of pesticides etc.) and lead to lesser availability of nesting sites /food resources impacting the vulture populations. It were also observed that the - vulture abundance varied considerably according to vegetation structure and degree of human disturbance (young, 2015) in their habitat.Food availability is an ecological factor of primary importance in scavenger populations. Vultures feed for the most part on the carcasses of domestic and other animals, and the abundance of carrion modifies their foraging activity, movement, breeding success and performance. In a habitat where food becomes scarce, interspecific competition among scavengers becomes more pronounced and adversely affect breeding success and increase annual recruitment. The present study is corroborated as showing greater activity in the flesh feeding portions in rocky and forest-edge habitats relative to agricultural habitats. The availability of livestock among these habitats may explain the variation. Houston (1976) showed that the distribution of food resources affects patterns of foraging and choice of habitat by vultures. Kaduna also observed much higher breeding success than in agricultural habitats where such a low effort and success have been reported respectively. The availability of nest sites differed in the rocky habitat so that the vulture's reproductive success may also reflect the quality of nest structures and environmental factors for breeding. Vultures normally like to breed in elevated places and cliffs (Houston, 1974) and high trees where they feel safer from attacks by predators. The low breeding success and recruitment in the agricultural habitats may be a consequence of constant disturbance from human activities like transportation, and land or building construction, which interfere with breeding and may lead to abandonment of nests and low breeding output. Environmental temperature, humidity and rainfall are generally prominent in vulture's as well as other bird's seasonal population and distribution patterns. The nature of climatic factors determines foraging period, and site selection and breeding behaviour in vultures. The seasonal and annual periodicity and nature of climatic factors such as temperature, rainfall , humidity, etc may alter movement, and daily and seasonal pattern of habitat utilization. Climate change has lately been noted as a very strong modifying factor for wild populations all over the world. Changes in temperature and rainfall may determine amount of life and the relationships between organisms in a habitat. Alterations in climate may cause changes in seasons of breeding (Nisbet *et al*., 1990) and in seasons of reproduction as well as the general availability of food resources to the avian scavengers. In general, our findings suggest that vultures face increasing and continued threats from humans.

Fragmentation and alteration of habitats has become an important factor in conservation and management of vultures, and environmental pollution by poisonous substances and dangerous chemicals (Shalloo, 2004) is of great importance, as a consequence of which there has been a dramatic decline of vultures. Diclofenac residue from the veterinary usage have been demonstrated to be a prominent influence in the decline of the service vultures provide and of rapid decline in population among the Gyps species (Oaks *et al*., 2004; Green *et al*., 2006). Though an inroad has been made and restrictions on the drug, diclofenac, have been issued, observation still continues.

The presence of vultures in a habitat is potentially of more interest than simply the agreed emphasis on biodiversity conservation since vultures provide great needed services to the private economic enterprise as well as to the Nigerian environment. By removing organic bodies and regulating disease, the vulture has kept scavengers such as wild dogs and rodents of the family, Muridae at reduced levels. Reports even connect that the increase in wild dog's populations and incidence of rabies and other zoonoses appears influenced by vultures. Our study also affirms the trend, and it strongly recommends protection as the only approach to rehashing the

extent of the damage. Attention should be focused on protecting the breeding habitats. Successful management of vultures will require public education.

The present study clarified that the habitat properties matter in determining the density of vultures found in a habitat and how species select areas to nest. Also how successful the vultures would be in reproduction from the environmental factors observed and the nutritional availability found in the areas as habitat types.

Conclusion

The present study assessed population status, distribution pattern, and habitat preference of vultures in the Bundelkhand region in Central India. Results indicate that habitat characteristics significantly shape vulture abundance, distribution, and habitat choice, as well as overall population structure. Parameter variability in population density among different habitat types indicated effect of ecological factors on species occurrence and survival. The study found that rocky habitats supported relatively higher population density and breeding success compared with other classes, where suitable nesting sites, roosting areas, and comparatively lower levels of anthropogenic disturbance is available. On the other hand, agricultural landscapes had lower abundance and breeding success suggesting that anthropogenic activities and habitat modifications pose threat to population sustainability. Availability of food is another important ecological factor affecting the distribution pattern of vultures. The more habitat types supporting sufficient food resources and suitable conditions, greater species occurrence, whereas ecological factors like climatic variables such as temperature and rainfall may influence habitat quality and population dynamics. The present investigation supports earlier findings indicating that habitat degradation, food shortage, and anthropogenic disturbances continue to threaten vulture populations. Despite conservation measures being implemented in recent years, continued monitoring and ecological management would prove beneficial for ensuring long-term population recovery. Conservation measures can focus on restricting anthropogenic disturbance around breeding sites, enhancing safe veterinary practices and awareness amongst local communities, and focus on long-term ecological monitoring and habitat management, which may prove beneficial for sustainable conservation of vulture populations in Bundelkhand region. The outcomes of the study provide baseline information regarding population status and habitat utilization of vultures in Central India and may be used in future ecological studies and conservation planning.

Recommendations

•Vulture population monitoring in Bundelkhand needs to be undertaken on a regular basis.

•High quality habitat protection initiatives need to be adopted, especially around known areas of breeding and nesting.

•Minimize human perturbation in and around important sites.

•Encourage wider acceptance of non-harmful alternatives to toxic veterinary drugs.

•Enhance community awareness and involvement initiatives.

•Perform additional work involving long-term ecological monitoring and advanced spatial analyses.

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