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Journal of Threatened Taxa

10.11609/jott.2023.15.11.24151-24290
www.threatenedtaxa.org

26 November 2023 (Online & Print)
15(11): 24151-24290
ISSN 0974-7907 (Online)
ISSN 0974-7893 (Print)



Open Access



Bhanga..



ISSN 0974-7907 (Online); ISSN 0974-7893 (Print)

Publisher
Wildlife Information Liaison Development Society
www.wild.zooreach.org

Host
Zoo Outreach Organization
www.zooreach.org

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Cover: Leaves and fruits of *Terminalia arjuna* in water colour artwork on cold pressed water colour paper by Bhama Sridharan.



OPEN ACCESS



A review of the status of vultures in the southern state of Karnataka, India

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Abstract: Vultures are vital scavengers that maintain ecological balance by feeding on carcasses. Among the nine vulture species in India, four are categorised as ‘Critically Endangered’, one as ‘Endangered’, three as ‘Near Threatened’, and one as ‘Least Concern’ as per the IUCN Red List. The vultures have experienced a global decline, while in India, majorly due to the use of diclofenac, a non-steroidal anti-inflammatory drug (NSAID). A review of all available literature on vultures from 1838 to December 2022 and extracting of all sight records from eBird to understand their status, occurrence, and distribution for the Indian state of Karnataka. The study reveals a total of seven vulture species recorded from the state, of them, one was misidentified, two are vagrants, and the other four species, namely Egyptian Vulture, White-rumped Vulture, Indian Vulture, and Red-headed Vulture, are residents. The resident vulture population in the state is experiencing a consistent decrease and has been confined in recent years to in and around Bandipur and Nagarahole tiger reserves, while Egyptian Vulture is mostly observed in human-inhabited areas. In contrast to the gradual recovery of the *Gyps* vulture population across the country, the population in the Ramadevarabetta Vulture Sanctuary remains relatively low or decreasing. Periodic systematic population assessments and monitoring of nest sites, evaluating breeding patterns, and ensuring the availability of undisturbed carcasses for vultures to feed on are suggested.

Keywords: Conservation status, conservation strategy, endangered species, *Gyps*, population status, Ramadevarabetta Vulture Sanctuary, scavengers.

Kannada: ರಾಜ್ಯದಲ್ಲಿರುವ ನಕ್ಷತ್ರ ಪ್ರಾಣಿಗಳನ್ನು (ಕಳೆದ) ತಿನ್ನುವ ಮೂಲಕ ನಿರ್ಗಲನಕ್ಕೆ ಒತ್ತಾಯಿಸುವ ಸ್ವಲ್ಪತಃ ಕರ್ಮಗಳಿಗೆ ತಮ್ಮದೇ ಆದ ಕೊಡುಗೆ ನೀಡುತ್ತದೆ. ಭಾರತದಲ್ಲಿ 9 ಜಾತಿಯ ರಾಜಕವುಗಳು ನೆಲೆಸಿವೆ. ಐಯುಸಿಎನ್ ತಯಾರಿಸಿರುವ ಕೆಂಪು ಪಟ್ಟಿಯ ಪ್ರಕಾರ ನಾಲ್ಕು ಹವುಗಳು 'ತೀವ್ರವಾಗಿ ಅಳಿವಿನಂಚಿನಲ್ಲಿರುವ', ಒಂದು ಜಾತಿಯ ರಾಜಕವು 'ಅಳಿವಿನಂಚಿನಲ್ಲಿರುವ', ಮೂರು ಜಾತಿಯ ರಾಜಕವುಗಳು 'ಅತಂತಕ್ಕೆ ಸಮೀಪವಿರುವ' ಮತ್ತು ಒಂದು 'ಲೆಸ್ಟ್ ಕಾಂಸರ್ನ್' ಹೊಂದಿರುವ ಎಂದು ವರ್ಗೀಕರಿಸಲಾಗಿದೆ. ಭಾರತದಲ್ಲಿ ತೀವ್ರಗತಿಯಲ್ಲಿ ರಾಜಕವುಗಳ ಸಂಖ್ಯೆ ಕಡಿಮೆಯಾಗುತ್ತಿದ್ದು, ವಿವಿಧ ಕಾರಣಗಳಲ್ಲಿ ಪ್ರಮುಖವಾಗಿ ನಾಡಿನ [ಜನರಿರುವ] ಪ್ರದೇಶದಲ್ಲಿ ಡೈಕ್ಲೋಫೆನಾಕ್ ಎಂಬ ನೋವು ನಿವಾರಕ ಔಷಧವಿರುವ ಜಾನುವಾರುಗಳ ಕಳೆದ ತಿಂದ ನಂತರ ರಾಜಕವುಗಳು ಮೃತಪಡುತ್ತವೆ. ರಾಜಕವುಗಳ ಕುರಿತು 1838 ರಿಂದ ಡಿಸೆಂಬರ್ 2022ರ ತನಕ ದೊರೆತಿರುವ ಅಂತಿಮಗಲು, ಮಾಹಿತಿಗಳನ್ನು ಮತ್ತು ಇ-ಬರ್ಡ್ ನಲ್ಲಿರುವ ಅವುಗಳು ಇರುವ ಮತ್ತು ಕಾಣಿಸಿಕೊಂಡಿರುವ ಕುರಿತು ಮಾಹಿತಿಗಳನ್ನು ಸಂಗ್ರಹಿಸಲಾಗಿದೆ. ಈ ಮಾಹಿತಿಯಿಂದ ರಾಜಕವುಗಳ ಸ್ಥಿತಿಗತಿ, ಅವುಗಳ ಆವಾಸಸ್ಥಾನ, ವ್ಯಾಪ್ತಿ ಮತ್ತು ವಿಸ್ತಾರ ಅರ್ಥ ಮಾಡಿಕೊಳ್ಳಲಾಗಿದೆ. ಈ ಅಧ್ಯಯನ ಪ್ರಕಾರ ಕರ್ನಾಟಕದಲ್ಲಿ ಎಂಟು ಜಾತಿಯ ರಾಜಕವುಗಳಿವೆ ಎಂಬ ಅಂಶ ಬೆಳಕಿಗೆ ಬಂದಿದೆ. ಒಂದು ಜಾತಿಯ ರಾಜಕವು ತಪ್ಪಾಗಿದ್ದು ಗುರುತಿಸಲಾಗಿದೆ. ಇನ್ನೆರಡು ಜಾತಿಯ ರಾಜಕವುಗಳು ಅಪರೂಪಕ್ಕೆ ಮಾತ್ರ ಕಾಣಿಸಿಕೊಂಡಿವೆ. ಆಲಮಾರಿ ರಾಜಕವುಗಳಾಗಿದ್ದು, ಇವುಗಳ ಮೂಲ ಮತ್ತು ವಲಸೆ ಜಾಗ ಬೇರೆಯಾದರೂ ದಕ್ಷಿಣಭಾರತದತ್ತ ವಾರಿ ತಪ್ಪಿ ಬಂದಿವೆ. ಇನ್ನು ನಾಲ್ಕು ಯಾವುದೇ ಆರೋಗ್ಯಕರ ರಾಜಕವು, ವಿಳಿಬೆನ್ನಿನ ರಾಜಕವು, ಭಾರತೀಯ ರಾಜಕವು ಮತ್ತು ಕೆಂಪುಲೆ ರಾಜಕವು ಇವು ಸ್ಥಳೀಯವಾಗಿ ರಾಜ್ಯದಲ್ಲಿ ಸಿಗುವಂತದ್ದು. ಆದರೂ ಕರ್ನಾಟಕದಲ್ಲಿ ಈ ರಾಜಕವುಗಳ ಸಂಖ್ಯೆಯಲ್ಲಿ ತೀವ್ರಗತಿಯಲ್ಲಿ ಕಡಿಮೆಯಾಗುತ್ತಿದ್ದು, ನಾಗರಹೋಳೆ ಮತ್ತು ಬಂಡೀಪುರದಂತಹ ಅರಣ್ಯದ ಸಮೀಪದಲ್ಲಿ ಸೀಮಿತವಾಗಿ ಕಾಣಿಸುತ್ತಿವೆ. ಆದರೆ ಈಜಿಪ್ಷಿಯನ್ ರಾಜಕವು ಮಾತ್ರ ಜನವಸತಿ ಪ್ರದೇಶಗಳ ಬಳಿ ಹೆಚ್ಚಾಗಿ ಕಂಡುಬರುತ್ತಿದೆ. (ಜಿಪ್, ವಲ್ಕರ್) ಹೇಗೆ ರಾಜಕವುಗಳ ಸಂಖ್ಯೆ ಕೊಂಚ ಮಟ್ಟಿಗೆ ಹೆಚ್ಚಾಗುತ್ತಿದೆ ಎಂದು ಹೇಳಲಾಗುತ್ತಿದ್ದರೂ ರಾಮನಗರದ ರಾಮದೇವರ ಬೆಟ್ಟ ಈ ರೀತಿಯ ರಾಜಕವುಗಳ ಸಂಖ್ಯೆ ಕ್ರಮೇಣ ಕಡಿಮೆಯಾಗುತ್ತಿದೆ. ನಿಯಮಿತವಾಗಿ ರಾಜಕವುಗಳ ಸಂಖ್ಯೆಯ ಮೌಲ್ಯಮಾಪನ, ಅವುಗಳ ಗೂಡುಗಳ ಮೇಲ್ವಿಚಾರಣೆ, ಸಂತಾನೋತ್ಪತ್ತಿಯ ಕುರಿತ ಅಧ್ಯಯನ ಮತ್ತು ಮುಖ್ಯವಾಗಿ ಅವುಗಳ ತಿನ್ನುವ ಕಳೆಬರಗಳಲ್ಲಿ ಅಂದರೆ ಜಾನುವಾರುಗಳ ದೇಹದೊಳಗೆ ಡೈಕ್ಲೋಫೆನಾಕ್ ನಂತಹ ಔಷಧ ಸೇರದಂತೆ ನೋಡಿಕೊಳ್ಳಬೇಕು ಎಂದು ಸೂಚಿಸಲಾಗಿದೆ

Editor: H. Byju, Coimbatore, Tamil Nadu, India.

Date of publication: 26 November 2023 (online & print)

Citation: Praphul, G. & H.N. Kumara (2023). A review of the status of vultures in the southern state of Karnataka, India. *Journal of Threatened Taxa* 15(11): 24184–24200. <https://doi.org/10.11609/jott.8627.15.11.24184-24200>

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Funding: Ministry of Environment Forest and Climate Change, Government of India.

Competing interests: The authors declare no competing interests.

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Author contributions: Both the authors have contributed equally for the manuscript.

Acknowledgements: We gratefully acknowledge the Ministry of Environment, Forest, and Climate Change, Government of India, for their generous funding support. Our sincere thanks to the Director of SACON for unwavering encouragement. Special recognition is extended to Mr. Guruprasad Thumbasoge for his invaluable assistance in translating the abstract into Kannada.



भारतीय वन्यजीव संस्थान
Wildlife Institute of India





INTRODUCTION

Scavenger bird populations are quickly dropping all over the world, with some populations already on the verge of extinction (Straub et al. 2015; Munstermann 2022). Among all raptors, vultures are the ones that scavenge, and their ecological importance cannot be overstated. Among vultures, old-world vultures are the most endangered (McClure et al. 2018). Any harm to them disrupts the natural balance, increasing the risk of pollution and illness in wildlife, humans, and livestock (Jha & Jha 2021). Thus, vultures provide vital ecological services and contribute significantly to ecosystem balance (Jha & Jha 2021). Vultures are spiritually, economically, and ecologically significant. They have traditionally been crucial in maintaining environmental health by clearing animal and human carcasses (Markandya 2008). Vultures are thought to be the most threatened functional guild on the planet (Şekercioğlu et al. 2004). Sixteen out of the world's 23 vulture species are classified as endangered, facing imminent risk of extinction in the wild (Şekercioğlu et al. 2004; Buechley & Şekercioğlu 2016) and nine of them are recorded in India (Ali & Ripley 1987), including White-rumped Vulture *Gyps bengalensis*, Indian Vulture *Gyps indicus*, Slender-billed Vulture *Gyps tenuirostris*, Red-headed Vulture *Sarcogyps calvus*, Egyptian Vulture *Neophron percnopterus*, Bearded Vulture *Gypaetus barbatus*, Himalayan Vulture *Gyps himalayensis*, Cinereous Vulture *Aegypius monachus*, and Griffon Vulture *Gyps fulvus*. The first four of the nine species have been classified as 'Critically Endangered', the fifth as 'Endangered', the next three as 'Near Threatened', and the last as 'Least Concern' in the IUCN Red List of Threatened Species (Bowden 2018).

Gyps vultures were formerly common and widespread over most of India, and their numbers were very high (Wilbur & Jackson 1983; Prakash et al. 2003). They are important scavengers, reaching particularly high abundance in human-dominated landscapes, where carrion from domestic ungulate corpses was their principal source of food (Pain et al. 2003). Further research has shown that the likelihood of transmission of zoonotic disease among people, cattle, and other animals grows with the duration of exposure and the variety of mammals present in the carcass (Heever et al. 2021). The vulture numbers began to fall in the early 1990s to 2007s in the Indian subcontinent (Cunningham et al. 2003; Prakash et al. 2003, 2007, 2012). It has been postulated that vulture population declines may result in an increase in the facultative scavenger community and ecological cascades due to increased predation, competitiveness, and incursion

(Buechley & Şekercioğlu 2016). It has been studied that replacing the natural process of carcass removal (usually performed by vultures) may increase greenhouse gas emissions, resulting in additional environmental and economic costs (Morales-Reyes et al. 2015).

In India, the fall of Gyps vultures, especially the White-rumped Vulture, Long-billed Vulture, and Slender-billed Vulture (Oaks et al. 2004), along with other vultures including the Egyptian Vulture and the Red-headed Vulture (Shultz et al. 2004; Cuthbert et al. 2006), was linked mostly to the intake of tissue from the remains of cattle that had been given the nonsteroidal anti-inflammatory medication (NSAID) diclofenac (Green et al. 2004, 2007; Oaks et al. 2004; Galligan et al. 2014; Cuthbert et al. 2015). This drug induces visceral gout, renal failure, and mortality in Gyps vultures (Swan et al. 2006). Secondary poisoning also induced high mortalities in them, compounded by vultures' inherently very low reproductive rate (Sarrazin et al. 1994).

The drop in population was observed by comparing results from road transect surveys of raptors in northern and central India in 1991–93 and 2000 (Prakash et al. 2003). Results indicated yearly drop rates of 33% for White-rumped Vultures and 27% for Long-billed Vultures (Green et al. 2004). Repeat surveys in 2000, 2003, and 2007 indicated that the decrease persisted, at unusual rates of 44% and 16% for White-rumped and Long-billed Vultures, respectively (Green et al. 2004). The estimated population drop for 1992–2007 was 96.8% for Long-billed Vultures and 99.9% for White-rumped Vultures (Prakash et al. 2007). It was also seen that there was a 35% decrease in the Egyptian Vulture population every year from 1999 and a 41% decrease concerning Red-headed Vultures, but there was no direct evidence linking this decline to diclofenac poisoning, but their range and rate of decline were similar to the Gyps species (Cuthbert et al. 2006). While in the Moyar valley there were abundant cattle species, the major diet of vultures was wild animal carcasses (90%) rather than cattle carcasses (Ramakrishnan et al. 2010, 2018); thus, they persist in the Nilgiri Biosphere.

While in southern India, efforts were made by Manigandan (2023) to assess the accuracy of vulture population estimation using three different methods: road transect surveys, counts from nesting sites, and camera trap carcass monitoring. The study identified fluctuations in the population of *Gyps bengalensis* during road transect surveys. Nest surveys revealed the existence of tree-nesting colonies of *G. bengalensis* and rock-cliff-nesting colonies of *Gyps indicus*. The estimated population range of *G. bengalensis* in these nesting colonies varied from

49 to 104 individuals, with maximum flock sizes observed ranging from 47 to 82 birds. While the population of *Gyps indicus* in the three breeding colonies remained relatively stable. For the account of the local migratory species, *S. calvus* was largely detected during road transect surveys, and *N. percnopterus* was mostly reported during carcass attendance counts.

The need to conserve the vulture population was taken up government and many research groups worldwide, including India. The conservation action plan was conceived to avert the extinction of the three endemic *Gyps* species, beginning with the removal (through effective prohibition) of the veterinary diclofenac, the finding of safe alternatives, and the initiation of an ex-situ breeding program for an ecological reintroduction (Bowden 2018). Following this, the Government of India prioritised an action plan for Vulture Conservation considering these major objectives: (1) removing diclofenac, the primary cause of vulture mortality; (2) preventing the transfer of diclofenac in its human form to the veterinary industry; (3) monitoring vulture conservation and recovery; (4) establishing and expanding a breeding and rehabilitation facility for vultures; (5) limiting additional mortality; (6) creating awareness among users of the veterinary diclofenac; and (7) monitoring the action plan's execution (MoEFCC 2020). These priority measures were achievable with agencies like the Drug Controller General of India (DCGI), which further banned the veterinary use of diclofenac in 2006, and later, with technical evidence from the agencies in 2015, the vial size for humans was also reduced to prevent misuse of the drugs. Further, with recommendations from the Drugs Technical Advisory Board, the Government of India legally banned two additional veterinary drugs, Ketoprofen and Aceclofenac, as well as their formulations for both human and animal use, as these drugs have also been identified as highly toxic to vultures (Government of India No. S.O. 3448(E) dt. 31-07-2023). The Central Zoo Authority of India, with support from the Bombay Natural History Society (BNHS), contributed to the monitoring, conservation breeding, and population estimation of vultures in India. They established eight breeding centres to breed three *Gyps* species. These breeding centres now house 731 vultures, of which 363 are White-rumped Vultures, 262 are Indian Vultures, and 106 are Slender-billed Vultures (MoEFCC 2020).

Further, the Indian Veterinary Research Institute (IVRI) in Lucknow, BNHS, and The Royal Society for the Protection of Birds (RSPB), suggested the use of meloxicam, which proved to have no ill effects on the vulture species (MoEFCC 2020). Although there was evidence of

ongoing poisoning (Cuthbert et al. 2015), later surveys indicated that the decrease in population was halted and populations are showing the first signs of recovery due to the implementation of various measures (Chaudhary et al. 2012; Prakash et al. 2012).

The remnant wild populations that are not exposed to diclofenac poisoning play an important role in population recovery (Majgaonkar 2018). Aiding to this, the creation of Vulture Safe Zones (VSZ) for the *Gyps* vulture species has aided in its recovery, and its additional plan to create VSZ in nine different states, including Madhya Pradesh, Uttar Pradesh, Assam, Jharkhand, Gujarat, West Bengal, Haryana, Tamil Nadu, and Kerala, would further aid in the long-term survival of these species in India (MoEFCC 2020).

In southern India, the population assessment, breeding, and nesting of vultures are from Moyar Valley of Nilgiri Biosphere Reserve in Tamil Nadu (Davidar & Davidar 2002; Ramakrishnan et al. 2010, 2012, 2014, 2018; Samson et al. 2015, 2016b, 2016c; Venkitachalam & Senthilnathan 2015, 2016; Chandrasekaran 2018) apart from few sight records (Gajamohanraj 2020; Kumaraguru 2021). The population assessment and nest count were done for Wayanad Wildlife Sanctuary in Kerala (Shashikumar 2001; Sashikumar & Vishnudas 2018) and distribution pattern and population status for a large part of Andhra Pradesh (Umaphathy et al. 2009; Manchiryala & Hussain 2018). However, the documentation in Karnataka is highly limited to sight records and reports of breeding locations. Although these southern states harbor small populations of vultures, it is crucial to comprehensively assess changes in their population status over time. This includes identifying potential gaps such as population status, breeding sites, foraging grounds and conservation issues. To achieve this goal, we reviewed all possible literature on vultures and here provided a comprehensive understanding of vultures to date for the state of Karnataka.

MATERIALS AND METHODS

Study Area

Karnataka is geographically located on a tableland where the Western and Eastern Ghat ranges meet to form the Nilgiri hill complex. The state of Karnataka is broadly bounded by latitudes of 11.516°N & 18.750°N and longitudes of 74.200°E & 78.683°E. The geography of Karnataka includes high mountains, plateaus, remnant hills, and coastal plains. To the west, east, and south, the state is bounded by mountain ranges. The northern re-

gion is mostly plateau with elevation ranging 600–900 m. The elevation highly varies up to 2,000 m with many peaks in the Western and Eastern Ghats.

Data Collection and Compilation

To search relevant literature, we used the keywords vulture, Karnataka, district names of Karnataka, and each vulture name while looking for literature on the Egyptian Vulture *Neophoran percnopterus ginginianus*, we used the search keywords ‘Egyptian Vulture,’ ‘*Neophoran percnopterus ginginianus*,’ Vulture, and Ranahaddu (Kannada word for the same), as well as Karnataka in Google scholar (<https://scholar.google.com>), and National Ornithological Database (<https://www.sacon.in/nod/>). We collected eBird data for each species and their location. We examined annotated databases, such as newsletters, magazine articles, and grey literature, all in conjunction with a snowball sampling method that covered all literature that discussed vultures.

The extracted data were categorised into 1) sight records and checklist records, 2) diversity and distribution studies, 3) ecological studies, 4) behavioural observation/record, and 5) conservation action or awareness. We recorded the ‘Year of Publication and Study Period’. The ecological components were initially investigated by gathering information on the general emphasis of the study, the number of species (checklists recorded individually), the study region or location, and the geographical scope, i.e., whether the study was limited to one state or encompassed many states/districts, forest status, and habitat type.

Analysis

We compiled a checklist of species found in the state of Karnataka based on all possible literature, and eBird data from 1970 to December 2022 (Supplementary Table S1). The eBird is often opportunistic, thus, we carefully considered the data and used considering its limitations. We provided the conservation status as in the IUCN Red List and Indian Wild Life (Protection) Act, 1972 for each species. Using the location of each detection, we depicted the spatiotemporal distribution pattern for all the species. We summarised the details available on breeding locations of the species and conservation initiatives taken up and their outcomes in the state.

RESULTS

A total of seven species of vultures have been recorded from Karnataka, including Egyptian Vulture, Indian

Vulture or Long-billed Vulture, White-rumped Vulture, Red-headed Vulture, Cinereous Vulture, Griffon Vulture, and Himalayan Griffon Vulture. Among them, the last three species are vagrant and occasionally recorded. The conservation status of all seven species in the Indian Wildlife (Protection) Act is ‘Schedule-I’ (Table 1).

SPECIES ACCOUNT IN KARNATAKA

Egyptian Vulture (Image 1): The vulture used to be seen on the plains of Manjrabad in Sakaleshpur (Taylor 1887), and also eastern plains of Kanara region, nevertheless birds were sighted at the edges of the forests and coasts of Honnavara and Kumta (Davidson 1898). During the birding visit to Mysore province in 1939-40, Ali & Whistler, (1943) reported that the bird is resident of the deciduous biotope, and intermediate zones close to human inhabits, the bird is common in coffee estates of the Biligiriranganatha Hills, Bandipur Tiger Reserve, Santanur, Mysore, Chitradurga, Bangalore, Doddaballapur, and Kolar gold fields. Two birds, one in Breeding plumage and another juvenile were sighted on the outskirts of Mysore, and later three individuals were recorded from the same location in 2000–01 (Pittie 2000a, 2001a). Though exploited by urbanization, the foothills of Chamundi Hills in Mysore city serve as roosting sites for the Egyptian vultures. The city dump yard in the foothills serves as a feeding area for these vultures. These dump yards also had cattle carcasses thrown in, and the vulture was seen feeding on them in 2012 (Samson et al. 2014). The scavenger was seen in Kodagu in mid-2000 (Pittie 2000a), four vultures were spotted in 2013 on the outskirts of Bellary and the adjoining Raichur districts (Martin 2013). Around 123 vultures including 79 adults, 22 sub-adults, and 22 juveniles were reported from in and around Ramadevarabetta of Ramanagara during the survey in December 2013 and April 2014 and reported that

Table 1. The status of vultures (Accipitriformes: Accipitridae) that are recorded from Karnataka in the IUCN Red List, all the listed species occur in Schedule I of the Indian Wildlife Protection Act.

Common name	Scientific name	IUCN status
Egyptian Vulture	<i>Neophron percnopterus</i>	Endangered
White-rumped Vulture	<i>Gyps bengalensis</i>	Critically Endangered
Indian Vulture	<i>Gyps indicus</i>	Critically Endangered
Himalayan Griffon Vulture	<i>Gyps himalayensis</i>	Near Threatened
Griffon Vulture	<i>Gyps fulvus</i>	Least Concern
Cinereous Vulture	<i>Aegypius monachus</i>	Near Threatened
Red-headed Vulture	<i>Sarcogyps calvus</i>	Critically Endangered

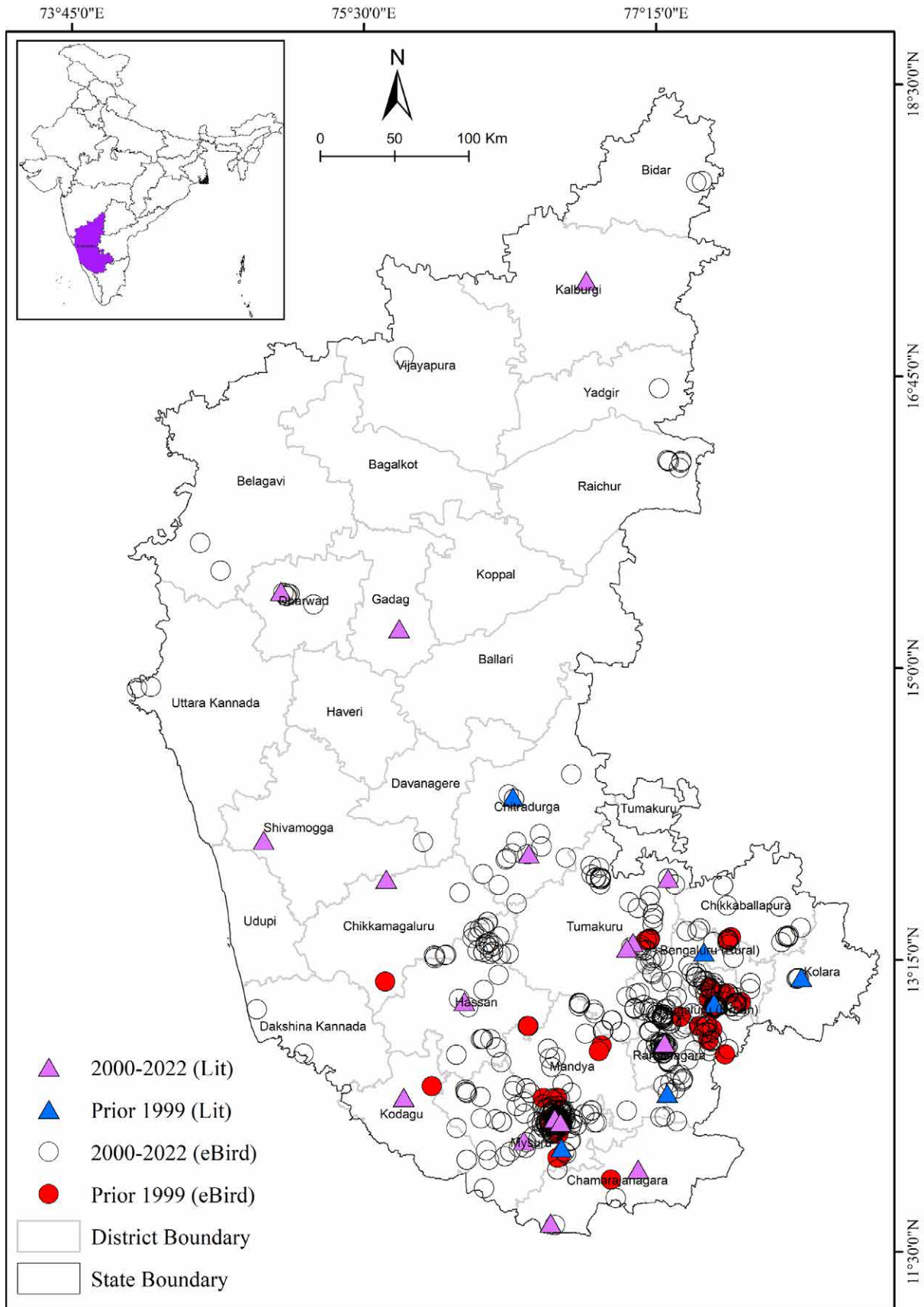


Figure 1. Sight record of Egyptian Vultures in Karnataka from 1838 to 2022.

they were dependent on silk processing sites and a dump yard of slaughterhouse waste (Samson & Ramakrishnan 2016a). Few individuals were sighted from 2003 to 2016 in the Mangala and Melukamanahalli area of Bandipur (Rajkumar 2018). Although the eBird data added more locations in the last two decades, more recordings were from southern districts, i.e., Mysuru, Mandya, Ramanagara, Bengaluru, Kolar, and Chitradurga, nevertheless, occasional sightings were recorded from the rest of the state (Figure 1).

White-rumped Vulture (Image 2): The initial record of the species was in the late 18th Century, e.g., Manjrabad fort area in Sakaleshpur (Taylor 1887) and several birds and their nests from the forests of Kanara (Davidson 1898). Later in the first half of the 19th Century, the species was recorded from many locations in the state, e.g., frequent sightings from Londa of Belagavi in 1938 (Koelz 1942), a good number of birds and nesting in moist forests of Shettihalli in 1939–40 and the evergreen forest of the Gersoppa falls (Ali & Whistler 1943). More records of the sighting were from the second half of the 19th century e.g., sighted frequently in Chikkamagaluru town in the 1990s (Chakravarthy & Tejasvi 1992), a mixed flock of 300 vultures were observed on a carcass in Bangalore between 1984 and 1988 (Satheesan 1990). The sightings in the last two decades (2000 - 2022) include six birds in the IISC campus in Bangalore in 2001 (Pittie 2001b), and two birds in September 2000 at Naryanadurga hills of Melkote WS (Thejaswi 2003), frequent sightings from Nagarahole, e.g., 30–40 birds and later few were recorded with other vultures on elephant carcass during January 2000 (Pittie 2000b; Sarath 2000), 90 birds on a deer carcass in June 2005 (Ramesh 2005), three birds with other vultures in January 2014 (Robson 2014), and Bandipur, e.g., frequently sighted from Byladkuppe cliffs, Rampura and Banur, and also reported them to nest and reproduce in the park (Rajkumar 2018), and Ankola and Karwar, e.g., 12 birds at Hattikeri Timber Depot in 2007 (Praveen 2007). Anoop et al. (2020) reported that these vultures occupy and nest on trees with good girth, especially on Arjuna trees in the riparian habitat, and predicted suitable habitat for the reintroduction in several protected areas of southern Western Ghats. The eBird data also indicate occasional sightings from the entire state but most of the sightings are confined to a few southern districts, especially to the forests of Bandipur and Nagarahole (Figure 2).

Indian Vulture (Image 3): Inhabitant of open areas and forested landscapes. The bird has been recorded from different parts of Karnataka, i.e., Kanara, Londa, and Tumkur (BirdLife International 2001), In December 1935,

a few birds were seen nesting on cliffs opposite Jog Falls (Abdulali 1936; Ali & Whistler 1943). In January 2000, 40–50 birds were feeding on the carcass of an elephant along with other vultures in Nagarahole (Sarath 2000; BirdLife International 2001). In January 2013, 16 vultures were recorded on the outskirts of Bellary (Martin 2013). Three nests with chicks and successful nestlings growing to adulthood were reported in 2006 from rocky edges of Ramadevarabetta of Ramanagara hills (Subramanya & Naveen 2006). However, only seven birds and two nesting were recorded in 2015–16, and one nest in 2016–17 but no chicks were observed from the same hills (Ashok 2018). In Bandipur, breeding was recorded from Moolehole in Rampura along with white-backed vultures in 1996 (Rajkumar 2018), and the continued monitoring of these nests reported breeding in 2002–03 and 2008–11 in Moolehole and Banur in the Gundre range (Rajkumar 2018). Prior to 1999, the species was infrequent throughout the southern part of the state. The sight record of the bird in the eBird shows that most of the sightings are reported from southern Karnataka except few sightings in the rest of the state, of them, most of the sightings are from Ramadevarabetta Vulture Sanctuary, Bandipur, and Nagarahole (Figure 3).

Himalayan Griffon Vulture (Image 4): The bird is spread over the Himalayan landscape and is an infrequent visitor to South India. Two individual birds were seen simultaneously in the Ramanagara Vulture Sanctuary and the Hesaraghatta Grasslands in February 2013 (Praveen et al. 2014). A juvenile was sighted in the Halga-Ulga region of Uttara Kannada District in January 2016 (Surve 2016) (Figure 4).

Cinereous Vulture (Image 5): The Cinereous vulture usually winters in North India and is a rare visitor to Peninsular India (Ali & Ripley 1987). The bird was sighted for the first time at Harangi Dam in Kushalnagara in December 1998 (Subramanya 2001), on the bank of Lakshman Thirta River in Krishnaraja Sagar Reservoir near Mysore in January 2002 (Shivanand 2004), and sighted between December 2016 and January 2017 at Kabini backwaters of the Nagarahole while feeding along with Long-billed Vultures and Red-headed vultures (Samson et al. 2019) (Figure 4).

Red-headed Vulture (Image 6): Except for a few sight records of the species, no other information is available on the species from the state. In the late 18th Century, three vultures were seen feeding on a donkey carcass and later one specimen was collected in and around Manjrabad fort in Sakaleshpur (Taylor 1887). The bird was speculated to be a resident of the Kanara region as it was sighted occasionally in all seasons and parts of



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Image 1. Egyptian Vulture



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Image 2. White-rumped Vulture



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Image 3. Indian Vulture



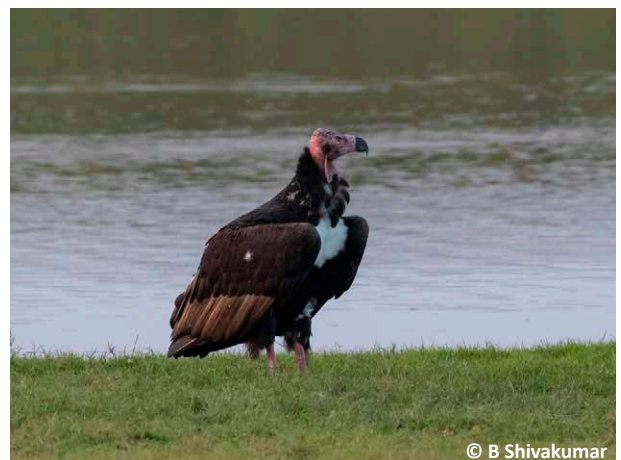
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Image 4. Himalayan Griffon Vulture



© Arindam Sinha

Image 5. Cinereous Vulture



© B Shivakumar

Image 6. Red-headed Vulture.

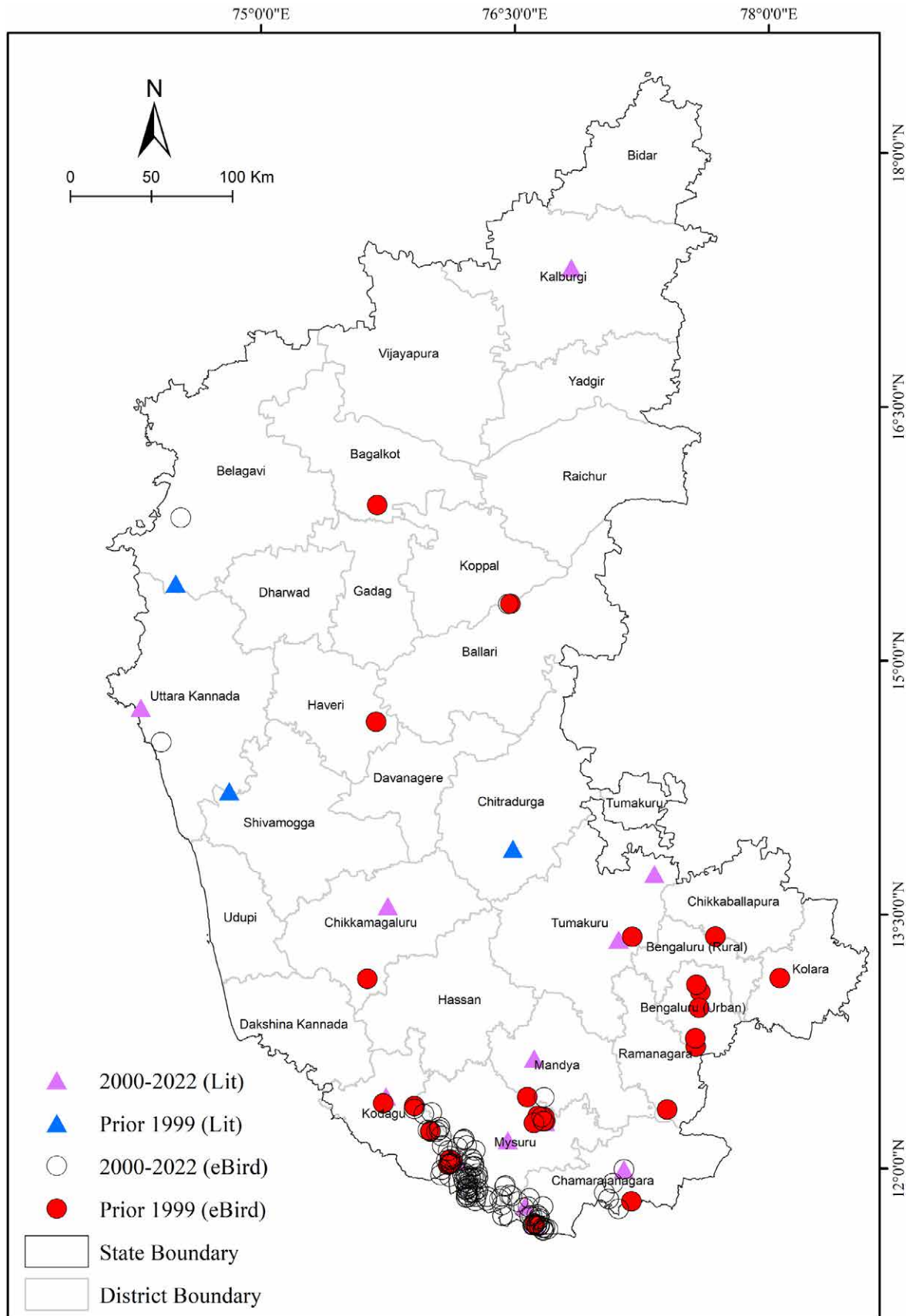


Figure 2. Sight record of White-rumped Vultures in Karnataka from 1838 to 2022.

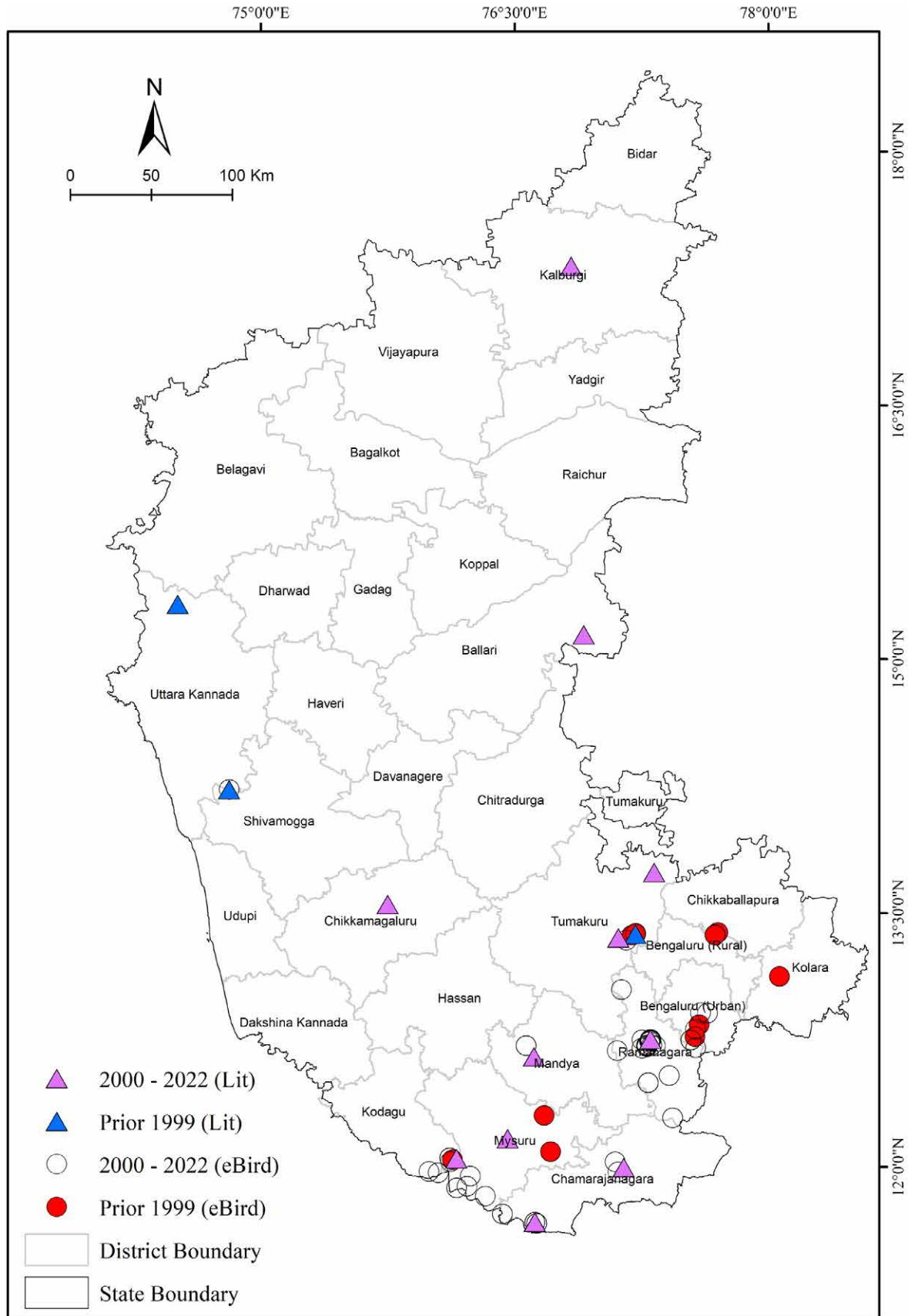


Figure 3. Sight record of Indian Vultures in Karnataka from 1838 to 2022.

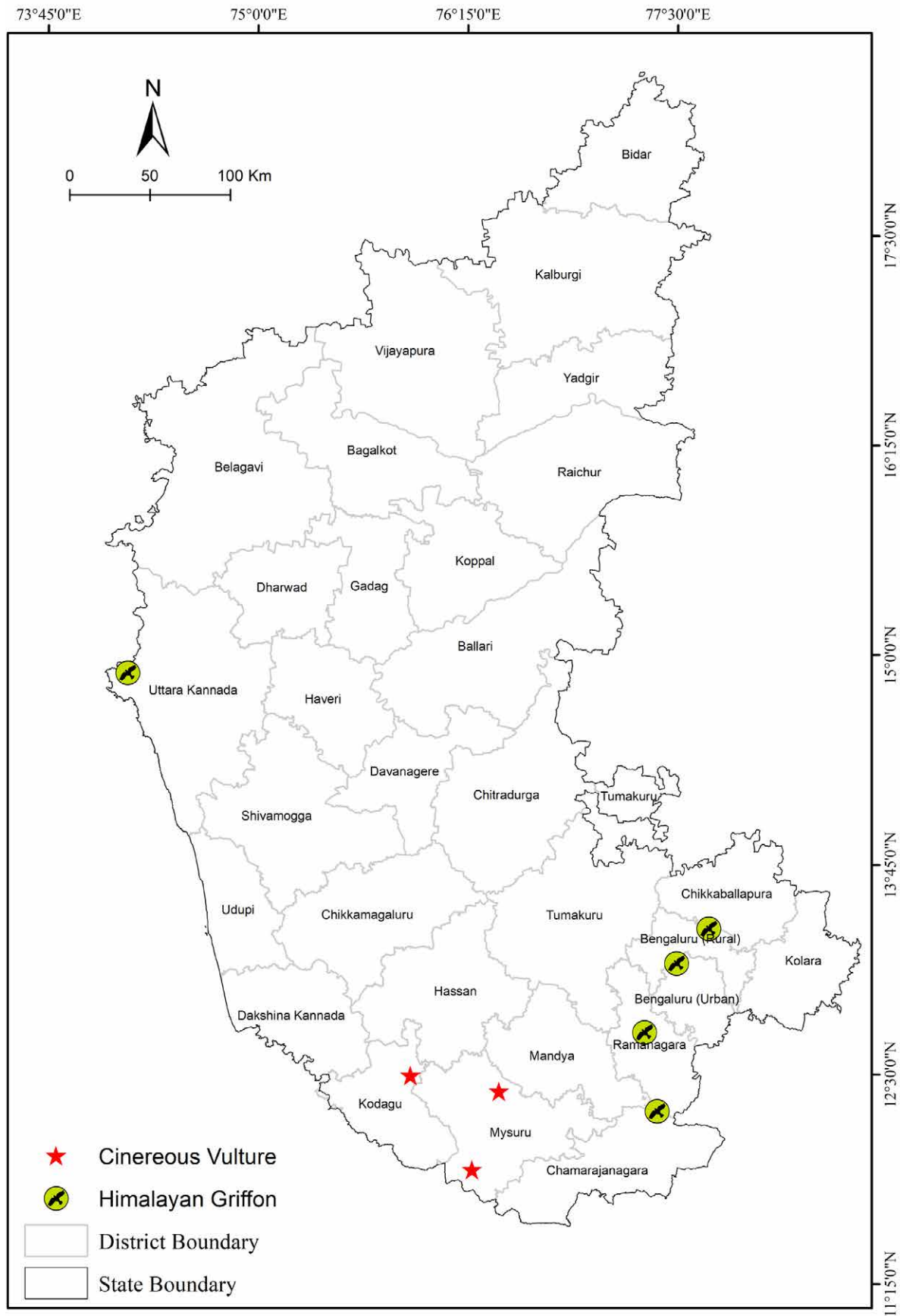


Figure 4. Sight record of Himalayan Griffon and Cinerous Vulture in Karnataka from 1838 to 2022.

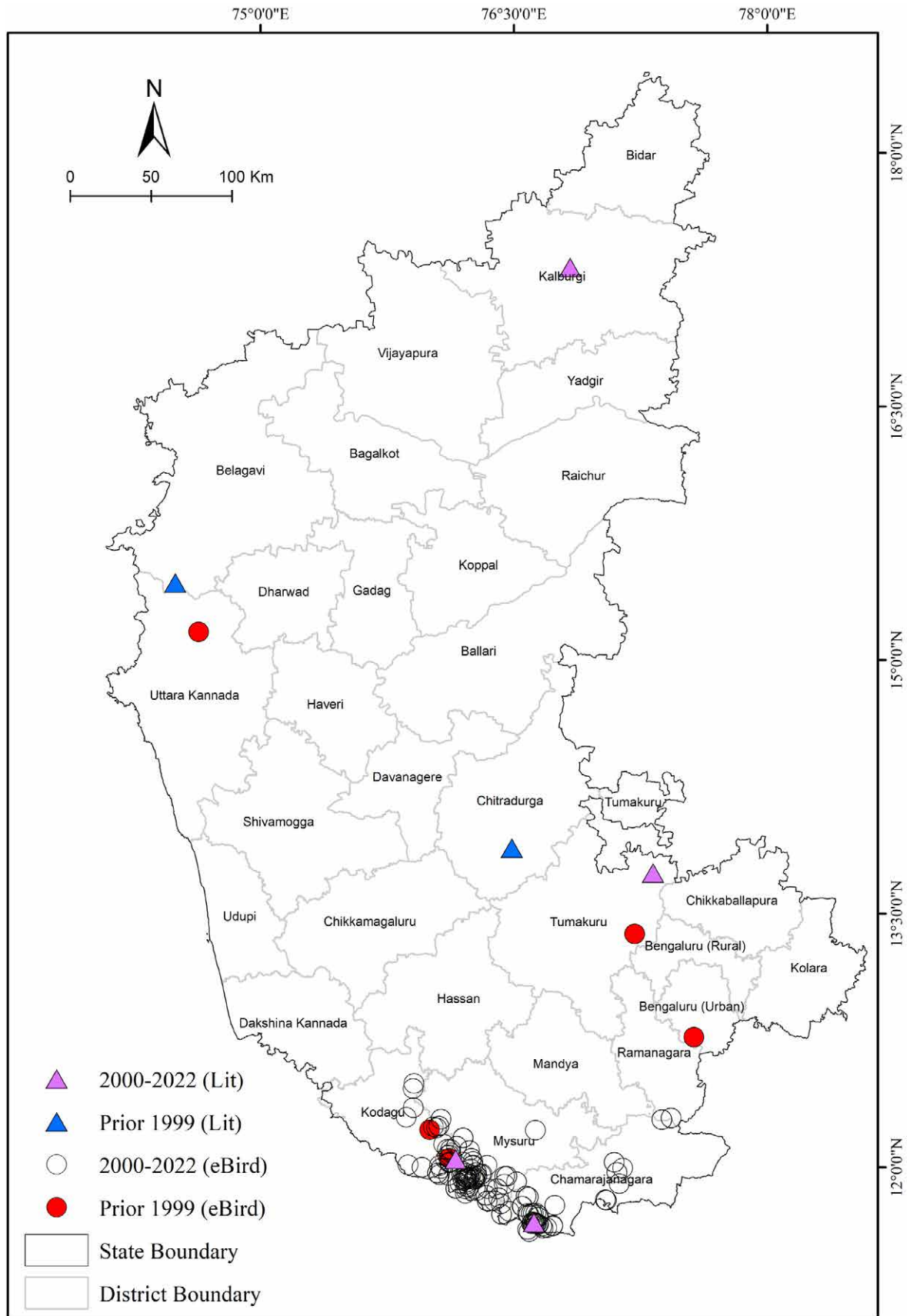


Figure 5. Sight record of Red-headed Vultures in Karnataka from 1838 to 2022.

the region (Davidson 1898). Single birds were occasionally seen in Bandipur and Maarikanive during 1939–40 (Ali & Whistler 1943). Intermittent sighting of the vulture was reported from Nagarahole, e.g., 8–10 vultures were observed feeding on elephant carcasses in January 2000 (Sarath 2000), two vultures were sighted later in 2000 (Pittie 2000b), one vulture was seen feeding on deer carcasses in January 2005 (Ramesh 2005) and two vultures in late January 2014 (Robson 2014). Rajkumar (2018) reported that the bird is a resident, usually single or two individuals are sighted frequently in Bandipur, but the population status is not available for the park. The eBird data also shows except for one or two recordings from northern and south-eastern Karnataka, many of the sightings are confined to forested areas of Kodagu, Mysuru, and Chamarajanagar, especially at Bandipur and Nagarahole (Figure 5).

Griffon Vulture (Image 7): Occasional reports of the species are recorded from the state, e.g., one bird was collected from a flock of 50 in 1938 from Jagalbet, Uttara Kannada District (Koelz 1942), and several pairs were sighted on ledges of rocky patches near the Gersoppa falls during 1939–40 (Ali & Whistler 1943b), and an individual was sighted with a mixed flock of vultures in Nagarahole in 2000 (Pittie 2000b).



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Image 7. Griffon Vulture

Sight records of different vulture species in protected areas and non-protected areas

From 1838 to December 2022, among all the seven

species of vultures, the sighting record of the Egyptian vulture (n = 1802) was more than all other species (White-rumped Vulture: 522; Red-headed Vulture: 521; Indian Vulture: 465; Himalayan Griffon: 5; and Cinereous Vulture: 3). Of them, more than 80% of the sight records of Red-headed Vulture, White-rumped Vulture, and Indian Vulture were from protected areas, while only 14% of sight records of the Egyptian Vulture was from protected areas (Figure 6).

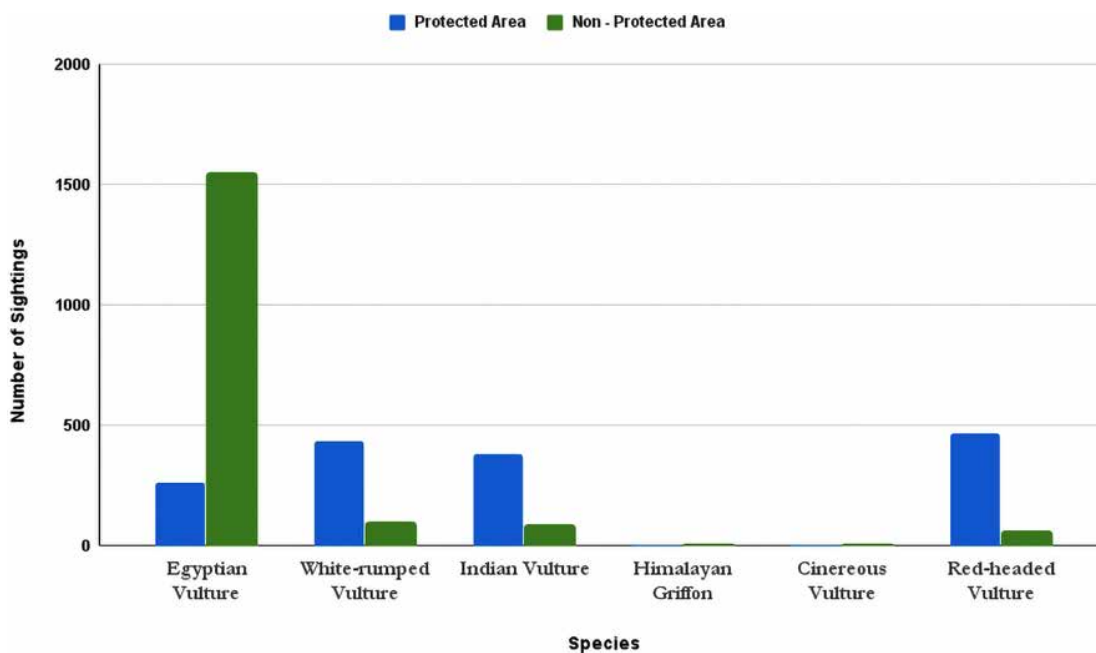


Figure 6. Sight records of different vulture species in protected areas and non-protected areas from 1838 to 2022.

Record of nest sites

Although nests of Egyptian Vultures, Indian Vulture, Red-headed Vulture, and White-rumped Vultures were recorded over a period of one century in different parts of the state, most of the recordings are largely from Ramanagara, Bandipur, and a few other locations in southern Karnataka (Supplementary Table S2). But in the last decade, the recordings of nest sites are only from Ramanagara, Bandipur, and their surroundings.

Conservation Initiatives

Considering the constant sightings and breeding records from Ramanagara Hills, Forest Department, Karnataka, declared this region for the conservation of vultures in January 2012 as 'Ramadevarabetta Vulture Sanctuary' (Government of Karnataka No. F.E.E.234.S.W.L. 2009, dated 31 January 2012).

DISCUSSION

In Karnataka, seven vulture species are recorded, with the Cinereous Vulture and Himalayan Griffon Vulture being occasional visitors, as documented by Praveen et al. (2014) and Samson et al. (2019), while the Egyptian Vulture, White-rumped Vulture, Indian Vulture, and Red-headed Vulture are permanent residents. This distribution pattern extends to the neighboring southern Indian states of Tamil Nadu and Kerala, with the additional presence of the Griffon Vulture as an infrequent visitor, as reported by Gajamohanraj (2020), Kumaraguru et al. (2021), and Roshnath & Sashikumar (2021). Most vulture sightings are concentrated in southern Karnataka, with sporadic observations in the central and northern regions. Notably, the Egyptian Vulture is the most prevalent species in the state, primarily outside of protected areas, while the White-rumped Vulture and Red-headed Vulture, previously sighted across various regions, have been mainly documented in Bandipur and Nagarhole over the past two decades. Similarly, the Indian Vulture is known to inhabit Bandipur, Nagarhole, and the Ramadevarabetta Vulture Sanctuary.

Before 2000, vulture sightings in Karnataka were scarce, likely due to a lack of birdwatchers and awareness. However, since 2000, platforms like eBird and iNaturalist have facilitated increased birdwatching and record-keeping, resulting in a higher number of bird sightings, including vultures. Nevertheless, this data hasn't yet covered every corner of the state or the country, which is essential for a comprehensive understanding of vulture occurrence, spatial distribution, and sighting

frequency. Despite these limitations, the findings have been carefully considered (Supplementary Figure S1).

The occasional vagrant sightings of Griffon vultures have raised concerns in Karnataka. Historical sightings reported by Ali & Whistler (1943) were later retracted due to misidentification, as was the case with Ali & Abdulali (1945) and their opinions on specimens collected from Koelz (1942) and the sighting of 50 vultures. Furthermore, the specimen collected by Koelz (1942) could not be located, leading to its omission from Rasmussen & Anderton's (2012) 'Ripley Guide to Birds of South Asia.' Gajamohanraj (2020) recommended removing this species from the checklist of Birds of Karnataka as per Praveen et al. (2016). While this species is also recorded in the Moyar Gorge of Mudumalai Tiger Reserve in Tamil Nadu, adjoining Karnataka (Gajamohanraj 2020), the bird's presence or visits in the state cannot be disregarded. Some evidence suggests long-distance vagrancy, with Himalayan Griffon vultures being sighted in southern India (Kumaraguru et al. 2021; Praveen et al. 2014; Surve 2010), possibly indicating a decline in their regular Himalayan breeding range's food supply coupled with the inexperience of immature birds in foraging and navigation (Ding Li & Kasornkorkbua 2008). Recently, a suspected case of electrocution of a Himalayan Griffon Vulture was documented in the nearby Mudumalai Tiger Reserve (Manigandan et al. 2021).

In recent times, India has seen a decrease in the rate of vulture population decline (Prakash et al. 2019), with some regions showing a slow recovery, such as a 12% increase in vulture population in Madhya Pradesh (Jha 2017). Prakash et al. (2019) reported significantly lower densities of the Indian vulture and White-backed vulture in southern India compared to the north. Unfortunately, the review highlights the absence of a comprehensive scientific population assessment in Karnataka, with available data stemming from sporadic records, eBird entries from the last two decades, and opportunistic sightings, except for one population monitored in Ramanagara by Ashok (2018). Given the significant population of Indian vultures in Ramanagara, the rocky outcrops in this region were declared the "Ramadevarabetta Vulture Sanctuary." However, the decrease in vulture numbers and breeding failures pose significant concerns, as the primary Indian vulture population in the state is centred around these hills.

White-backed vultures and Red-headed vultures, although occasionally sighted in various parts of the state, are now primarily concentrated in Bandipur, Nagarhole, and their surroundings, likely due to the availability of uncontaminated carcasses in these areas (Prakash et

al. 2012; Galligan et al. 2014). Conversely, the Egyptian vulture is predominantly found outside protected areas and is recorded over a more extensive region in South Karnataka. In South India, their abundance seems better in Karnataka than in Tamil Nadu (Byju & Raveendran 2022) and Kerala (Sashikumar & Vishnudas 2018). However, the population trend of this species in South India, including Karnataka, remains unclear. Although recent records of nest sites for Egyptian Vultures are lacking, sightings of juveniles in various locations suggest that they are breeding in nearby areas.

White-rumped vultures (Gadhvi & Dodia 2006; Thakur & Narang 2012; Khan 2013; Ramakrishnan et al. 2014; Majgaonkar et al. 2018) and Red-headed vultures (Chhangani 2007; Dhakal et al. 2014) typically construct their nests on tall trees. Several nest sites for White-rumped Vultures have been identified in Bandipur, Nagarahole, and adjacent areas in Tamil Nadu and Kerala. For instance, approximately 68 nests were documented in the riparian habitat of the Nilgiri North Forest Division (Ramakrishnan et al. 2014). Later, 36 pairs of an active nesting population were observed in the same area and the adjoining Mudumalai Tiger Reserve (Venkitachalam & Senthilnathan, 2016). Furthermore, a population range of 49 to 104 individuals was recorded in nesting colonies across the Mudumalai Tiger Reserve (Manigandan et al. 2023). Additionally, 12 nests were recorded in the Wayanad Wildlife Sanctuary in Kerala (Sashikumar & Vishnudas 2014). In recent years, a single nest of the Red-headed vulture has been identified in Bandipur.

Indian Vultures in Karnataka are known to nest on rocky cliffs, particularly in Ramanagara. However, previous studies also indicated that they occasionally build their nests on trees, for example, in Moyar Gorge in Tamil Nadu and various locations in Andhra Pradesh. This adaptability is likely driven by the availability of a good food resource (Prakash et al. 2012). In Mudumalai Tiger Reserve, three Indian vulture breeding colonies—Ebbanad, Nilgiri Eastern Slopes, and Kallampalayam—recorded 92 (2020–21), 142 (2019–2020), and 144 (2019–2020) vultures, respectively, with remarkable population stability over the three years (Manigandan et al. 2023).

The review underscores the ongoing vulture population decline in Karnataka, emphasising the necessity for systematic population assessment and monitoring in the state. Identifying vulture nest sites and monitoring their breeding success are crucial steps for effective management interventions, particularly given the major surviving vulture populations around Bandipur, Nagarahole Tiger Reserves, and Ramadevarabetta Vulture Sanctuary. Ensuring the availability of uncontaminated food

resources in their habitat is essential to guarantee their survival.

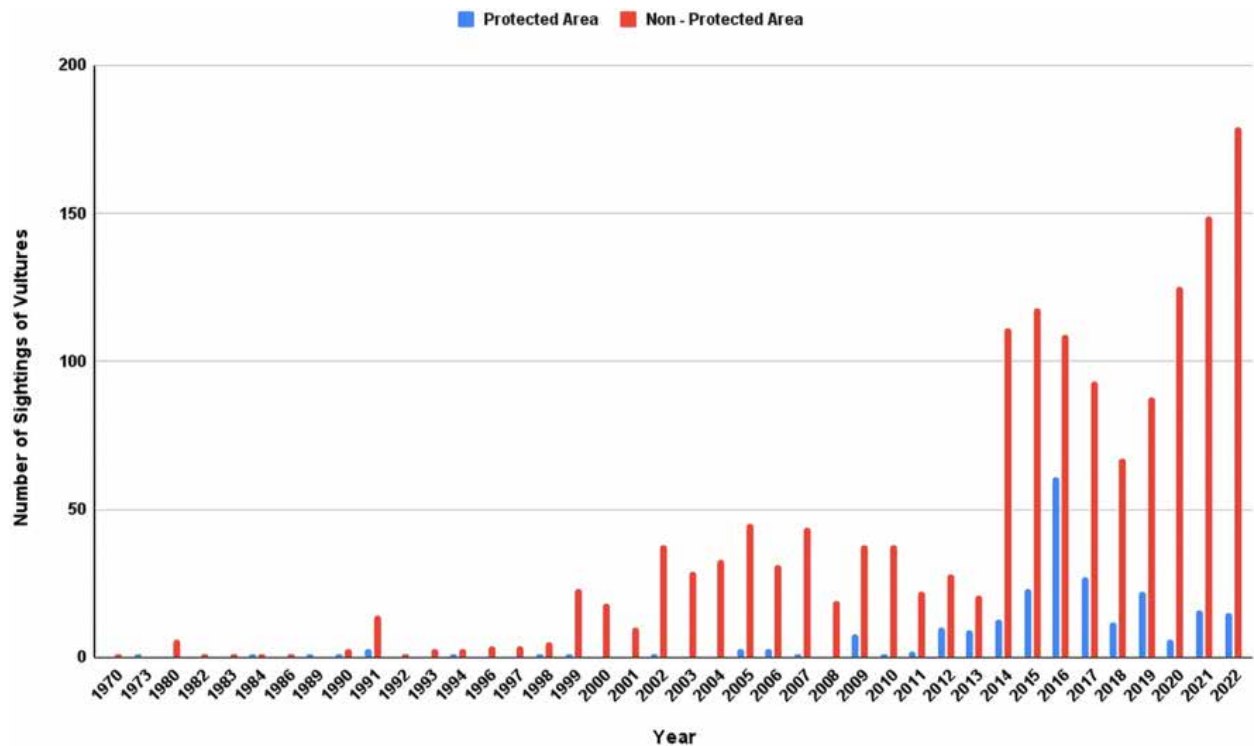
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Supplementary Figure S1. Sight record of vultures as per eBird records in different years from 1970 to 2022.

Supplementary Table S1. Published literature and Ebird Data from 1838 to 2022.

The supplementary table has been deposited in the repository:

<https://data.mendeley.com/datasets/n3ytc6rdx/1/files/868459fa-0112-43f7-b0fd-7c1fa49b94d3>

Supplementary Table S2. The nesting location of all vulture species in Karnataka recorded in the literature.

The supplementary table has been deposited in the repository:

<https://data.mendeley.com/datasets/n3ytc6rdx/1/files/78f67410-004b-43d0-ba46-9d70b7574162>



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Print copies of the Journal are available at cost. Write to:
The Managing Editor, JoTT,
c/o Wildlife Information Liaison Development Society,
43/2 Varadarajulu Nagar, 5th Street West, Ganapathy, Coimbatore,
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ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

November 2023 | Vol. 15 | No. 11 | Pages: 24151–24290

Date of Publication: 26 November 2023 (Online & Print)

DOI: 10.11609/jott.2023.15.11.24151-24290

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