Rare raptors of Iran and recent conservation efforts

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Abstract. Approximately, 57 species of birds of prey were recorded in Iran. According to the IUCN red list of threatened species, six of these raptors are considered threatened and rare. These include Saker Falcon, Steppe Eagle, Eastern Imperial Eagle, Egyptian Vulture, Lammergeyer and Black Vulture. These raptors spend a considerable portion of their migration in Iran. Therefore, there is a need to gather and update the recent knowledge about the conservation of these raptors in Iran. Several procedures, including the systematic search throughout different databases, and search for studies in the reference list of the peer reviewed journals, were applied to achieve a high-quality list of references for this review. The general trend of conservation studies of rare raptors in Iran is more towards understanding both habitat use and habitat suitability. The findings of these studies indicated reconsideration of the boundaries of current protected areas since these reserves were initially set based on the distribution of wild mammals.

1. Introduction

Study of raptors in ancient Iran/Persia can be traced back to a long time ago (14th century) when these birds were participated in hunting. For instance, the book of “Qawaninsayyad” describes how to train merlins to catch prey and what kinds of instruments are required for falconry [1]. However, first comprehensive falconry book in Iran is called “Baznameh-e-Naseri” commissioned by Nasraddin Shah, the Qajar king, in 1867. This book is still considered as one of the valuable resources for falconry and it has been translated into English, French and German [2]. Being placed between Eurasian breeding grounds and wintering grounds, such as Indian subcontinent, Southwest Asia and Africa, Iran’s land is reported to be of interest by 450 species of migratory birds [3]. These migratory routes are mainly along the northeast-southwest axis of Iran which connects the Palearctic breeding grounds to the Ethiopian region’s wintering grounds [4].

Having various types of biome, Iran has been a habitat for many birds of prey. These include 57 species of raptors categorised into Falconiformes, Accipitriformes, or Strigiformes orders [5]. Some of them are residents, some use these habitats for breeding activities (breeding migrants) and ultimately, some of these raptors are passengers or seasonal visitors. Saker Falcon, Egyptian Vulture, Lammergeyer, Black Vulture, Steppe Eagle and Eastern Imperial Eagle were more highlighted in this study, mainly because of their critical conservation status. In spite of considerable number of raptors species in Iran, only a handful of ornithological studies were focused on raptors. These studies mainly consisted of identification of migratory routes, determination of habitat use, assessment of habitat suitability, study of toxic metals’ concentrations, and reports of diseases in these birds. Here we present the current knowledge and conservation efforts made to protect raptors in Iran, especially for those raptors with threatened conservation status.
2. Methods
To ensure that a high quality and thorough search were done throughout different databases, several procedures were followed. The databases were inclusive of Scopus, PubMed and Google scholar. First, using a wide range of key terms, a comprehensive search of peer review journals was done. Articles found in this step were subjected to full-text assessment. After full-text assessment, eligible studies were included in study. Reference section of the included articles were searched for additional literature. When the reference section of the eligible studies was being searched for potential literature, conference papers and reports were also considered to be added to the included studies. Ultimately, officials from both public and private organizations, such as department of environment (DOE), Tarlan Ornithological Society, IUCN vulture specialist group (VSG) and Iran bird records committee, were sought for additional information.

3. Results and Discussion
3.1. Data collection and assessment:
Extracted data consisted of characteristics of the study (first author’s surname and year of publication), subject of the study, species of birds of prey and main results. The extracted data from the included indexed peer reviewed studies are summarized in Table (1). Main results of the studies can be found in discussion part.

| Author (year)           | Subject of study                 | Species                        |
|------------------------|----------------------------------|--------------------------------|
| Esfandeh (2019)        | Habitat suitability             | Eastern Imperial Eagle         |
| Farashi (2019)         | Distribution (Niche modelling)   | Egyptian Vulture               |
| Gavashelishvili (2012)| Movement and habitat use        | Black Vulture                  |
| Ghazaei (2007)         | Babesiosis treatment            | Saker Falcon                   |
| Ghoddousi (2007)       | Habitat suitability             | Saker Falcon, Egyptian Vulture |
| Hossinei-zavarei (2008)| Habitat use                     | Steppe Eagle, Eastern Imperial|
| Arsouei (2009)         | Habitat use                     | Eagle, Saker Falcon            |
| Meyburg (2012)         | Migration strategies            | Steppe Eagle                   |
| Parchami-Araghi (2015)| Myiasis treatment               | Eastern Imperial Eagle         |
| Poessl (2018)          | Movement & habitat use          | Eastern Imperial Eagle         |
| Tohidifar (2009)       | Habitat use                     | Steppe Eagle, Eastern Imperial|
| Zarei (2018)           | Mercury concentration           | Saker Falcon, Lammergeyeyer    |
| Zolfaghari (2007)      | Steppe Eagle, Saker Falcon,     | Eastern Imperial Eagle, Saker |
|                       | Lammergeyeyer, Black Vulture    | Saker Falcon                   |

In order to determine the general tendency towards conservation of the rare raptors in Iran, percentage of different conservation studies conducted for each raptor was presented as a graph in Figure 1. This graph indicates that the major trend of conservation studies on these raptors is towards assessment of suitability of protected areas by looking at movements and distributions of these raptors in Iran. These studies can play a key role in possible reconsideration of wildlife reserves that were initially set based on the distribution of terrestrial mammals. Considering the migrant nature of these rare raptors, identification of migration routes and suitable habitats are more highlighted. Permanent visitors of the winter or breeding seasons, including Eastern Imperial Eagle, Saker Falcon, Egyptian Vulture and Lammergeyeyer, should be prioritise in this assessment.
3.2. Accipitridae

In this family, a total of 31 species were observed and recorded in Iran. In addition, Osprey from Pandionidae family is commonly reported to hunt on both north and south shores of Iran. The Egyptian Vulture, Lammergeyer, Black Vulture, Steppe Eagle and Eastern Imperial Eagle are the most important species of this family in terms of their conservation status.

3.2.1. Lammergeyer. Lammergeyer (G. barbatus), also called bearded vulture, mainly reside in Caucasus area between black and Caspian Sea. This area consists of several countries inclusive of Armenia, Azerbaijan, Georgia, some parts of the Russian Federation, Turkey, and Iran. Lammergeyer prefers open landscapes with abundance of food for breeding purposes, and avoids the harshness of higher elevations [6]. The bone eating habit of this bird was reported in Old Persian literature and was examined by Emperor Jahangir in 1625 [7]. In Persian culture, this bird is called “Huma” or “Homa”, and it is the symbol of luck and happiness. Bearded vulture is considered as an endangered species in Iran. Reports indicating breeding activities of this species in north and west parts of Iran have been issued [8,9]. These findings are consistent with favourable conditions of north-west and south-east habitats of Iran [10,11]. A promising population of Lammergeyer inhabits and breeds in abundance in both Alborz and Zagros mountain ranges. Unfortunately, there is no well-organised conservation plan for the Bearded Vulture, and most of the efforts are related to identification of movement routs and nest-sites in order to avoid any human disturbances.

3.2.2. Effect of diclofenac on wild population density. Widespread usage of diclofenac as an anti-inflammatory drug has led to devastating impact on wild population density of vultures in central Asia. Oriental White-backed Vulture (Gyps bengalensis), Long-billed Vulture (Gyps indicus) and Slender-billed Vulture (Gyps tenuirostris) are three species of vultures that has undergone 95% population decline over 10 years since 1990s [12,13]. White-backed Vulture has not been seen for many years in Iran. Visceral gout as a typical clinical sign of renal failure was observed in the necroscopy of vulture’s carcasses with diclofenac residue in their kidneys [14]. Further studies indicated that diclofenac is highly toxic for the Gyps species [15]. Lack of proper waste management in both slaughterhouses and livestock industries has increased the exposure of drugs and toxins to wild populations of raptors, like the effect of diclofenac on vultures. For this concern, complete ban on diclofenac usage in veterinary practices was set through the efforts of department of environment and Iran veterinary organization with the cooperation of Tarlan Ornithological Society and IUCN vulture specialist group (VSG).
3.2.3. **Egyptian vulture.** Another species of Accipitridae family who is suffering from diclofenac poisoning is Egyptian vulture (*Neophron percnopterus*). Listed as an endangered species in the IUCN red list (IUCN 2017), only 12,000 to 38,000 mature individuals of Egyptian vulture are estimated to remain globally. Apart from the migratory population, a population of this raptor is considered as resident in Iran which breeds and inhabits all year round. Some migratory individuals are summer visitors and some are winter visitors. Regions with low vegetation cover that are located in middle or high elevations are the preferable habitats for the Egyptian vulture [16,17,18]. In a recent study [19], suitability of Iran’s wildlife reserves was assessed for Egyptian vulture. It was found that protected areas only cover a small proportion of suitable habitats for both summer and winter visitors. This indicates the fact that assignment of these protected areas was mainly based on the distribution of terrestrial animals. In general, the Egyptian vulture has got a promising population in Iran. The highlands of both Alborz and Zagros mountain ranges are considered as breeding grounds in summer, and coastal regions in south are formed the suitable habitat for residents and winter visitors (Figure 2).

![Figure 2](image_url)

**Figure 2.** Habitat suitability of Egyptian vulture in Iran. Reproduced from Farashi et al. (2019).

3.2.4. **Black vulture.** Another rare species of vulture in Asia is the black vulture or cinereous vulture (*Aegypius monachus*). Conservation status of black vulture’s population is considered as near threatened. Like most of threatened species of vulture, population of black vultures also suffers from poisoning. For this concern, satellite telemetry studies were conducted for better understanding of movement ecology and habitat suitability of this species of birds of prey. For instance, Gavashelishvili et al. [20] used the information that was collected for four years using satellite transmitters attached to six juvenile black vultures in Georgia. The implication of the results indicated that Caucasus area was used frequently as natal area, while open-dry habitats in Iran and Saudi Arabia formed the wintering ground for the juvenile black vultures. However, there was no consistent migration pattern, and in most of the cases both dispersive and migratory behaviour showed mix patterns. More recently, there were records of this bird of prey in Western Iran [9]. Although there are some breeding reports of this species in Iran, there is not any thorough plan for conservation purposes of the Black Vulture.

3.2.5. **Steppe eagle.** Steppe eagle (*Aquila nipalensis*) is a long-distance migrant who starts its journey from both breeding and summer grounds located between the Aral and Caspian Sea in Kazakhstan and Russia to its wintering grounds ranged between Arabian Peninsula and South Africa with the maximum
of 200 km mean daily flight distance [21]. Steppe Eagle is considered rare migrant in north and center parts of Iran. In coasts of Persian Gulf, however, it is rare winter visitor [22]. Migratory pathway of steppe eagles that were equipped with platform transmitter terminal (PTT) showed that these birds always across Iran during their journeys [21]. Consistent observations have been confirmed from satellite telemetry data collected by the steppe eagle work in Oman.

3.2.6. Eastern imperial eagle. As a critically endangered species, there is not much information on migratory routs and suitable habitats of Eastern Imperial Eagle (Aquila heliaca). In the study conducted by Meyburg and Meyburg [23], six Imperial Eagles were equipped with satellite transmitters (PTT) in their wintering grounds of Saudi Arabia in order to investigate the home range of this rare species. This was the first time that such kind of satellite telemetry studies were carried out on the imperial eagles. It was found that China formed the most preferable summer home range, and five of the birds migrated and stayed in Russia and Kazakhstan for the spring. In addition, it was found that the habitats of Iran play a crucial role in the survival of this species as all of the studied Eastern Imperial Eagles travelled across Iran. Recently, it was found that central habitats of Iran can provide a suitable home for this raptor all winter long without the need for migration to further south (Figure 3) [24]. However, it was found that the protected area in this part of Iran only covers half of the criterion required for protection of wild animals including Eastern Imperial Eagle [25]. Another Imperial Eagle associated study in Iran is related to conservation medicine by which the first wound myiasis infestation in an Imperial Eagle was reported. This bird was fitted with leg ring in its breeding site at nestling stage in Kazakhstan. Calliphora vicina was found to be responsible for the myiasis in the necrotic wounds of left-wing fracture. Due to the severity of the infestation the wing was amputated [26].

![Figure 3. Movement data collected from five eastern imperial eagles. Reproduced from Poessel et al. (2018), with permission of the British Trust for Ornithology.](image-url)
3.3. Falconidae
In this family of birds of prey, 12 species with different conservation status have been recorded in Iran. However, the saker falcon is of great importance due to its conservation status as an endangered species and also being widely participated in falconry activities. The falconry history in Iran is estimated to be traced back to 10,000 years ago in Pishdadian/Pishadid dynasty. Therefore, a parallel evolution is believed for the origination of falconry in both Mongolia and Persia [27]. Despite the old background of falconry in Iran, the latest official falconry in Iran was believed to operate in the late 19th century.

3.3.1. Saker Falcon. Saker Falcon (Falco cherrug) is considered as a resident raptor with a few numbers of breeding populations in the north-eastern borders of Iran which is hard to reach by the hunters. Historically, large breeding populations of this magnificent species were inhabiting in central and north-east highlands [28]. In addition, the consistent observational records of the Saker Falcon in different geographical distributions of Iran indicates the permanent visits of this raptor and the potency of these areas in providing resourceful habitats for this species [29,30,31]. Illegal trapping of the live birds in order to sell them in the black market, habitat loss and decrease of prey seem to be the major reasons of the rapid population decline. Study of population genetics of Saker Falcon has revealed the presence of two haplotypes among the two subspecies. Initially individuals were only B haplotypes and the presence of haplo-group A is speculated to be the result of hybridization with Gyrfalcon (F. rusticolus) at high altitudes between Kazakhstan and Mongolia. These hybrids were then seemed to be more favored by natural selection due to the cold climate of these regions. Therefore, their population increased and expanded south and west towards Iran and Tibet. This indicates the suitability of habitats in Iran where a considerable proportion of both haplotypes was reported [32].

One of the conservation efforts to save the wild population of Saker Falcons was establishment of rehabilitation centers for Falcons and Houbara bustards to save the wild population of this endangered species. Captive-breeding is one of the primary goals of these centers to reduce the harvest pressure on wild populations by providing stocks of birds to replace illegal hunt [33]. However, most of the breeding efforts were confined to pilot projects related to captive breeding of Houbara Bustards. In 2003, forty-six Saker Falcons was released in Iran to study the home range of the species. This release program was under a bigger program entitled “Sheikh Zayed Falcon Release Program” or “SZFR” by which a total of 1545 Saker and Peregrine Falcons were reintroduced to the wild between 1995 and 2013 in several countries. Falcons participated in this study were donated from the falconries, rehabilitation centers, or were confiscated from hunters or keepers by the authorities. Unfortunately, only two of the 46 Saker Falcons, that were released in Iran, were equipped with PTT (Platform Transmitter Terminal) and therefore there is no exact report on the fate of these falcons. However, the monitor of other birds showed that Kazakhstan is one of the most preferred habitats for the Saker Falcon [34].

Birds, particularly birds of prey can be a good bioindicators for biological components and heavy metals in an ecosystem since they are at top of their food chains [35,36]. In addition, heavy metal poisoning can pose a threat to the health of these birds, like immunosuppression caused by mercury toxicity (Hg). Therefore, Zolfaghari et al. [37] conducted a study to measure the Hg concentration in feathers collected from Southwest of Iran. Results indicated that the feathers of the Saker Falcon had the highest concentration of Hg after common kestrel, but the concentration wasn’t toxic. Another study associated with the health of Saker Falcon in Iran was the diagnosis and treatment of babesia infestation in a Saker Falcon in Northwest of Iran [38]. In this infestation, the B. shortii was speculated to be the causative agent due to previous reports in Saudi Arabia by Samour and Peirce [39]. Imidocarb di-propionate was applied and showed effective treatment potency.

4. Conclusion
Birds were always one of the most important attractions for tourists in Iran. In addition, globally, there is a growing interest and concern about conservation of raptors during recent years. For this concern, Iran’s department of environment (DOE) has signed up Iran as one of the signatories of the memorandum of understanding on the conservation of migratory birds of prey in Africa and Eurasia.
Falcons and vultures task forces are important missions which were successful to bring together the stakeholders under global action plans like Saker GAP whereby conservation and monitoring of the saker falcon has been made economically possible. Poor efficacy of protected areas, shooting at raptor as a mobile target, lack of proper waste management, capturing the nestlings by poachers as well as getting trapped in the nets that are set to hunt the waterfowls in the north provinces are the main threats to raptors in Iran. In addition, the trafficking network of falcons and raptors that were poached in Center and East Asia, passes right through Iran to reach the black markets in middle east. These indicate that there is an urgent need for law enforcement effort and establishment of specialised centers in order to stop poaching and trafficking as well as providing health care for confiscated raptors.

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