



A Review of Egyptian Vulture *Neophron percnopterus* (Linnaeus, 1758) Studies in Türkiye

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Abstract: The Egyptian Vulture *Neophron percnopterus* is classified as Endangered (EN) globally and Vulnerable (VU) in Europe, with an overall declining population trend. In Türkiye, it breeds in most regions. However, targeted studies for this important part of the species' range are scarce and fragmented due to limited expertise and funding. In this review, we compiled information from the ongoing and completed studies in Türkiye (17 studies) in the period 2006–2022. We conclude that the current evidence-based knowledge on the Egyptian Vulture in Türkiye is insufficient to inform any future conservation programme or explicit breeding population monitoring scheme. As Türkiye hosts important breeding and feeding areas for the Egyptian Vulture, comprehensive studies should be carried out to inform the appropriate and efficient conservation of the species, including improvement of nature-related policies, national strategic documents (such as species action plans) and any other *in situ* conservation efforts.

Key words: population, breeding, threatened species, habitat loss, conservation

Introduction

The Egyptian Vulture *Neophron percnopterus* is the smallest of the European vulture species, measuring 55–65 cm with a wingspan of 155–170 cm (BIRDLIFE INTERNATIONAL 2023). It is a long-distance migrant breeding in Europe and Asia and wintering in Africa and Asia (NIKOLOV et al. 2016). There are also non-migratory breeding populations in Africa, India and the Canary Islands (MEYBURG et al. 2004, BIRDLIFE INTERNATIONAL 2023). The Egyptian vulture is classified as endangered (EN) globally (BIRDLIFE INTERNATIONAL 2023) and as Vulnerable (VU) in Europe (BURNS et al. 2021). The species migrate alone or in small groups, following the Black Sea-Mediterranean flyway, with key migration bottleneck sites at Gibraltar (Spain), Bosphorus and Dardanelles, Sa-

rimazi Ceyhan, Amanos Mountains (Türkiye), Eilat (Israel), Suez (Egypt) and Bab-el-Mandeb (Djibouti) (OPPEL et al. 2014, JOBSON et al. 2021).

Türkiye also represents very important breeding ground for the Egyptian Vulture (KATZENBERGER et al. 2019, ARSLAN et al. 2022a, BIRDLIFE INTERNATIONAL 2023). In addition, individuals from the Balkan breeding population migrate through Türkiye. The Egyptian Vulture is one of 28 globally threatened bird species found in Türkiye (KILIÇ & EKEN 2004, YAVUZ et al. 2021). While the Egyptian Vulture is distributed across Türkiye, there are currently no published records of breeding populations in Western Anatolia and coastal areas of the Black Sea Region (BOYLA et al. 2019). By the beginning of March, individuals begin to arrive at their breeding territories and migrate to the wintering grounds

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from late September to mid-October (KIRWAN et al. 2008, ARSLAN et al. 2022a). The most significant threat faced by the Egyptian Vulture in Türkiye during migration is electrocution with energy infrastructure. Poisoning and direct persecution are other important threats under consideration (OPPEL et al. 2021). In terms of habitat in Türkiye, the species prefers rocky habitats close to open areas; feeds on anthropogenic steppes maintained through traditional grazing (Şen 2012, BALABAN & YAMAÇ 2018). Traditionally, if livestock dies, the carcasses are left, functioning as a critical food source for the species. The Indigenous Production Landscapes throughout Anatolia steppes provide vital feeding and breeding grounds for the species (DOĞA, unpublished data). Due to its small size, it feeds on rabbits, birds, and organic waste (BALABAN & YAMAÇ 2018). It is also known that it feeds on tortoises and eggs. It is a solitary breeder, nesting in cavities on steep cliffs, but occasionally on the ground or in the trees (Şen 2012, BALABAN & YAMAÇ 2018).

Although Türkiye is in an important part of the range for the Egyptian Vulture, it is noteworthy that the studies are limited and scattered. In this context, we have brought together all the results from the past to the present to inform conservation efforts of academics, NGOs and decision-makers.

Materials and Methods

Study area

The area of Türkiye, including lakes and islands, is 814,578 km², and its projection area (mountainous and rugged terrain excluded) is 783,562 km² (Fig. 1). Türkiye, Egyptian Vultures prefer open, rocky and steppe areas as habitats. Traditional grazing activities in these areas directly relate to the species' life. Dead farm animals form an important part of the diet of Egyptian Vultures (BALABAN & YAMAÇ 2018, ARSLAN et al. 2022). In most areas where the study occurs, animal husbandry activities are carried out using the traditional grazing method (DOĞA, unpublished data).

Review of literature

Peer-reviewed papers and grey literature were reviewed (17 studies) on the Egyptian Vulture in Türkiye from 2006 to 2022. A list was created (Table 1), and these studies were evaluated by clustering over three topics: (1) breeding research and monitoring, (2) migration monitoring, and (3) conservation studies. Some of these studies were carried out in the same region at different times, while others included preliminary research and findings.

Results

Breeding research and monitoring was carried out in five areas, migration monitoring has been carried out in one area, and conservation studies are carried out at national level to reduce threats (Fig. 1). Overall, the breeding research and monitoring constitute 47% of all studies, migration monitoring 18%, and conservation studies 35%. (Table 1).

Breeding research and monitoring

Different studies were carried out within the scope of Egyptian Vulture breeding research and monitoring in Türkiye (Table 2). The most important breeding grounds in Türkiye are the Key Biodiversity Areas (KBAs), namely Kirmir Valley, Nallihan Hills, and Sariyar Dam, which include Beypazarı steppes. In the fieldwork conducted between 2006 and 2011 in the Beypazarı steppes, 37 active Egyptian Vulture nests were detected and monitored yearly during the breeding season (DOĞA, unpublished data). Şen (2012) updated the information on the breeding population size in the region, reaching to 45 pairs in the same region in 2010 and 2011. In the following years, the reasons for the preference of these nests were determined in Beypazarı and their characteristics were revealed. It has been determined that the species generally nests at lower altitudes and on south-facing cliffs (Şen et al. 2017). In 2020, a breeding population of 90 pairs was identified in this region (ARSLAN et al. 2022a). Şen et al. (2017) stated that the density of 45 pairs in the region was six pairs per 100 km²; in the study where 90 pairs were detected, the density was determined as 6.92 pairs per 100 km² (ARSLAN et al. 2022a).

The other important areas for the species are the Middle and Upper Sakarya Basin, Bolkar Mountains, Cappadocia, Sivas, Çorum and Kars regions (EKEN et al. 2006). A study from 2013–2014 on the breeding populations and food preferences of the Egyptian Vultures breeding in the Middle Sakarya Region revealed 29 nests in 2013 and 30 in 2014. The first data sets for the Middle and Upper Sakarya Region were established. The breeding success (number of fledglings divided by the number of laying pairs) of the population was 1.09 in 2013 and 1.21 in 2014, while the fledgling success (number of fledglings divided by the number of successful pairs) was 1.35 and 1.27, respectively (BALABAN & YAMAÇ 2018). Moreover, 11 characteristics of the nests and the breeding rocks were evaluated to determine the population's nesting preferences. In this context, it was found that in Türkiye, the Egyptian Vultures nest in cavities and ledges located in the middle parts of cliffs, with a



Fig. 1. Map of the Egyptian Vulture locations in Türkiye and study areas included in the current review.

Table 1. List of the studies on the Egyptian Vulture conducted in Türkiye, subject of the current review and presented by topics and period of research

Reference	Breeding research and monitoring	Migration monitoring	Conservation	Period
DOGA (unpublished)	x			2006-2011
Şen (2012)	x			2010-2011
BALABAN & YAMAÇ (2018)	x			2013-2014
BALABAN & YAMAÇ (2019)	x			2013-2014
DOGA (unpublished)	x			2015
ARSLAN et al. (2022a)	x			2020
ARSLAN (2022)	x			2021
VELESKI et al. (2015), DOKU DERNEGI (2022, unpublished data)	x			2013-2022
OPPEL et al. (2014)		x		2014
ARSLAN et al. (2019)		x		2019
DOGA (2022)		x		2018-2022
DOGA (unpublished)			x	2006-2011
BUECHLEY et al. (2018)			x	2012-2015
DOGA (unpublished)			x	2017
YAMAÇ et al. (2019)			x	2019
OPPEL et al. (2021)			x	2021
ARSLAN et al. (2022b)			x	2022

preference to limestone as a substrate. Furthermore, it was determined that the nests are mainly facing southwest (BALABAN & YAMAÇ 2019).

In 2015, a project to conserve the Imperial Eagle (*Aquila heliaca*) and the Egyptian Vulture in Sivas, Cappadocia, Edirne, Kırklareli, Tekirdağ, Bolu, Eskişehir and Istanbul was conducted by Doğa with the partnership of BSPB (BirdLife Bulgaria). In Central Anatolia, a significant number of new Egyptian Vulture breeding grounds were discovered in Sivas, Nevşehir and Kayseri. As part of the project, face-to-face interviews were conducted with the shepherds and farmers who live in the same areas as these species. Their socioeconomic status, land use, and means of living were determined, and their relationship with the Egyptian Vulture was studied via questionnaires. Kayseri's Soganlı and Sivas' Hafik were identified as areas suitable for community-based conservation efforts regarding the Egyptian Vulture. During the preliminary research, 24 Egyptian Vulture nests were located in the region (DOĞA, unpublished data).

Two active Egyptian Vulture territories were determined in Kırklareli province, Thrace Region, in 2013 (VELESKI et al. 2015). According to the most recent monitoring in 2018–2022, it was observed that a single juvenile individual successfully fledged from this nest in 2022 (DOKU DERNEGI, unpublished data, D. DEMERDZHIEV, unpublished data).

In 2021, Doga Derneği surveyed for breeding Egyptian Vultures in the Mersin Bolkar Mountains and their surroundings in southern Türkiye. As a result, eight active and 13 occupied territories were identified (ARSLAN 2022).

Breeding research and monitoring have not targeted the estimation of Türkiye's breeding populations. Although these studies do include important areas for the species, they were carried out in relatively restricted areas so should not be considered a whole Türkiye estimate. However, some evaluations show that the population in Turkey is declining. KASPAREK (1992) stated that the Türkiye population started to decline at the beginning of the 20th Century, and EKEN et al. (2006), has emphasized that this decline continues. There are variable estimates on the Egyptian Vulture population in Türkiye. KATZENBERGER et al. (2019) stated that 1,500 to 3,000 pairs breed in Türkiye, while TERRAUBE et al. (2022) estimated about least 1000 pairs.

Migration monitoring studies

In 2014, the Sarımazı area of Adana's Ceyhan District was determined to be a bottleneck region for raptors, particularly the Egyptian Vulture (OPPEL et

al. 2014). This initiated an ongoing monitoring programme at three sites around Sarımazı, supported by the EU LIFE funding in the period 2018–2022. During the migration count in the autumn of 2018, there were 813 Egyptian vultures recorded, while in the autumn of 2019, the recorded number of Egyptian vultures was 903 (ARSLAN et al. 2019). Limited monitoring was carried out in 2020 and 2021 due to the Covid-19 pandemic, and 275 and 71 Egyptian Vultures were counted respectively. In 2022, 553 individuals were counted throughout September but is unlikely to be a decline but rather an effect of counting effort (DOGA 2022).

Conservation studies

Since 2006, a network with local shepherds and farmers in the region of Beypazarı was established to halt the decline in traditional animal husbandry and ensure the future of the Egyptian Vulture. Studies conducted in Beypazarı have revealed an important connection between the Angora goat and the Egyptian Vulture regarding the conservation of the feeding grounds (i.e. pasturelands) of the species and the use of Angora wool as nesting material by vultures (DOĞA, unpublished data). Doğa collaborated with shepherds who were familiar with the causes of Egyptian Vulture deaths. A shepherd network with 162 relevant people was established to monitor the species. This network had continued to grow. It was further used as a tool to collecting information on the arrival and departure dates, breeding and feeding locations, threats and occupancy status of nests.

Between 2012 and 2015, 10 Egyptian Vulture of different age groups, were trapped in Türkiye and fitted with a satellite transmitters to study their home ranges throughout their annual cycle (BUECHLEY et al. 2018). The median summer home ranges were determined to be larger than the median winter home ranges across all age classes, but different age groups had different sizes of home ranges. The smallest home range for an adult in the winter season was defined as 218 km², and the largest summer range was determined as 125,864 km² for the fourth year. Median sub-adult home ranges (27,280 km²) in the summer range were found to be larger than those of non-adult breeders (2,921 km²), which was in turn greater than that of adult breeders (465 km²). In addition, during the winter range, the median sub-adult home ranges (5,730 km²) were seen to be larger than those of adults (2,082 km²). Typical areas of use by different individuals were revealed and areas, which are a priority for protection, were identified such as the Gulf of Iskenderun migration

Table 2. Summary with Egyptian Vulture breeding numbers found during surveys in the last 10 years in Türkiye

Reference	Location	Results	Period
ARSLAN (2022)	Mersin- Bolkar Mountains	8 breeding pairs and 13 occupied nests	2021
ARSLAN et al. (2022)	Beypazarı-Ankara	90 breeding pairs	2020
DOGA (unpublished)	Kayseri's Soganli and Sivas' Hafik	24 breeding pairs	2016-2017
BALABAN & YAMAÇ (2018)	Middle and Upper Sakarya Region	53 territorial breeding pairs	2013-2014
VELESKI et al. (2015), DOKU DERNEGI (unpublished)	Kırklareli	2 territorial breeding pairs	2013-2022

bottleneck site.

In 2019, heavy metal accumulation was studied in Türkiye for the first time on Egyptian Vultures. It was observed that the mean value of heavy metal accumulation is below the lethal threshold level (Pb = 32.26 ± 74.71 µg/g d.w. ve Cr = 17.82 ± 33.74 µg/g d.w.). However, these values in all heavy metals other than Hg and Zn have been seen to be critical levels, which may result in lethal and sublethal effects on individuals depending on their concentrations (YAMAÇ et al. 2019).

Poisoning is a priority threat to vultures globally (BOTHA et al. 2017). Six poisoned Egyptian Vultures (and one more potential case without evidence from the lab) were identified in 2000-2022 in Türkiye. However, we suggest that the detected cases are far below the actual cases in the country due to the lack of targeted research and detection of this threat and the small number of toxicological labs with the needed expertise. Cases were identified from carcasses brought to laboratories at different times, and the exact locations and dates are generally unknown because these details are not recorded in the field. A booklet has been prepared to increase awareness of the threat of poisoning and to determine the current poisoning case severity in Türkiye, forming the basis for future studies (ARSLAN et al. 2022b). This will be distributed to decision-makers, relevant researchers, and institutions. During the Shepherd Network fieldwork, the Doğa team has interviewed many shepherds, farmers and veterinarians. No evidence of poisoning was collected from the institutional interviews, but during the field study conducted in Beypazarı in 2020, it was revealed that four individuals died in agricultural fields and although definite conclusion could not be obtained, the most probable cause of death was poisoning (ARSLAN et al. 2022a, b).

Investigation was also carried out to identify and then insulate hazardous power lines to prevent electrocution, which is known as the most important threat in Türkiye during the migration of the species (OPPEL et al. 2021). In this context, the insulation of

276 electricity poles in Ankara, Mersin, and Adana, which are important breeding areas and stop-over points during migration, has been completed. Insulation works continue in different areas.

Discussion

Our review shows that the timing and study clusters (Breeding Research and Monitoring, Migration Monitoring, and Conservation) differ over the last 16 years. This is because there was no consistency in the research topics and methods applied to study the Egyptian Vulture in the country. The lack of suitably qualified experts, budget, and the fact that Egyptian Vulture's range in Türkiye covers a large area and therefore challenging to cover, can be considered the main factors that have made systematic studies at a national level very challenging.

In Türkiye, studies on Egyptian Vultures are conducted with the aim to assess the breeding and migrating populations, identifying the threats, and targeting conservation measures to ensure survival of the species. However, in general, it is considered that studies are insufficient and limited for a country that is in such an important geographic position for the species.

Breeding research and monitoring

Comprehensive research has been concentrated in the Middle Sakarya Region and Beypazarı regarding the breeding population of Egyptian Vultures (Şen 2012, BALABAN & YAMAÇ 2018, KATZENBERGER et al. 2019, ARSLAN et al. 2022a). The reason for this is that according to the early studies, it was thought that the region contains dense breeding colonies and that these areas have more accessibility and long term datasets. Moreover, the Upper Sakarya Basin, Bolkar Mountains, Cappadocia, Sivas, Çorum and Kars have been known as other breeding grounds for the species (EKEN et al. 2006). However, the data from these regions don not include comprehensive observations. There should be intensive and regular research and monitoring in these regions to iden-

tify the breeding locations and numbers of breeding pairs. Comprehensive studies need to be carried out in eastern Türkiye as well. Yet, there are some challenges as the nests there are more scattered, and there are issues with accessibility and safety in these regions. For this reason, breeding research and monitoring studies are progressing very slowly.

It is estimated that the global population decreased by 30-49% between 1990 and 2013, and although the magnitude of the downward trend decreased to 20-29% between 2000 and 2012 globally the Egyptian Vulture is still classified as Endangered (BIRDLIFE INTERNATIONAL 2023). These estimates play a vital role in determining priority studies for the species. For the realistic National population size and trend estimations in Türkiye, it is necessary first to identify the locations and sizes of breeding population clusters at local or regional level. As a second step, there is a need to build a habitat or nest-site suitability models that can help extrapolating these results to a country-level, and including verification of such outputs.

Migration monitoring studies

Migration monitoring carried out regularly in bottleneck sites can help to determine the population sizes of species with large breeding areas and to detect any population change (FARMER et al. 2007, OPPEL et al. 2014). A significant part of the Eastern Eurasian-African Flyway goes through Türkiye with several migration bottlenecks for migratory bird species (Üner et al. 2010). One of these bottlenecks is located in Adana Sarımazı region (OPPEL et al. 2014). Monitoring studies targeting Egyptian Vultures and other raptors were carried out in this region from 2018 to 2022 during the month of September (ARSLAN et al. 2019, JOBSON et al. 2021, DOĞA 2022). Yet, to continue the monitoring both expert and volunteer observers as well as budget are needed. The absence of these resources or unexpected events affecting the whole region (such as earthquake, pandemic, etc.), result in fragmentary and poorer quality data collection. To sustain this monitoring programme in long term, support from local stakeholders, but also from international organizations and projects is a must.

Conservation studies

It is known that habitat loss or alteration is one of the important threats to vultures (CONCEPCION et al. 2018, McCLURE et al. 2018, GRANDE et al. 2018). In addition, human disturbance is one factor that impact negatively vultures in their breeding areas (ARSLAN & KIRAZLI 2022). In this context, an important threat is also mining activities within a Egyptian

Vultures' breeding grounds (ARSLAN et al. 2022a). Threats such as these pose increasing pressure on biodiversity in Türkiye. Moreover, Türkiye is less advanced in biodiversity conservation than many other European countries (Şekercioğlu et al. 2011) regarding capacity and networks, which may impact the conservation of priority species such as the Egyptian Vulture. Poisoning is an important threat to Egyptian Vultures (YAMAÇ et al. 2019). However, the lack of specialised toxicological laboratories and targeted poisoning field studies does not allow the evaluation of the real magnitude of poisoning cases in Türkiye. The common feature of the landscapes inhabited by Egyptian Vultures is pasturelands, which due to the traditional system of livestock husbandry, no poison is used or only used in a limited way. At the same time, Egyptian Vultures benefit from the dead animals left in the natural environment by shepherds. However, considering the use of poison in closed-system livestock and production farms, it is seen that poisoning is an important threat that needs to be fully investigated. Additionally, as part of the efforts to conserve the Egyptian Vulture, many collaborations were established with the local people, shepherds and female producers to sustain and popularise the production of Angora wool products (Doğa, unpublished data). This study is important in terms of supporting traditional pasture animal husbandry in the region.

It has been found that the most severe threat for the Egyptian Vulture in Turkey during migration is electrocution (OPPEL et al. 2021). Although intensive work has been done to identify and retrofit hazardous power lines in Ankara, Mersin and Adana regions, there is an urgent need to spread the insulation work in other areas important for the species (Central Anatolia, Thrace, Istanbul and Hatay provinces) and even to introduce a new bird-safe design of electric pole. Direct involvement of stakeholders (e.g. Turkish electric companies) and decision makers (e.g. Turkish Ministry of Energy) is essential to assure the success of this process.

In order to carry out Egyptian Vulture conservation studies, local decision-makers and local people should have basic knowledge about the species and high awareness of its threats. In the Doğa project conducted between 2006 and 2007, Beypazari Doğa Evi (Nature House) was established with the support of GEF-SGP and Beypazari Municipality. More than 300,000 people visited the Beypazari Doğa Evi. Doğa Evi was designed to reach these visitors and inform them about the cultural values of Beypazari, as well as its importance regarding biodiversity and birds. Informative boards and panels

were placed at the front and presented to the visitors, accompanied by a guide. Furthermore, many bird-watching training events were carried out in the district, and information boards about the birds and biodiversity of Beypazarı were placed on a series of facilities in Inozu Valley and Central Beypazarı. Due to these efforts, the Egyptian Vulture was recognised and embraced by the local people as one of the important emblems of the region (DOĞA, unpublished data).

In 2017, nature conservation organisations from fourteen countries, including Doğa, came together to ensure the safety of the globally endangered Egyptian Vulture along its flyway as a part of Egyptian Vulture New LIFE (LIFE16NAT/BG/000874). In this joint project, the organisations operating in the Balkans, Middle East and Africa worked together to prevent Egyptian Vulture deaths caused primarily by electrocution, poisoning, and poaching.

Implications for conservation

As a conclusion, this review provides information on the current state of the Egyptian Vulture in Türkiye and recommendations for future conservation efforts. The identified gaps in the local knowledge on the species should be fixed urgently to inform effective conservation. There is also an urgent need to increase the local capacity of scientists and conservationists to conduct high quality research and evidence-based conservation, as well as to increase the level of awareness and engagement of stakeholders and decision makers.

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