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ŞAFAK ARSLAN

CİHANGİR KİRAZLI

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Turkey's largest Cinereous vulture population in a recently discovered breeding area in North-west Anatolia

Şafak ARSLAN[1,4], Cihangir KİRAZLI[2,3,*]

[1]Department of Wildlife Ecology and Management, Institute of Graduate Studies, Bolu Abant İzzet Baysal University, Bolu, Turkey
[2]Department of Wildlife Ecology and Management, Faculty of Agriculture, Bolu Abant İzzet Baysal University, Bolu, Turkey
[3]Wildlife Research Center, Bolu Abant İzzet Baysal University, Bolu, Turkey
[4]Doğa Derneği (BirdLife Turkey), İzmir, Turkey

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Abstract: Studies regarding the cinereous vulture (*Aegypius monachus*), classified globally as near threatened, have recently accelerated in Turkey. Comprehensive studies particularly about the northwestern Anatolian population, have been conducted. Also, the genetic studies carried out, have revealed that the cinereous vulture population in Turkey is panmictic and that it has recently suffered a bottleneck. The main aim of this study conducted across the Köroğlu Mountains in Bolu was to determine the population size and the breeding success of the species. A total of 37 field surveys in 2018 and 2019 have revealed Turkey's largest breeding cinereous vulture colony and have detected 60 breeding pairs. However, breeding success remained low. Considering this and other pertinent population studies, at least 200 pairs are estimated to breed in northwestern Anatolia. Conservation of the species is crucial in terms of the health and sustainability of the ecosystem; therefore, data related to nests must be incorporated into local forest management plans to sustain the Cinereous vulture population and breeding here.

Key words: Cinereous vulture, breeding success, population, Köroğlu Mountains, north-west Anatolia

1. Introduction

The cinereous vulture (*Aegypius monachus* L.) is one of the largest primary scavenger species situated at the top of the food chain. It is classified globally as 'near threatened' with a decreasing population, particularly in the breeding regions of western Palearctic outside Europe (Andevski et al., 2017). Due to the complete disappearance of the species in the past (at 19th and 20th centuries) in some breeding parts of Europe (Italy, Poland, Slovakia, Austria, Croatia, Romania, Moldova, and Cyprus) (Cramp and Simmons, 1980), a patchy distribution range was formed across Europe, and the distribution has concentrated mostly in Western Europe[1]. The ecological studies on the species carried out since the last quarter of the 20th century, revealed positive results in at local populations of the species in Europe, especially in Spain, Portugal, France, and partially in Greece[2] (Sánchez, 1998; Skartsi et al., 2008; Del Moral and De la Puente, 2010; Andevski et al., 2017). For example, reintroduction schemes (e.g., France) and recolonization (e.g., Portugal) have enabled extinct populations of the cinereous vulture, to be reappeared on their ancestral grounds particularly along the Mediterranean floristic zone in Europe[1] (Lourenço, 2011; Mihoub et al., 2014a, 2014b; Andevski et al., 2017). However, some reintroduction efforts (e.g., Bulgaria) have not yielded results, yet are still continuing for the past several decades (Stoynov et al., 2017; Sanchez et al., 2019; Stoynov et al., 2019). Although the European population has increased significantly in the last 20 years (Andevski et al., 2017), the cinereous vulture is considered endangered in Greece, France, and Azerbaijan (Skartsi et al., 2008; Andevski et al. 2017), vulnerable in Russia (Andevski et al., 2017), and rare in Europe (BirdLife International, 2004), while populations in Armenia, Azerbaijan, Russia, and Turkey are estimated to be declining[2] (Andevski et al., 2017; Kirazlı, 2019). Therefore, there is still room for ecological and demographic studies on this species, and it is stated that approximately 80 million Euros have been

[1] BirdLife International (2020). Species factsheet: Aegypius monachus. Web site http://www.birdlife.org. [accessed 12 July 2020].

[2] Barov B, Derhé MA (2011). Review of the implementation of species action plans for threatened birds in the European Union 2004-2010, Final report. BirdLife International for the European Commission, 269 p. Website http://ec.europa.eu. [accessed 19 July 2012].

* Correspondence: cihangirkirazli@ibu.edu.tr

spent in the EU for those studies since 2000 (Andevski et al., 2017).

Despite having the second largest population of the Western Palearctic region, studies on Cinereous vultures in Turkey have only recently gained momentum (Kirazlı and Yamaç, 2013; Kirazlı, 2016; Yamaç et al. 2018). In particular, nesting areas in Eskişehir, Ankara, and Kütahya borders were determined and ecological findings about those colonies were revealed (Yamaç, 2004; Kirazlı and Yamaç, 2013; Kirazlı, 2013; Özcan and Yamaç, 2015). In addition, it was determined that among its colonies in northwestern Anatolia, a panmictic population genetic structure was present, the population has recently passed through a bottleneck and had an average nuclear genetic diversity as well as a low level of mitochondrial genetic diversity (Çakmak et al., 2019a). The mitochondrial lineages of this population, together with the Caucasian one, were reported to rank between the European (Balkan and Iberian) and north Asian (Mongolian) genealogies (Çakmak et al., 2019b).

Mount Türkmenbaba and the Sündiken Mountains in Eskişehir, and the northern forests of Kızılcahamam and Ankara are the notable habitats of the species in Turkey. Although, there are plenty of other potential breeding grounds are estimated throughout the country, relevant studies are currently not sufficient (Yamaç, 2004; Kirazlı and Yamaç, 2013; Kirazlı, 2013; Özcan and Yamaç, 2015; Yamaç et al. 2018). Furthermore, it is still emphasized that there is insufficient ecological data for the cinereous vulture population of Turkey and the high necessity of research on the subject[1] (Andevski et al., 2017). Eastern Turkey stands out as the primary potential site; however, no comprehensive study has been conducted so far. Preliminary surveys in Erzurum have revealed active nests, which is important in terms of being the first record within the locality (Kirazlı and Arslan, 2020).

Although important breeding areas of the species are known in the northwestern Anatolia, potential new breeding areas are still waiting for investigations. This study presents a new set of surveys, the population size and breeding success of the cinereous vulture population across the Köroğlu Mountains, known to have been one of the potential breeding sites of the species in northwestern Anatolia.

2. Materials and Methods

2.1. Research Site

The research was conducted across the portion of the Köroğlu mountain range, situated at the south of Bolu province in northwestern Anatolia (40°53′ N, 31°97′ E) (Figure. 1). Located to its west is the Seben district of Bolu; to the north, Bolu province center and the Dörtdivan district of Bolu; and south, Beypazarı district of Ankara province. The altitude of the Köroğlu Mountains varies from 910 to 2390 m. While these mountains in their entirety cover an area of 146.330 hectares (Eken et al., 2006), the study area encompassed 22.215 ha. The average rate of precipitation in the locality is reported to be 11.6 days per month (1929–2018), while that rate is shown to be 10.8 days per month during February–September[3]. The livelihood of the locals mostly relies on forestry, agriculture, and livestock. The uplands are used as summer pastures. Poultry farms abound, and, although, outside the study area, a ski resort is located nearby.

The flora of Bolu is broadly diverse owing to the province's location, where three different types of floristic zones appear. Prevalent in the north and south are the characteristics of the Euro-Siberian and the Irano-Turanian floristic regions, respectively; smaller in extent is partial coverage of the western and northern portions of river valleys by the Mediterranean floristic region. The climate as well as the flora of the province is further diversified by local climatic conditions that occur in valleys with considerable altitudinal variance (Tunçkol and Akkemik, 2013).

The research site was determined a Key Biodiversity Area (KBA) in 2006 by Eken and colleagues. The KBA of the Köroğlu Mountains is home to dwarf oak groves; coniferous upland forests, predominantly with Scots pines, black pines, and firs; altitudinous montane meadows; and, to a smaller extent, agricultural lands. The KBA is important also for birds, which include cinereous vulture (*Aegypius monachus*), imperial eagle (*Aquila heliaca*), and bearded vulture (*Gypaetus barbatus*) known to primarily breed here, and for wild mammals such as the European snow vole (*Chionomys nivalis*) and the southern crested newt (*Triturus karelinii*) (Eken et al., 2006; authors' pers. observ.).

2.2. Field Surveys

Although it is known that the cinereous vulture has been observed in the Köroğlu Mountains, no occupation and breeding activity could been detected until this study. We collected information from foresters, villagers, shepherds, and animal owners, as well as on-site observation data, and these together with the knowledge of nest site selection of the species led us to the first field surveys. It's known that the northwest anatolian population of the species exhibit loose colony with various density, and typically building its nest in old pine trees (Yamaç, 2004, Kirazlı and Yamaç, 2013). Due to the loose colony behaviour of the species, when we detected one occupation in a steep valley, we then tried to locate other breeding pairs around that valley.

A total of 37 sets of field surveys, 15 in 2018 and 22 in 2019, were carried out as part of this research. The field

[3] Turkish State Meteorological Service, 2019. Website https://www.mgm.gov.tr [accessed 17 February 2021].

Figure 1. The study area indicating by red border.

study began early in the mornings and lasted until dusk. The fieldwork was conducted in order to determine the occupied nests in the study area from early March until December. Nests were detected from a certain distance kept stable throughout breeding periods in order not to disturb the species according to the data of Kirazlı (2016). The geographic coordinates of detected nests were recorded with GPS. The detection was performed by employing 10x42 binoculars and 20–60x spotting scope. Additionally, nests, parents, and chicks were photographed using a 75–300 mm optical lens attached to a body.

To determine breeding success, active nests were monitored during breeding periods. Nests were considered active in the respective year of monitoring if:

a) eggs were laid,

b) chicks were sighted,

c) adults were observed to brood in the same one more than once (Yamaç, 2004).

Each nest was checked a minimum of 3 and a maximum of 9 times within the breeding periods. After determining active nests according to the foregoing criteria, nests were considered to be abandoned in the respective breeding period if:

a) no eggs were laid,

b) no chicks were sighted,

c) no adults were observed to brood in the same one more than once (Yamaç, 2004).

The rate of active nests of the cinereous vulture colony at the Köroğlu Mountains in Bolu was figured by calculating the ratio of the number of nests determined to be active during the breeding periods within the research time frame to the total number of nests. The rate of abandoned nests was figured by calculating the ratio of the number of nests with breeding failure in the breeding periods to the number of nests determined to be initially active. The breeding success was figured by

calculating the ratio of the number of fledglings who left their nests in the breeding periods—when pairs lay only one egg—to the number of nests determined to be active. Lastly, we estimated the breeding density of the cinereous vultures within the research site. The area was marked out in 1x1-kilometer squares, following which the density was calculated by dividing the number of active nests by the number of squares the active nests fall into. The breeding density was calculated based on the data gathered solely in 2019 to avoid any erroneous findings that might have stemmed from the incomplete detection of nests in 2018. We estimated the beginning of incubation, hatching time, and fledging time from well-observed active nests using the data of the growing process of the species presented by De La Puente and Gamonal (2006).

Finally, to describe each nest tree (a total of 76 occupied and unoccupied nest), tree species, tree height, diameter at breast height (DBH), and crown class (suppressed, intermediate or dominant) were recorded according to Yamaç (2004) and Kirazlı (2013).

3. Results

The research included a total of 37 sets of fieldwork carried out in 2018–2019 across the Köroğlu Mountains in Bolu. The work in March–December of 2018 yielded 43 nests, 39 of which were active, and, in 2019, 83 nests, 60 of which were active. 26 and 44 fledgling individuals were observed to leave their nests in 2018 and 2019, respectively. The breeding success in each of the breeding periods is shown in Table 1.

At the beginning of the incubation period of the cinereous vultures, the field could not be reached mainly because of unfavourable weather conditions. However, the ages of the chick were able to be determined by means of photography and the use of binoculars and telescope starting at the time of hatching until the stage of flying. Given the difficulty of precisely timing the stages of incubation, hatching, and flying, periods of 10 days were applied for dating. The results have shown that the cinereous vulture colony actively breeding within the mountain range of Köroğlu incubated mostly from the 1st through 10th of March (Table 2). The first egg-laying is estimated at the 7th of February, and the incubation period of the colony seems to occurred between early February and late March. Considering the data of the study, the eggs of the Köroğlu colony in active nests were mostly hatched between 1–10 May (Table 2). The first hatching is estimated on the 1st of April and the last one on the 10th of May. The individuals that succeeded through the breeding periods flew from their nests between 1st August and 10th September, most frequently from the 21st through 31st of August (Table 2). It was determined that the breeding period of the colony in the study area extended from February to September.

Table 1. The cinereous vultures' breeding status in 2018 and 2019 in the Köroğlu Mountains.

	2018	2019
Number of nests	43	83
Number of active nests	39	60
Number of successful nests	26	44
Number of abandoned nests	13	16
Proportion of active nests (%)	91	72
Proportion of abandoned nests (%)	33	27
Breeding success (%)	67	73

Surveys carried out in Bolu Köroğlu Mountains in 2018 and 2019 revealed that the cinereous vulture nest abandonment period was the highest in July, and the lowest abandonment period was in August. (Table 2).

The breeding density of the cinereous vulture population within the mountain range of Köroğlu was calculated to be 2.60 pairs/km^2 in 2019 and was found to be higher in the south, whereas lower in the north of the research site (Figure 2).

The results indicated that all the nest trees were black pine (*Pinus nigra* subsp. *pallasiana*). Also, it has been determined that cinereous vulture build nests in old (mean trunk diameter: 47,24±21,13), high (mean height: 11,77±5,54 m), and dominant (95%) pine trees (Figure 3).

Certain human activities in the region of the Köroğlu Mts. have been affecting the cinereous vultures adversely. The primary threat to the species is thought to be forestry. It was found out that besides planned intensive logging activities, illegal logging was present. Moreover, due to the intense forestry activities, new forest roads continued to be constructed in order to transport the logged trees and caused disturbance to the nesting vultures. Such cases were frequently encountered in the study area. During the road construction, it was observed that the offspring, which were disturbed by the nests near the construction area, threw themselves from the nests.

4. Discussion

Studies intended to determine breeding sites of the cinereous vulture have recently accelerated in Turkey, yet the information gathered so far is limited to a small region. The first comprehensive study carried out around Türkmenbaba Mountain in Eskişehir in the early 2000s revealed a colony of 26 breeding pairs, which was updated as 28 in 2018 (Yamaç, 2004, 2018). Afterwards, a larger colony of 46 pairs was introduced in the Sündiken Mountains adjacent to the Türkmenbaba breeding area (Kirazlı, 2013). In addition, it has been reported that 12–16

Table 2. Frequencies of the nest abandonment and beginning time of incubation, hatching and fledging period of the cinereous vulture in the Köroğlu Mountains (The frequencies are given as percentage rate).

INCUBATION		**7–17 February**	**18–28 February**	**1–10 March**	**11–20 March**	**Unknown**
	2018	17.95	15.38	41.03	7.69	17.95
	2019	11.67	26.67	51.67	6.67	3.33
	Total	**14.14**	**22.22**	**47.47**	**7.07**	**9.09**
HATCHING		**1–10 April**	**11–20 April**	**21–30 April**	**1–10 May**	**Unknown**
	2018	18.75	9.38	12.50	59.38	0.00
	2019	10.34	12.07	17.24	60.34	0.00
	Total	**13.33**	**11.11**	**15.56**	**60.00**	**0.00**
FLEDGING		**1–10 August**	**11–20 August**	**21–30 August**	**1–10 September**	**Unknown**
	2018	23.08	19.23	38.46	19.23	0.00
	2019	11.36	25.00	47.73	15.91	0.00
	Total	**15.71**	**22.86**	**44.29**	**17.14**	**0.00**
NEST ABANDONMENT		**May**	**June**	**July**	**August**	**Unknown**
	2018	15.38	38.46	46.15	0.00	0.00
	2019	12.50	12.50	68.75	6.25	0.00
	Total	**13.79**	**24.14**	**58.62**	**3.45**	**0.00**

breeding pairs were located in the breeding areas observed around Ankara (Güdül, Beypazarı, Kızılcahamam) (Özcan and Yamaç, 2015; Yamaç et al., 2018). Finally, this study has revealed that the biggest cinereous vulture colony in Turkey, with 60 breeding pairs. Hence, it is clear that the Köroğlu Mountains, where the largest colony of the species in the Western Palearctic outside Spain exists, function as a very important breeding area as part of the northwestern Anatolian cinereous vulture population. Although it was previously thought to be 100 pairs (Yamaç et al., 2018), after this study and taking into account all breeding areas studied in the last two decades and potential breeding sites such as Akdağ together (Kirazlı, 2013), the cinereous vulture population in northwestern Anatolia is estimated to be at least 200 pairs.

Most recently, Kirazlı and Arslan (2020) have located another breeding site in the east of Turkey but still unknown total numbers of breeding pairs. This data could change all we know about the Turkish cinereous vulture population, such as the panmictic population structure, as the eastern population was not subjected to phylogenetic analysis (Çakmak et al., 2019a). Therefore, potential connection breeding sites between the colony of northwestern Anatolian population revealed by this study, and the recently elicited colony in northeastern Anatolia should be studied urgently, as also required for the potential breeding sites in nortwestern Anatolia. As a result of such surveys, a more reliable population demography and status can be evaluated for the total Turkish cinereous vulture population. Nevertheless, it is undeniable that Turkey, which is the second largest population of the cinereous vulture in the Western Palearctic, has a larger population than the specified population size of 100-200 breeding pairs (Andevski et al., 2017).

Breeding season of the cinereous vulture is known to be significantly long (Cramp and Simmons, 1980; Del Moral and De la Puente, 2010). Investment of nearly yearlong energy for a single egg reduces breeding failure (Donázar et al., 2002). However, as occurred in the Köroğlu Mountains, the breeding success of the colonies observed in Turkey was lower than expected (Yamaç, 2004; Kirazlı, 2013). In general, it was determined that the decrease in breeding success and density of cinereous vulture in traditional nesting areas, particularly in Turkey, was related to the destruction of nesting sites and high levels of human-induced disturbance (Donazar et al., 2002; Kirazlı, 2013). The coincidence of tree-felling with the breeding period is probably the main reason for the disturbance in the study area; hence, intensive logging is considered to reduce the habitat quality. Moreover, the frequent dropping of the young from the nest, and the cases of nest abandonment, which intensify in the summer months, indicated that the level of disturbance is high due to forestry practices in the region. Those threats are thought to be one of the main reasons for the low breeding success observed in the study area. To prevent this adversity, forest management plans should be revised to take into account the species' breeding sites, which requires felling and other forestal activities in

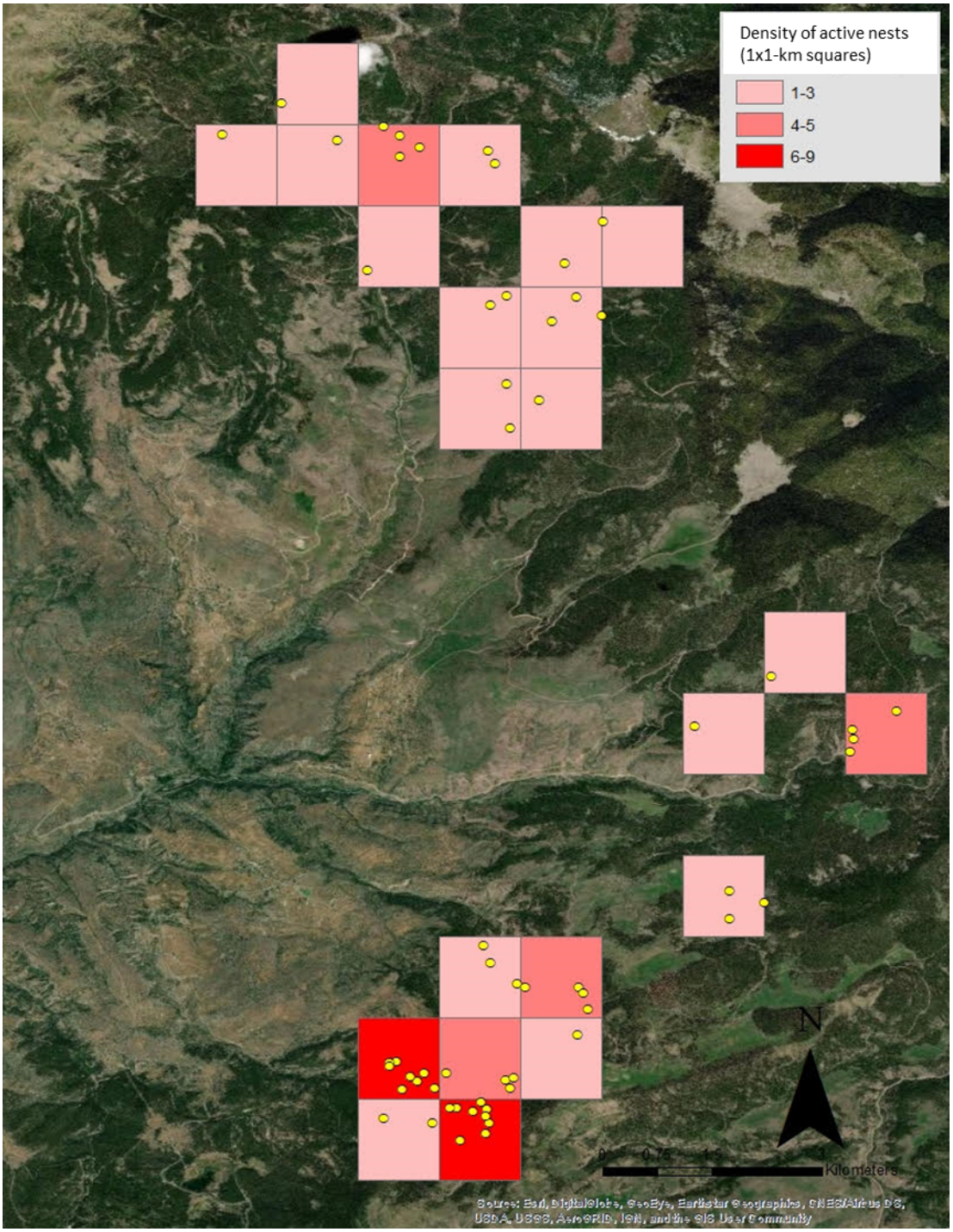

Figure 2. Density of active nests of the cinereous vulture population at the Köroğlu Mountains, calculated within a grid of 1x1-km squares.

nesting areas to either be halted or done at a minimal level during breeding periods. As a result, more detailed studies on the effect of forestry and other threat factors on species in the study area are still required for more adequate and precise evaluation.

As occurred in the study area, the failure of approximately one out of every three active nests observed in the northwestern Anatolian population may create a downward status for the Turkish population and cause a re-bottleneck (Çakmak et al., 2019b) with the shrinking

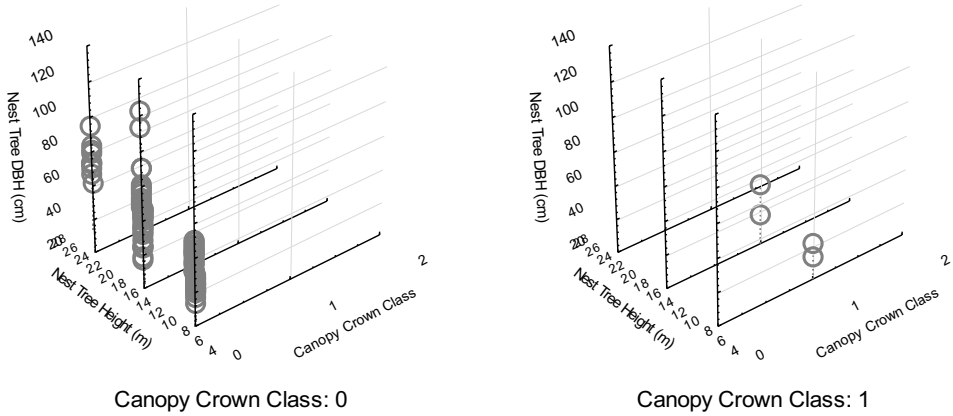

Figure 3. Nest Tree DBH against Canopy Crown Class and Nest Tree Height, categorized by Canopy Crown Class (O: Dominant, 1: Intermediate, 2: Supressed).

population and genetic diversity. Carrete et al. (2009) showed that habitat fragmentation and change, which may occur due to forestry practices, negatively influence raptor richness, diversity, and abundance. They also indicated that only a few raptors can colonize the area (homogenization) due to the shrinkage of the habitat and its surroundings due to human-induced activities. It is also known that high levels of anthropogenic disturbance caused by intensive forestry activities around shrunken habitats result in poor ocean-like matrix quality, especially for sensitive raptors (Jullien and Thiollay, 1996; Thiollay, 1997; Carrete et al., 2009). Accordingly, the decrease in critical resources resulting from the shrinking of habitats causes sensitive raptors with specific habitat demands to move away from the home range or to be trapped in certain breeding sites. This explains the fact that the colonies in the northwestern Anatolian population are stuck in certain breeding sites due to the ocean-like matrix quality as in the Köroğlu Mountains, and patchy distribution.

It has been determined that the cinereous vulture breeding density in Spain increases with the increase of rough areas containing old trees and decreases with the human disturbance and road density (Donázar et al., 2002). It has been stated that a similar preference is also found in the colony of Sündiken Mountains (Kirazlı, 2013, 2016). The breeding density observed in our study area supports those evaluation, and a higher breeding density is observed in the southern part, which exhibits a more suitable orographic structure. On the other hand, the calculated breeding density of the species in the study area supports the loose colony characteristic as in Spain and other colonies of the northwestern Anatolian population (Donázar et al., 2002; Yamaç 2004; Del Moral and De la Puente, 2010; Kirazlı, 2013).

According to the results, our findings of the timing of the reproduction period of the cinereous vulture is the nearly same as the other known breeding sites of northwestern Anatolia (Yamaç, 2004; Kirazlı, 2013; Kirazlı and Yamaç, 2013). While incubation in the study area started in early February, the first egg hatching and the first flight from the nest took place at the beginning of April and in early August, respectively. The results indicated that the reproduction period of the colony in the study area extends from February to September.

The entirety of cinereous vulture nests around the Köroğlu Mountains are situated in old black pines (*Pinus nigra*). All of the nests in the localities of the Sündiken Mountains and Mount Türkmenbaba were also found to be situated in old black pines (Yamaç, 2004; Kirazlı, 2013). Conversely, oleaster-leafed pear (*Pyrus elaeagnifolia*) has been reported to serve as a nesting tree for the cinereous vulture in the region of eastern Anatolia (Kirazlı and Arslan, 2020). In continental Asia, on the other hand, the species more often nests on rock outcrops (Cramp and Simmons, 1980; Reading et al., 2005; Zhatkanbayev, 2011), while in continental Europe, it does so mostly on crowns of old trees. Pairs who build nests on rock outcrops in Spain have also been sighted (Poirazidis et al., 2004; Moran-Lopez et al., 2006; Azcarate et al., 2012; Dobado et al., 2012). Iberian populations tend to prefer old cork oaks (*Quercus suber*) and holm oaks (*Quercus ilex*) as well as junipers (*Juniperus spp*.) and pines (*Pinus spp.*) as nesting trees. In fact, the cinereous vulture is known to choose old trees that are capable of upholding its nest rather than tree species or forest stands (Poirazidis et al., 2004; Yamaç, 2004; Moreno-Opo et al., 2013; Kirazlı, 2013).

As is known, the bigger and older nest trees are more important for the species than the nest tree type (Poirazidis et al., 2004). In this context, nest trees with an average height of 17.6 m and a trunk diameter of 63.8 cm are seen in Rascafria colony in Spain, while in Greece 11.46 m height, 49.84 cm trunk diameter, in Turkmenbaba 11.47 m height, 42.91 cm trunk diameter, in Sündiken Mountains 11.62 m height, 58.56 cm trunk diameter, and

in Georgia 4.9 m height and 30.96 cm trunk diameter (Yamaç, 2004; Poirazidis et al., 2004; Gavashelishvili et al., 2006; Del Moral and De la Puente, 2010; Kirazlı, 2013). The average height of 11.77 m and a trunk diameter of 47.24 cm determined in our study area are similar to the data above and show that cinereous vultures prefer large and old trees to meet their need for bulky nests. Furthermore, in the study area, it was determined that cinereous vultures mostly preferred trees at higher levels than forest cover for nesting. This situation has also been detected in Sündiken and Türkmenbaba colonies, and dominant trees are thought to be important for as high vantage points and good for thermal use (Yamaç, 2004; Kirazlı, 2013).

In conclusion, this study has revealed that the most populous cinereous vulture colony in Turkey, which comprises 60 pairs, exists in the region of the Köroğlu Mountains. This figure outnumbers that of the species in most European countries. In addition, this study re-states the low breeding success observed in the northwestern Anatolian cinereous vulture population. The protection of the species' habitat(s) is crucial in terms of sustainability. Therefore, this research must be incorporated into forest management plans or, alternatively, we recommend halting the forestry activities in the colony breeding area and increasing its protection status. Finally, it is recommended to locate new breeding sites, particularly in north-central and eastern Anatolia, for the Turkish population of the species, to investigate the possible threat factors (e.g., forestry) for the species in more detail and to determine the nesting site preference of the species for the total Anatolian population.

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