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NEST-SITE PREFERENCE OF GRIFFON VULTURE (*GYPS FULVUS)* IN HERZEGOVINA

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Abstract - Although formerly an abundant species, the Eurasian Griffon (*Gyps fulvus* Hablizl, 1783) has undergone a dramatic decline in Herzegovina. Such an unfavorable trend may be associated with frequent poisoning incidents (consumption of poisoned baits), shortage of food and hunting. This species disappeared from its breeding habitats in Herzegovina during the last decade of the 20th century. The extinction was probably caused by military activities during the civil war. Using data that were collected over a period of long-term (1980-1991) monitoring of the breeding population, we discovered optimal environmental conditions for the nesting of the Eurasian Griffon Vulture in Herzegovina. Information on nest-site preference is valuable for conservation programs and the possible reintroduction of the Eurasian Griffon, not only in Herzegovina, but also to a much wider region. During the study period, we observed 61 nests and 252 nesting cases in four colonies of Eurasian Griffon Vulture. Most nests were located on limestone and dolomite rocks. The average altitude of nests was 378 m a.s.l.; most of nests (85%) were located below 500 m a.s.l. Also, the majority of nests were located on west-exposed sites.

Key words: Gyps fulvus, Eurasian Griffon Vulture, Herzegovina, abiotic factor, nesting sites

INTRODUCTION

All three vulture species native to Europe (Bearded Vulture *Gypaetus barbatus* Linnaeus 1758, Eurasian Griffon Vulture *Gyps fulvus* Hablizl, 1783 and Egyptian Vulture *Neophron percnopterus* Linnaeus 1758) used to inhabit eastern Herzegovina (Talsky, 1882; Reiser, 1939; Rucner, 1970; Tutman, 1952). Populations of Eurasian Griffon, Egyptian and Bearded Vulture were present in this region up to the beginning of the civil war in 1992. After this period, however, these populations disappeared from eastern Herzegovina, probably due to disturbances caused by military activities. Sporadic observations of Eurasian Griffon have been documented recently. However, the colonies and breeding population of this species are not yet established in Herzegovina.

During the past few decades, there has been a steady increase in the population of vultures in Europe, because of improved protection measures and organized reintroduction programs (Terrasse et al., 2004). The successful protection of vultures on the Iberian Peninsula and in France suggests that their return to historical breeding sites in Herzegovina is possible. To achieve this goal, we must elaborate and implement suitable protection and conservation measures.

Formerly compact populations of the Eurasian Griffon have undergone a dramatic decline in abun-

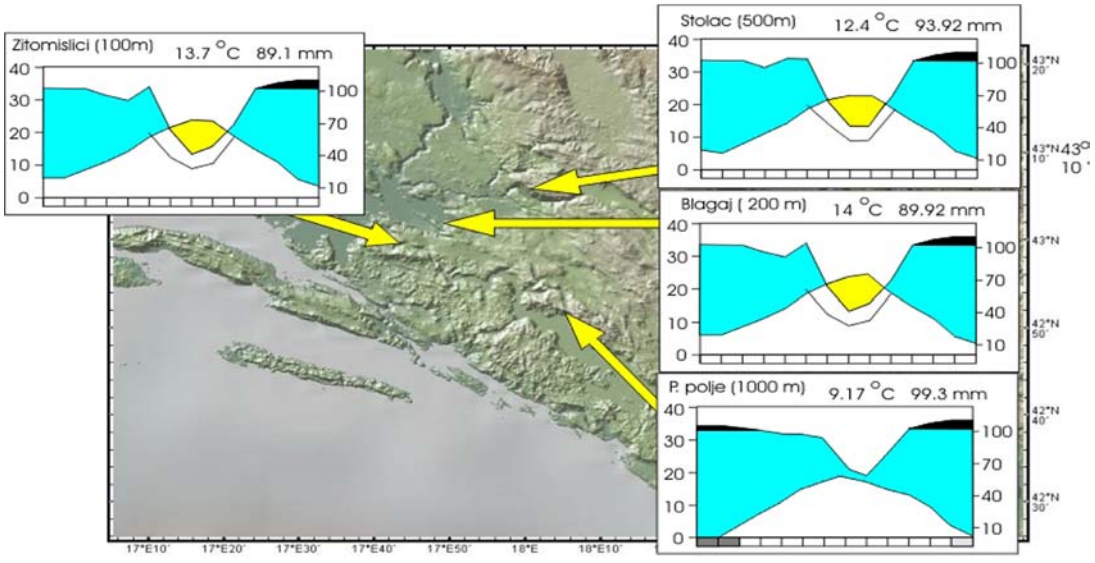

Fig. 1. Climediagrams of study area.

dance and distribution all across the Balkans. The populations decreased and disintegrated into small fragments in most of the Balkan regions, except in Serbia, where the population of this species has increased (Marinković, 1999). The Eurasian Griffon has a huge area of activity. The improved state of Eurasian Griffon populations in Serbia offers an opportunity for its spontaneous dispersal to habitats with optimal environmental conditions, such as Herzegovina.

In this article, we analyzed data that were collected during the systematic monitoring of vultures from 1980 to 1991. Each nesting place was analyzed with respect to orography, geology and climate conditions, in order to detect the environmental preferences of Eurasian Griffon in colony establishment. This baseline information can be used for reintroduction programs and restoration of extinct avifauna not only in Herzegovina, but also in a much broader region.

Study area

The systematic monitoring of vultures was performed in eastern Herzegovina, more precisely in the southwestern parts of the Dinaric region. In this region, we found four colonies of the Eurasian Griffon. Three colonies were located in canyons of the Neretva River and its tributaries. A fourth colony was located on the edge of the Popovo polje karst field.

Within this region, the highland area covers 5,599 km^2, while the lowland area covers 4,236 km^2 (Cvijić, 1991; Marković,1980).The Humine and Rudine mountains are located east of the Neretva valley, between the Orjen and Zelengora mountains. The high mountains Razvršja, Površi, Čabulja, Visočica, Treskavica and Prenj, represent a geographic border to the northern Herzegovina region. The study area comprises numerous gorges and canyons such as Radimlja, Žitomislići and Bregava (Fig. 3).

Popovo polje is a karst field, which was created by the sinking of the central part of a large limestone area at the end of Pliocene (Cvijić, 1991).

MATERIALS AND METHODS

We performed the systematic monitoring of vultures in eastern Herzegovina continuously from 1980 to

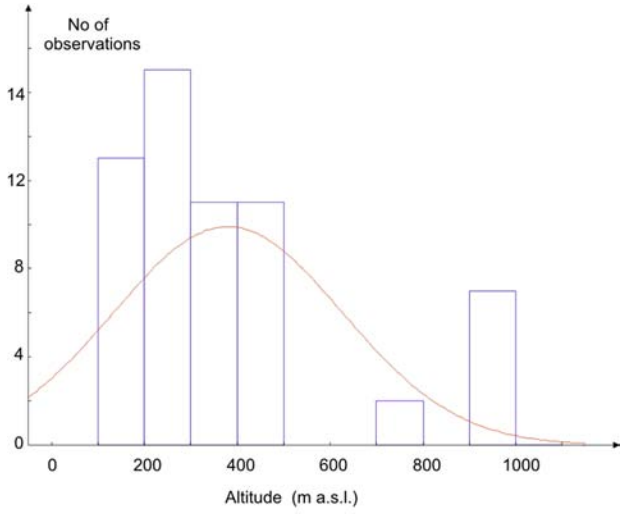

Fig. 2. Nests above sea level.

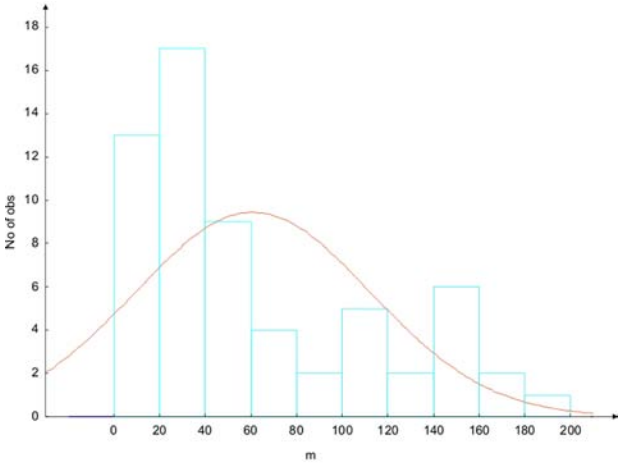

Fig. 4. Height of rocks below nests in meters.

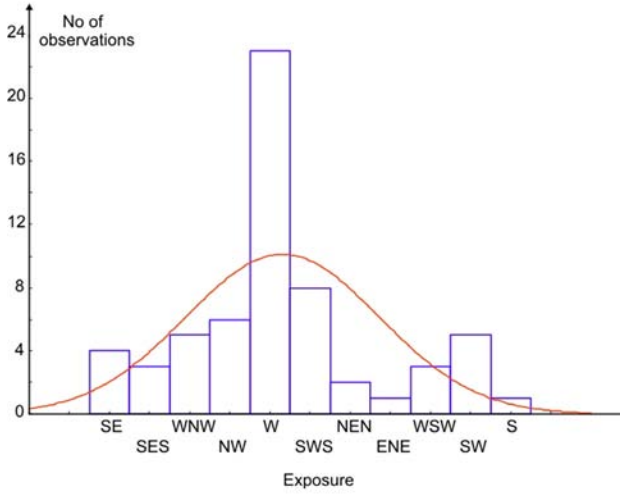

Fig. 3. Exposures of nests.

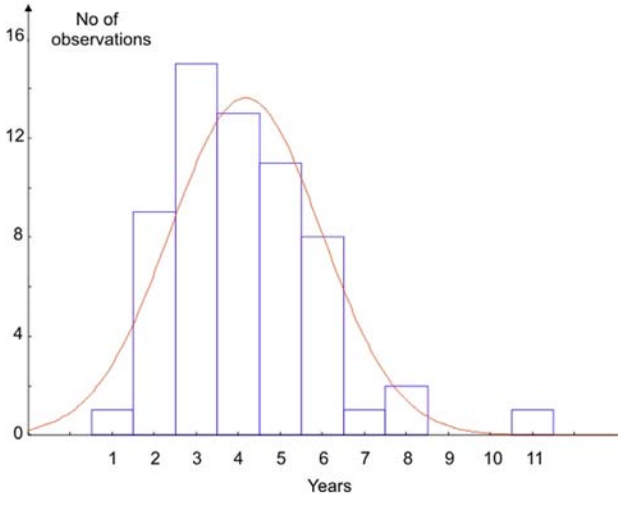

Fig. 5. Period of using nests.

1991. Observations along transects were executed in accordance with the methodology of Fuller and Mosher (1987). Identification of the Eurasian Vulture from long distances is simple, because it is one of the largest birds of prey, with a characteristic flight pattern.

Stationary observations were conducted from a distance of 150-800 m, using both binoculars and telescopes (7-90x magnification). We selected observation sites with a good view, on the opposite side of the breeding colonies and at approximately the same height as the nests (Bibby et al., 1992, Gibbons et al.,1996).

A variety of behavioral cues, such as adults visiting the nest, carrying food to the nests, etc., were used to locate the nests. Each nest was marked by a separate number. We carried out a census twice a day: from 07:00 to 12:00 when thermal lifts initiate vulture activity, and from 14:00 to 19:00, when the thermals weaken (Pennycuick, 1972). Based on the presence

of eggs, or more frequently of juveniles, consecutive observations were used to compare the activity of the nests. Nest observations were documented with photographs and the nesting sites were mapped in 1:25,000 scale charts. We identified three age-classes of Eurasian Griffon Vultures (adults, sub-adults and juveniles) easily, according to their morphological characteristics (von Blotzheim and Bauer, 1971).

Climate diagrams of the investigated area were constructed as suggested by Walter (1963), using the climate data for a 50-year period (Anon. 1972). Bedrock types were detected using the geology map (Anon, 1999).

RESULTS

Climate conditions

Due to the proximity of the Adriatic Sea, a sub-Mediterranean climate prevails in the lower part of eastern Herzegovina. The maritime, moderately humid and temperate climate of this region may be classified as "*Cfb*" type of Köppen's climates. While summers are hot and sunny, autumn, winter and spring are rainy seasons. The orography of the Herzegovina lowlands enables the influence of a Mediterranean climate. In the Herzegovina highlands, however, the sub-Mediterranean climate shifts to its mountainous variant. This region receives large amounts of rainfall. The Crkvice village, on Orijen Mountain in Montenegro is the wettest place in Europe, with the highest precipitation of over 7000 mm/m^2. A similar, but not so extreme precipitation regime is characteristic for all sub-littoral Dinarids, including the mountains in Herzegovina. Walter's climate diagrams of the analyzed area are presented in Fig. 1. At lower altitudes, the climate in Herzegovina is characterized by a drought season during summer months. This is a consequence of the uneven distribution of precipitation. At higher altitudes, however, the climate is more humid, without well-expressed summer drought.

The analyzed Eurasian Griffon colonies are located in a region with permanent Mediterranean winds. Daily winds, "mistrals", are anabatic sea-breeze winds that blow in the summer, when the east Adriatic coast gets warmer than the sea (Pennycuick, 1972). It is thus a mild sea-to-coast wind. Breaking on the rocks, this wind lifts the hot air mass upwards. This Mediterranean upslope wind enables the flight of Eurasian Griffon Vultures. Rock formations in Herzegovina, which are under the regular and permanent influence of winds, provide suitable nesting sites for Eurasian Griffon.

Geology

The substrate of a large area, between the Adriatic shore and the highest peaks of the Dinaric Mountains (2,200 m), consists of lime slopes and karst field planes (Marinković et al.. 2005). This bedrock also prevails in Herzegovina. Most of the analyzed nests were located on Mesozoic limestone and dolomite rocks. Colonies were located either in limestone gorges or on the edge of limestone fields.

Orography

Most nests (85.2%) were situated at a relatively low altitude, below 500 m a.s.l. The mean altitude of the nests was 378 m. The lowest and highest nesting sites were observed at 100 m and 997m, respectively (Fig. 2).

Nearly half of the nests (50, 8%) were located on western exposures (WSW; W; WNW). Other nests were mainly located on southern exposures (SWS, S, SES, 19, 6%; SE, 6, 6%; SW, 21, 3%) (Fig. 3).

The proportion of nests was much greater in caves (31%) and half-caves (36.1%) than in other geomorphologic structures.

The height of the nests (mean distance between the nest and the bottom of the cliff) varied from 3 to 181 m. The mean height of the nests was 60 m (Fig. 4). The optimal height of the nest in most colonies ranged between 20 and 40 m. An exception to this regularity was the colony at Blagaj rock, where greater nest heights (over 100 m) were probably caused

by anthropogenic disturbance, since the colony is located close to an urban area.

Nest density and sites of bird aggregations

The average distance between two neighboring nests was 137 m. In most cases (over 75%), the distance between two nests was 20 m. The closest distance between two neighboring nests was recorded in the Žitomislić area (only 0.5 m). The single nest in the vicinity of Bregava River was isolated since it was 5000 m from the closest nest. Solitary nests were rare. In the case of Bregava River, the solitary nest may be explained either by poisoning of the birds or by colony displacement.

Within each colony, we recorded the furthest distance between nest. The furthest distance between two nests in the Blagaj colony was 4500 m. The most distant nesting sites in the Žitomislić area were located 2000 m apart. The greatest density of nesting sites was recorded in the Radimlja colony.

In the Herzegovina region, we identified two different flocks, 27 km away from each other. One flock was located in the canyons of the Neretva River and its tributaries: Blagaj colony (43°15'N, 17°54'E), Stolac colony (43°07'N, 17°57'E) and Žitomislić colony (4 3°13'N, 17°4 9'E) (Fig. 3). The second flock was located at the Popovo polje karst field, with two centers on Siljevica and Kapak (42°32' N, 18°02'E).

Eight sites of bird aggregation were recorded. Five aggregation sites were located on cliffs above rivers. Other aggregation sites involved the edges of karst fields.

The average period of using the same nest during the observation period was 4 years (Fig. 5). Frequent changes of nest sites were probably caused by anthropogenic disturbance (poisoning, hunting, etc.). The most severe disturbance occurred during the civil war. This finally interrupted the further nesting of the Eurasian Griffon in Herzegovina.

DISCUSSION

The Eurasian Griffon inhabits the "ancient Mediterranean" region. Distribution of breeding populations comprises an area from 24° and 45° N, and from 10° to 90° E (Cramp et al. 1979). Eurasian Griffon Vulture is a Mediterranean species and proximity of the sea positively influences its distribution (Marinković, 1984; Marinković et al., 1985). The abundance of Eurasian Griffon colonies tends to decrease with increasing continentality, from the west to east of the Balkans (Marinković, 1999). Continentality of climate represents the tendency of land to experience more thermal variation than water due to the land's lower specific heat capacity.

Duration of snow cover, which prevents the formation of thermal lifts, is a limiting factor for the distribution of Eurasian Griffon Vulture (Marinković, 1999). Due to influence of the Mediterranean climate, the average duration of snow cover in Herzegovina varies from 1 to 5 days. Such conditions are optimal for Eurasian Griffon. This species occurs not only in the Mediterranean area, but also in mainland enclaves. These enclaves are located in gorges and canyons that represent biodiversity hotspots in the central parts of the Balkan Peninsula (Karadžić et al., 1996; Karadžić et al., 1997).

The Eurasian Griffon nests in Balkan regions with significantly different amounts of precipitation: from the island of Crete with only 400 mm of annual rainfall (Marinković et al., 1994), to the vicinity of the city of Kotor (Krstac area) with 3000 mm of annual rainfall (Schenk, 1917). Nevertheless, it has been documented that Eurasian Griffon Vulture avoids both deserts and over-humid regions. This species nests in regions with semiarid and subhumid conditions (Marinković, 1999). A climate with an annual precipitation of 600-800 mm is optimal for the Eurasian Griffon. In the critical period (March to April), when juveniles have hatched and there is a need for frequent feeding, the Eurasian Griffon Vulture prefers regions with a monthly precipitation of 50-100 mm (Marinković, 1999). At the Popovo polje karst field, the Eurasian Griffon nests

in a humid area (up to 250 mm of rainfall during March and April).

Eurasian Griffon Vulture nests in regions with frequent and strong winds and storms. The daily winds, "mistrals", that permanently blow in Herzegovina lift the hot air mass upwards. This Mediterranean upslope wind enables the flight of Eurasian Griffon Vultures.

The Eurasian Griffon has nested in Herzegovina selectively, on limestone and dolomite rocks (Talsky, 1882, Reiser, 1939). It prefers rocks for nest construction, with limestone being the preferred type of rock, since 92% of nesting sites in the Balkans (Marinković, 1999), and 74% on the Iberian Peninsula (Donazár, 1993) are located on different limestone variants. Limestone is the prevailing bedrock of the Dinaric Mountains. These mountains therefore offer optimal conditions for Eurasian Griffon Vulture nesting.

The lowest altitude of nesting site in the Balkans was recorded on Cres Island at only 8 m a.s.l. (Sušić, 1985). The average altitude of nesting sites on Velebit Mountain is 413 m a.s.l (Lukač, 2003). The average altitude of nests gradually increases with increased continentality, so that in Serbia it attains 811 m (Marinković, 1992). On the Iberian Peninsula, the Eurasian Griffon nests at altitudes ranging from 100 m to 1600 m a.s.l. In extreme cases, nests are positioned at 1800 m a.s.l. (Donazár, 1993). In the Caucasus, nesting sites are usually situated at 1000 m a.s.l., but some are located even at 2750 m a.s.l. (Glutz et al., 1971, Snow et al., 1994). Nesting sites of the Eurasian Griffon in Herzegovina were usually situated between 100 and 300 m a.s.l. Most nests (85%) were located below 500 m. However, in the Popovo polje karst field, the altitude of nesting sites varied from 500 to 900 m a.s.l. This may be explained by the fact that caves and cliffs in Popovo polje are located at higher altitudes.

Two main factors that affect the nesting site selection of the Eurasian Griffon are availability of suitable habitats (caves and cliffs) and permanent winds. The direction of permanent winds strongly affected nest site preference of the Eurasian Griffon in Herzegovina. Nearly half of all nests (50.8%) were located on western and southern exposures. The same pattern was recorded on the Iberian Peninsula, where the majority of nesting sites are west-exposed (14.5%). Nests on western sides receive a larger amount of sunshine, and usually have higher air temperature than east-exposed nests. The daily variations in temperature on west-exposed slopes (cold mornings and warm afternoons) create permanent winds. In regions where the climate is less suitable, such as the Iberian Peninsula or Caucasus and mountainous regions in Serbia, birds avoid northern exposures. However, if west-exposed sites are not available, the Eurasian Griffon then selects the most suitable sites. For example, on Cres Island, most of the nesting sites of Eurasian Griffon (85%) are northeast-exposed, due to a lack of suitable nesting terrain on other exposures (Sušić, 1985). Southern exposure is less suitable since it can cause the overheating of juveniles and increased juvenile mortality (Fyfe et al., 1976). The Eurasian Griffon selects nests at suitable altitudes and exposures. Moreover, nests should be open enough for landing and lifting off (Newton, 1979). The nests are not exposed to rain and snow, because they are usually sheltered. The nest entrance is often sheltered by trees or bushes, and in such cases, the birds must land beside the nest and then reach it by walking. The proportion of nests was much greater in caves (31%) and half-caves (36.1%) than in other geomorphologic structures. The selection of such types of nests is connected to the survival of young birds. According to Marinković (1999), the survival of juveniles was greater in the cave nests (0.88 juveniles survived per adult pair) than in the nests that were established on semi-open terraces (0.83 juveniles per pair).

In most cases (over 75%), the distance between two nests was 20 m. Such aggregation is an effective means of minimizing the risk of predation of eggs and youngsters. Moreover, dense colonies affect the social behavior and learning of young birds.

Nests of the Eurasian Griffon in the Balkans are usually located on cliffs, at heights from 20 to 40 m (Marinković, 1999). The average height of nests in Herzegovina was 60 m. Eurasian Griffon Vultures in Herzegovina inhabited suburban zones. We found out that the height of nesting sites was strongly correlated with the avoidance of human-induced disturbances. The highest nest was recorded at Blagaj rock, close to an urban area. High nests were also specific for the Žitomislići area, where roads pass nearby the colony (Marinković et al., 1983). The mountainous area of the Popovo polje karst field is inaccessible for humans. Therefore, the height of nesting sites in this region was lower than in other colonies. The height of nesting sites is inversely related to the percent of urbanization and to the distance from human settlements (Newton, 1979). This regularity was confirmed in our study.

Together with abiotic conditions (climate, orography), the main limiting factor for Eurasian Griffon population growth is food availability. Despite a significant decrease in cattle numbers during the last 50 years, the amount of available food is sufficient for the establishment of new colonies of Eurasian Griffon in the Herzegovina region (Marinković et al., 1999). Two feeding sites that were established in Herzegovina since 1981 may be used as an additional source of food for the Eurasian Griffon (Marinković et al., 1996, Marinković et al., 2002).

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