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Individually Marked Eurasian Griffon Vulture (Gyps fulvus) Occurrence Phenology in the Eastern Rhodopes, Bulgaria

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Abstract. The Eurasian Griffon Vulture is a large raptor species with a vast range. The species is breeding in Bulgaria and its population is estimated at more than 100 pairs distributed in several sites in the country nowadays. The aim of the current study was to track the resighting frequency, age and phenology of presence of marked Griffon Vultures in the Eastern Rhodopes, Bulgaria and possibly to record the origin of the tagged individuals. During the study (n=10 years) we recorded 1888 observations of 231 marked Griffon Vultures in total. The number of vulture resightings was 42 ± 8.4 marked individuals per year. The age of 80% of the recorded Griffon Vultures was established. Adult vultures had the highest resighting rate (0.35 ± 0.03). Most of the observed marked Griffon Vultures were recorded during the autumn season, especially the immature birds. The largest portion (n = 1343 resightings) were of Griffon Vultures marked in different parts of Bulgaria. Our results can be easily complemented with GPS telemetry data to reveal entirely movement ecology of Griffon Vulture in the Eastern Rhodopes.

Key words: resighting, *Gyps fulvus*, wing tag, resighting frequency, tagging origin.

Introduction

The Eurasian Griffon Vulture, *Gyps fulvus* (Hablizl, 1783), is a large Palearctic, Indohimalyan and Afrotropical Old-World vulture, classified as 'Least concern' spreading over 18M km^2 globally (Birdlife international, 2020). Its distribution is land locked between Portugal and Nepal (Grubach, 2014). The global population of the species is estimated at 648,000-688,000 mature individuals (Birdlife International, 2020) unevenly distributed among species' populations within the range (Grubach, 2014). The European population of the Griffon Vulture is estimated at 32 – 34 thousands of pairs. The species population marked a nearly 200% increase in its size during last few decades (Birdlife international, 2020). The largest population of the species both in Europe and worldwide is the one in Spain (Botha et al., 2017). The historical range and size of the Griffon Vulture population in the Balkans are well studied. The species has fragmented distribution and size in Bulgaria, Croatia, Greece, North Macedonia and Serbia (Andevski, 2013). Following the rediscovery of the species in Bulgaria in 1978 and the long-term conservation program in the area, more than 90 pairs are breeding in the Eastern Rhodopes, Bulgaria nowadays (Dobrev et al., 2019). The national population is estimated to

number 105 – 118 pairs in 2018 with 25 pairs in 3 of the release sites and over 80 pairs in the Eastern Rhodopes (Stoynov, 2019). The species is listed as „Endangered" in the Red Data Book of the Republic of Bulgaria, in Annex I of the Birds directive and is also strictly protected by the National Law (Annex 2 and 3 of the Biodiversity Act) (Golemanski, 2015).

Individual marking is a specific approach widely used to estimate birds' survival, breeding biology, behaviour, age related mortalities, longevity of birds and their phenology (Sweeney et al., 1985). Wing tags and rings are often used in studies for number of bird species. Based on markings and capture re-capture techniques survival rates of vultures can be obtained (Monadjem et al., 2012; Monadjem et al., 2014). Such methods are further applied in reintroduction projects to explore vultures' dispersal (Mendelssohn & Leshem, 1983; Le Gouar et al., 2008; Stoynov & Bonchev, 2012; Peshev et al., 2018). Markings are an useful tool to study migration (Young & Kochert 1987), foraging movements and occurrence phenology of different vulture species (Charalambou, 2003; Botha, 2007; Zuberogoitia et al., 2013).

The aim of the current study was to survey the frequency of resighting rates and occurrence phenology of the marked Griffon Vultures in the Eastern Rhodopes, Bulgaria, their age and origin. Marked Griffon Vultures can bear not only biological information, but also to reveal data on different threats. Therefore, our results can support future conservation studies and actions in the Eastern Rhodopes and elsewhere.

Materials and methods

Study area. The study was conducted in the Eastern Rhodope Mountains, Bulgaria (Fig.1). This low mountainous area is approximately 5,900 km^2 in range and is characterized by high diversity of natural habitats, rich biodiversity and human population with a low density (Kopralev, 2002). The mean daily temperatures in winter vary between + 1^{0}C - + 2^{0}C, while the summers can be relatively hot and dry with mean daily temperatures of 24 - 25^{0}C. The yearly temperature amplitude is small with an annual rainfall in the area between 450 and 900 mm. Days with permanent snow cover reach 20 annually (Kopralev, 2002). The area retains the highest diversity of breeding raptor species in Bulgaria (Stoychev et al., 2004).

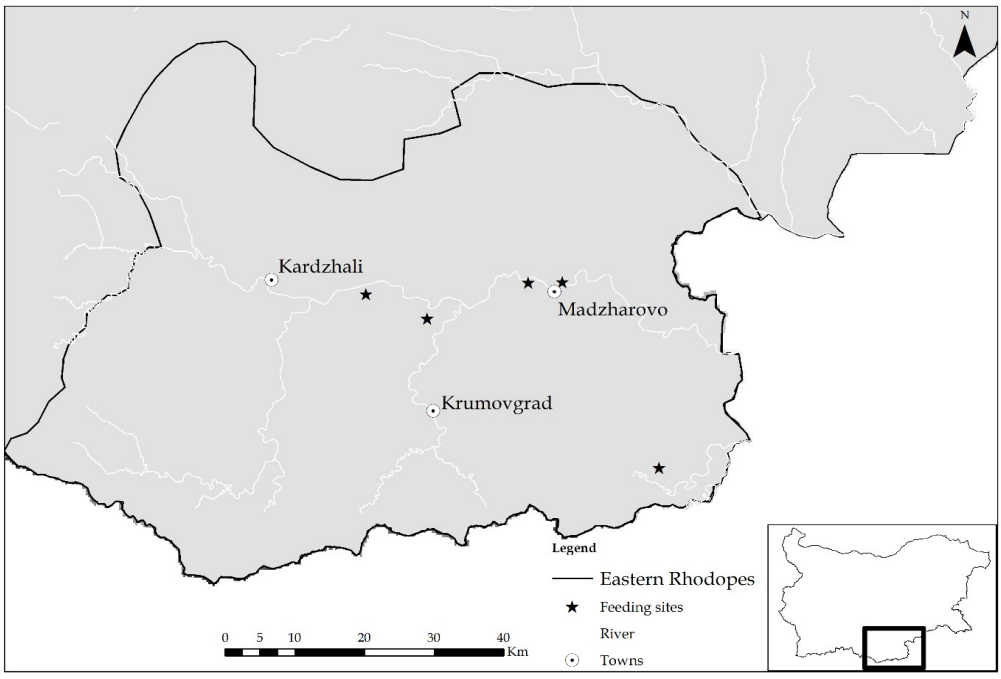

Fig. 1. Map of the study area and the feeding stations.

Data collection methods. The study was implemented in the period 2009 – 2018. All observations were conducted during supplementary feedings with a frequency of minimum of 2 feeding events per month. The observations were conducted at four of the feeding sites (Fig.1) with different frequency (42 ± 11.3 observation events per year; range 2 - 108). The observations and data collection that followed the feedings were carried out up to the entire consumption of the delivered food. The observations were done from a stationary view point, distanced far enough to avoid disturbance (Zuberogoitia et al., 2008) and with spotting scopes. The observer recorded the start of the count and at any round hour the number, age and markings of the vultures. Griffon Vultures were divided into 4 age classes (adult, subadult, immature, juvenile) (Blanco et al., 1997). Information on the type of the marking (wing tag, ring, transmitter), the color, digits, and its position (left – right; wing - leg) was recorded. Observations were held only in days with favorable weather conditions. In order to improve the data collection trail cameras were used since 2016. They were deployed to record the number and details of the marked vultures and ease the monitoring whenever the conditions were not suitable or supporting view point monitoring was absent. The trail cameras (n = 1 to 3) were deployed at distance about 5 - 10 m from the carcass so that they could photograph vultures without causing disturbance. The data on the Griffon Vulture age and markings were collected in blank sheets up to 2016 and via the SmartBirds Pro mobile application after that (Popgeorgiev et al., 2015).

Data analysis. The mean values were retrieved through descriptive statistics. The resighting rate was calculated as a proportion between the numbers of the observations of a given individual or age group, divided by the total number of observations in the given year/period. The seasonal distribution was set as follows: winter (December, January, February), spring (March, April, May), summer (June, July, August) and autumn (September, October, November). All vultures' resightings with rings and wing tags that were not entirely read were excluded from the sample analysis.

The significance values were set up to $p < 0.05$ for all tests. Mean values were presented with standard error (SE). Statistical analysis was performed using the Past software package (Hammer et al., 2001). Spatial data were mapped and processed using QGIS software (QGIS Development Team, 2016).

Results

Count and occurrence phenology. During the study we recorded 1888 observations of 231 marked Griffon Vultures during 424 monitoring events. The least number of marked birds was registered in 2010 (n=2) and the highest (n=79) was recorded in 2018 (Fig.2). The number of birds marked with rings was 36 and those marked with wing tags was 195. Some of the Griffon Vultures were both tagged with rings and wing tags.

We recorded 42 ± 8.4 marked Griffon Vultures per year. The mean resighting rate in the period was 0.09 ± 0.004. The resighting rates of marked Griffon Vultures had the highest values in 2010 (0.5 ± 0.001) and the lowest in 2016 (0.06 ± 0.01).

Age structure and phenology. The age of 80% of the recorded Griffon Vultures was established. Adult vultures had the highest resighting rate (0.35 ± 0.03), followed by the immatures (0.3 ± 0.05), subadults (0.06 ± 0.01) and the juveniles (0.04 ± 0.01). The age of 20 % of the Griffon Vultures could not be determined (Fig. 3).

Most of the observed marked Griffon Vultures were recorded during the autumn season. However, adult birds were relatively constant throughout the year, whereas non-adult (juveniles, immatures and subadults) birds were mainly recorded in the autumn (Table 1).

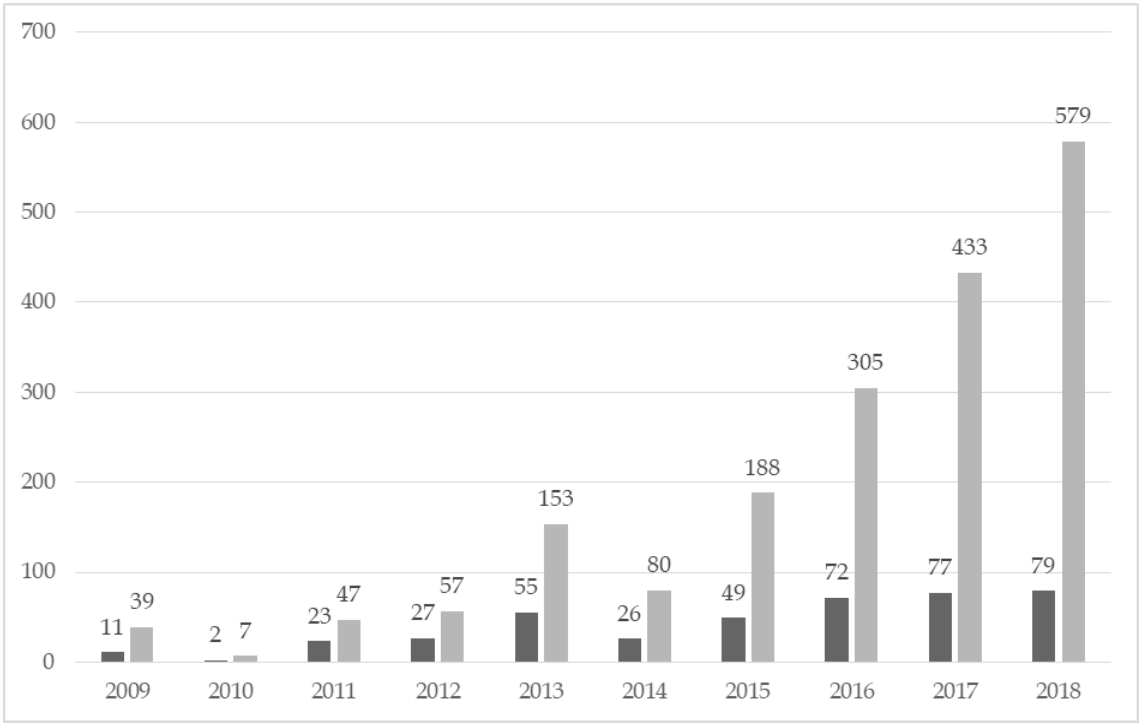

Fig. 2. Number of the registered marked individuals in the study area (black bars) and the number of resightings per year (grey bars).

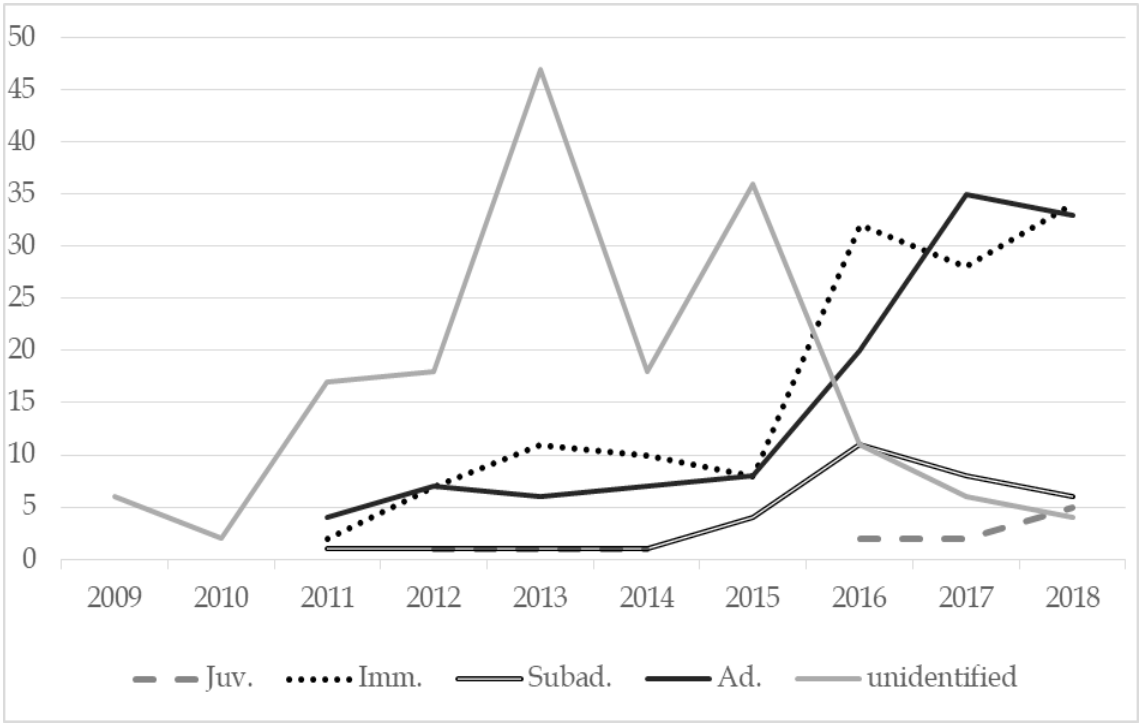

Fig. 3. Number of the observed marked Griffon Vultures by age classes during the study period.

Table 1. Percentage of marked vultures in the different seasons.

Season	Winter	Spring	Summer	Autumn
Non-adults	22.09%	26.72%	18.17%	33.02%
Adults	21.90%	26.59%	22.36%	29.15%
Total	22.01%	26.66%	20.01%	31.32%

Table 2. Number of the resightings by the place of marking of the Griffon Vultures.

Site of marking	Count of resightings	Percentage	Number of individuals
Eastern Rhodopes	589	31.2	40
Central Balkan	128	6.8	12
Vrachanski Balkan	112	5.9	13
Sinite Kamani	83	4.4	12
Kresna	80	4.2	8
Kotel	77	4.1	8
Reintroduced not specified	274	14.5	59
Bulgaria	**1343**	**71.1**	**93**
Dadia	180	9.2	23
Nestos	1	0.1	1
Greece	**181**	**9.6**	**24**
Hai Bar Carmel NP	65	3.4	5
Sde Boker	47	2.5	11
Gamla NP	29	1.5	4
Israel not specified	37	1.8	16
Israel	**178**	**9.4**	**33**
Serbia – Uvac	**103**	**5.5**	**25**
Unknown	**83**	**4.4**	**10**

Fig. 4. Locations (black dots) where Griffon Vulture marking schemes were applied regularly.

Marked birds origin. The largest portion of the resightings (n = 1343, 71.1%) were of Griffon Vultures marked in various parts of Bulgaria. We recorded 181 resightings of birds marked in Greece, 178 resightings of vultures marked in Israel and 103 resightings of birds marked in Serbia. We were not able to track and find information on the origin and sampling site for 10 of the Griffon Vultures (4.4%) recorded during the study (Fig. 4).

The resighting rate of Griffon Vultures in the Eastern Rhodopes marked in Bulgaria was 0.7 ± 0.1, Greece – 0.1 ± 0.01, Israel – 0.09 ± 0.02 and from Serbia – 0.05 ± 0.01.

Discussion

The increased number of observations of marked Griffon Vultures is a result of the increased species population, the increased monitoring effort and the larger number of marked individuals during the last years. Nearly 350 birds were released in the reintroduction program for the species in 4 former breeding sites in Balkan Mountains and Kresna gorge in Bulgaria since 2009 and all were individually marked (Stoynov, 2019). This increased the chances of observing marked birds as some of the released vultures moved into the natal colonies in the Eastern Rhodopes (Stoynov & Peshev, 2011, 2012, 2013, 2014; Peshev & Stoynov, 2015; Stoynov et al., 2015). The population in the Eastern Rhodopes has grown considerably in the last 25 years (Demerdzhiev et al., 2014) and 52 individuals have been marked and tagged until 2019 (authors unpublished data). Adult birds from the native population rarely wander outside their natal areas as revealed by GPS telemetry (BSPB unpublished data). Normally, such birds have much higher resighting rates. Furthermore, we have registered Griffon Vultures, marked in Greece and breeding in the Bulgarian side of the mountain. Such shifts were registered before and prove that vultures can exchange between the Bulgarian and the Greek side of the Eastern Rhodopes (Demerdzhiev, 2007; Skartsi, 2009). On the other hand, juveniles and immatures can roam for several years before start breeding (Zuberogoitia et al., 2013) reaching as far south as Africa (Arkumarev et al., 2019) and the Middle East. Our results confirm that some immature birds observed in our area are marked in other areas of the species range from Bulgaria and the Balkans – Greece, Serbia and reintroduced birds considerable part of the juvenile Griffon Vultures from the Balkans, take yearly roamings. They start in September – November and explore sites further away from the natal colonies in Asia Minor, Arabian Peninsula, Northern Africa and Sahel region (Griesinger, 1998; Susic, 2000; Grubach, 2014; Tsiakiris et al., 2018; Arkumarev et al., 2019). Similarly, over 90% of the juvenile birds in Spain leave their natal colonies in October and minimum of 30 % of them migrate to Africa (Griesinger, 1998). This stage of vultures' life is essential in gaining experience, sexual maturity and enriching social interactions (McGrady & Gavashelishvili, 2006; Xirouchakis & Andreou, 2009; Garcia-Ripolless et al., 2011). Moreover, long-term stability of the population could be strongly affected by the juvenile survival (Van Beest et al., 2008). In spring some juveniles, can return back to the natal colonies where they stay mostly around the feeding sites and breeding colonies. However, as those individuals are not breeders they can roam over vast areas and thus become more vulnerable to different threats. Our data showed that large groups of vultures, especially immatures and juveniles can congregate at the feeding sites from September to November. Hence, birds arriving in the Eastern Rhodopes in this period might stay wintering in Bulgaria where they find abundant food and conspecific presence. Therefore, the Eastern Rhodopes may be of great importance for the survival of juvenile and immature birds wintering there and thus support the high demography rates of their natal colonies. Our study showed that some juveniles from Serbia remain to winter in the Eastern Rhodopes. Griffon vultures from the

reintroduced population were also registered wintering, but also breeding either alone or in a mixed pairs with birds from the natal colonies in the Eastern Rhodopes. A Croatian study showed that marked immature Griffon Vulture was registered in Bulgaria, travelling almost 1,000 km from its natal colony in Croatia (Susic, 1994). In our study we did not register any birds of Croatian origin. Probably due to the fact that the birds are marked with rings which are far more difficult to record than wing tags. Being in small numbers they may have remained unrecorded.

Subadult vultures in our study area are an important part of the population although only 19% of the resighted vultures belonged to this age group. However, this might be a consequence of the sample size, species demography and the survival particularly. According to García-Ripollés et al. (2011) subadult birds are able to roam over large areas. This may play a crucial role in their survival and gaining experience. Therefore, age structure and survival of the population are obligatory to understand population demography and development (Newton, 1979; Steenhof & Newton, 2007).

We demonstrated that significant part of the immature vultures observed in our study area in spring were marked in Israel. We hypothesize these are mostly birds of Balkan origin, wintering or migrating through Israel and the Middle East. Immatures return back to their natal colonies in spring. This was confirmed by the current results and our long-term monitoring, but also data from Israel where less Griffon Vultures were established in spring in comparison to the autumn and winter seasons (Choresh et al., 2019). For example, Griffon Vultures marked in Israel are currently breeding in the Eastern Rhodopes. The same phenomena were observed in other countries as well and may be attributed to the spring migration of some of the Griffon Vultures due north (Xirouchakis, 2007; Boshoff et al., 2009). The autumn migration of the Griffon Vultures from Serbia and Croatia pass through Bulgaria over a wide front towards the Bosphorus (Fulop et al., 2014). Some of these vultures are most likely heading Greece to the south to winter as well. We can argue those are mainly Croatian birds as such were not established in the Eastern Rhodopes in our study. They might be passing in lower numbers and thus are difficult to record outside the feeding sites, though. However, our study underlines the importance of the Eastern Rhodopes as a hot spot for the Griffon Vultures. The high availability of free-ranging domestic livestock and abundant game species there determines the presence of the Griffon Vulture (Boev & Michev 1980; Arkumarev et al., 2019.). Furthermore, supplementary feeding sites in the area supply regular and safe food for the vultures. Because of the spatial and temporal unpredictability of the carcass, it is very difficult to record marked Griffon Vultures outside feeding sites. Therefore, feeding sites can be used to manage and collect important information on the vulture age structure and numbers and act as main monitoring and conservation tool (Terrasse, 1985; Houston, 1987; Piper, 2005). The supply of safe and high-quality food can reduce some negative factors causing mortality of scavengers e.g. poisoning (Robb et al., 2008; Moreno-Opo et al., 2015). Supplementary feeding stations can maintain higher breeding rates of vultures (Gonzalez et al., 2006), increase the important nutrients level such as calcium (Piper, 2005) and decrease the chance of poisoning (Grande, 2006; Oro et al., 2008).

Results of the current study prove the importance of the marking methods to reveal the phenology of the Griffon Vulture. It complements other studies from Europe, the Middle East and Africa (Mendelssohn & Leshem, 1983; Botha, 2007; Monadjem et al., 2012; Monadjem et al., 2014; Peshev et al., 2018) and provides good insight for processing resighting type of data. Our results can be easily combined with GPS

telemetry data to create comprehensive spatial study for the Griffon Vulture movement ecology in the Eastern Rhodopes. This will reveal important demography rates such as survival and population recruitment. Such knowledge will establish a sound base for further population viability analysis to project the Griffon Vulture population trend and outline respective conservation measures.

Conclusions

Monitoring of feeding sites is important tool to trace Griffon Vulture population dynamics and to record resighting rates of marked individuals (231 marked vultures in our study with various origin). Wing tagged birds were easier to record in comparison to birds marked with only rings, however, the use of trail cameras can significantly improve the monitoring in this regard. The rate of observations differed among age classes and was seasonally determined. Therefore, a combination of monitoring methods to record marked vultures and GPS technologies can bring knowledge on the population status, spatial ecology and phenology, vultures origin, threats and also help to calculate mortality rates and survival within different age classes and the entire population.

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