

Seasonal and Spatial Dynamics of the Population of the Griffon Vulture *Gyps fulvus* (Hablizl, 1783) (Aves: Accipitridae) in Southwestern Bulgaria

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Abstract: Movements and sojourn of the griffon vulture *Gyps fulvus* in Bulgaria are poorly known. In the light of multiple reintroductions of the species in Bulgaria and by means of introduction of modern technologies, a lot of new data were collected. Here we analyze data of seven birds tracked by GPS/GPRS transmitters in South-western Bulgaria and additional five vultures from other colonies in the country and adjacent areas. Our results indicate that immature griffon vultures travel long distances across Bulgaria and neighbouring countries (maximum daily distance = 234.3±87.2 km; minimum convex polygon = 28,347±42,439 km²; home-range 95% kernel = 7,893±20,645 km² and core area 50% kernel = 772±1,826 km²). However, they almost exclusively roost and feed in already established griffon vulture colonies or join seasonal gathering of conspecifics, which are usually found within a zone of 15 km radius from a complex of feeding site or abundant, easily accessible food in close proximity to suitable roosting places. Strategically placed and permanently supplied vulture restaurants in close proximity of roosting sites, may concentrate large numbers of griffon vultures in a relatively small and possible to control areas. This, in combination with implementation of site based conservation activities (e.g. creation of Vulture Safe Areas), may buffer the impact of any, otherwise, hardly controlled and acting on large scale threats, such as poisoning and electrocution.

Key words: Kernel Density Estimation, Home-range, Sojourn, Kresna Gorge, GPS tracking, Vulture Safe Areas

Introduction

The griffon vulture was widely spread in Bulgaria throughout the 19th Century, being numerous in many places of the country until the first half of 20th Century (CRAMP & SIMMONS 1980, DEMERDZHIEV et al. 2007, 2014). As a result of the national campaign for eradication of predators through the use of poisonous baits, the species disappeared from the territory of the country in the 1960s and was considered extinct until 1978, when a small group was discovered in the Eastern Rhodopes (MICHEV et al. 1980, DEMERDZHIEV et al. 2014). After conservation efforts, its population increased to over 56 pairs in 2011 (DEMERDZHIEV et al. 2014). The sporadic observations in Southwest Bulgaria between 1979 and

1987 were classified as individual cases of wandering birds (YANKOV & PROFIROV 1991).

In 2010, reintroduction of the species was started in the Kresna Gorge resulting in the release of 63 birds by the end of 2016. The vultures were imported from rehabilitation centres in Spain or from zoos in Western Europe. All the birds released after 2011 were immature between 0 and 4 calendar year. The griffon vultures usually reaches sexual maturity after their fifth year of age and the first successful nesting of two pairs was recorded in 2016 (PESHEV et al. 2015, 2017). The newly founded colony has quickly started to be visited by vultures from all parts of the Balkan Peninsula, which was proven

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by the many observations of marked birds. Some of the birds have joined other colonies and constant movements in both directions between the colonies in the Kresna Gorge and Macedonia were observed. During the spring and autumn migrations, the biggest aggregations were recorded and 63 vultures were observed overnight in November 2016 (PESHEV et al. 2017).

In Southwest Bulgaria there is only one feeding site for birds of prey, which was constructed and maintained for species reintroduction in the Kresna Gorge, being supplied 3-4 times a week with 3 to 10 tons corpses of livestock monthly.

Through the use of ringing and radio transmitters, it was proven that griffon vultures and especially the young specimen undergo distant migrations (ELOSEGUI & ELOSEGUI 1977, BAHAT et al. 1993, GRIESINGER 1998, BAHAT et al. 2001, GIL et al. 2009, XIROUCHAKIS & ANDREOU 2009). A detailed analysis of the movement and spatial parameters in the behaviour of the griffon vulture according to data, collected by satellite transmitters have been conducted in Spain (GARCÍA-RIPOLES et al. 2011).

The goal of the current study is to present and analyze data on movements of seven griffon vultures reintroduced in Kresna Gorge, equipped with GPS/GPRS transmitters. The home-range, core area, daily movements, nocturnal roosting places and the difference between seasonal movements are presented and comparison with data from other colonies provided. Five more birds from different colonies in Bulgaria (autochthonous and reintroduced) were equipped with transmitters and the data compared with the birds from Kresna Gorge resulting in the first of its kind analysis of the griffon vulture on the Balkan Peninsula.

Detailed data about the movements of the vultures is of particular importance to analyze the success of the reintroductions and for conservation activities of the fragile Balkan griffon vulture population. The study provides some fundamental understanding about the Griffon Vulture spatial and seasonal movements and presents valuable information to managers to address effectively the threats for the species e.g. poisoning, unsecured power lines and the construction of wind parks in areas, which are commonly used by the large birds.

Materials and Methods

Bulgaria is situated in the middle of the Balkan Peninsula. Following dramatic decline since the first half of XX Century, the griffon vulture has become extinct from Bulgaria in late 1960s. Although the

species naturally recovered in Eastern Rhodopes in late 1970s and after conservation efforts, its population increased to over 56 pairs in 2011 (DEMERDZHIIEV et al. 2014). In 2010, projects to restore the species in Kresna Gorge and at four other places in the country were initiated. Until 2016, 63 griffon vultures were released in Kresna Gorge (UTM, FM73) and this same year the first successful reproduction in the area was recorded. From 6-8 formed pairs, two laid eggs and two chicks successfully fledged (PESHEV et al. 2017).

The idea of the reintroduction of the griffon vulture in the Kresna Gorge was to connect the increasing Eastern Rhodope population with the declining population in FYR of Macedonia (11-15 pairs), while also supporting the last one with direct release of birds (restocking).

The Kresna Gorge is situated in Southwest Bulgaria along the Struma River valley between the village of Krupnik to the north and the town of Kresna to the south. The foot of the Pirin Mountain on the east and the foothills of the Maleshevska Mountain on the west form the Struma River valley and the gorge. The climate is transitory Mediterranean. The Kresna Gorge is a rocky complex on a silicate base. It features steep stony slopes, a rock massif with vertical cliff walls and smaller rocky habitats (KOSTADINOVA & GRAMATIKOV 2007).

Seven griffon vultures, released within the reintroduction project, were equipped with GPS/GPRS transmitters in the Kresna Gorge in the period 2012-2017. All the birds were immature (<4 years old). For the purpose of the study we call this group of birds "Group 1".

Other five griffon vultures, of which two wild (native to Balkans) caught at the feeding site in Kresna Gorge, as well as one released in Kotlenska Planina, one released in Vrachanski Balkan and one wild-born in Kotlenska Planina were also fitted with GPS/GPRS transmitters in the period 2013-2017. Their data was used to add to the current study for comparison and for increasing the data sets for certain analyzes. Since their main occupancy is outside the Kresna Gorge and represent all the other known colonies of the species in Bulgaria – the autochthonous in Eastern Rhodopes and the reintroduced ones (Vrachanski Balkan and Kotlenska Planina – Sinite Kamani), they are treated separately. For the purpose of the study we call this group of birds "Group 2".

The vultures from Group 1 stayed for adaptation period in aviary next to Rakitna village (41°50'39.62"N, 23°9'41.21"E) for a period of 5±2 months. The transmitters were attached during the release, as the birds were marked with metal and PVC

rings and wing-tags. The weight of 6 of the transmitters is 90 g (about 1% of the body mass, since <3% is recommended for flying birds) and were attached to the back of the birds with teflon ribbon harness, according to the backpack method (NESBITT et al. 1979, KOCHERT et al. 1983, FULLER et al. 2005). A vulnerable knot, made out of silk rope, was left in order for the transmitter to fall off and release the bird after a couple of years. During the placing of the transmitters, we were trying to reduce the stress of the birds to a minimum, covering their heads and reducing the transmitter placement time to less than ten minutes. In one of the birds a transmitter was attached to the wing of the bird OX, where the axis of the device is used to hold the wing-tag in the *patagium*. The weight of such a transmitter is 33 g and is supplied with power by solar panel. The number of received coordinates per day varies for the time of the study, due to the battery charge levels, which were supposed to be kept in certain limits. During winter, due to the slower rate of recharge of the solar panel, the number of acquired coordinates is lower. All data download and transmitter reprogramming was made remotely via internet.

The daily distances covered by the vultures were calculated summing the straight-line distances between successive locations on the same day. The home-range shows the 50% (core area) and 95% home-range (FIEBERG 2007) of the vultures. It is calculated using the classical kernel method (kernelUD, points, extent=0.1) (CALENGE 2006).

We took out all coordinate locations acquired between 20:00 and 06:00h and they were used only for defining nocturnal roosting places. The analysis was made using QGIS 2.18.9, OpenJUMP HoRAE toolbox for OpenJUMP GIS 1.7.1 (STEINIGER & HUNTER 2012), the package adehabitat for the R software, R package, Version 3.4.0 (MAECHLER et al. 2013). We calculated the overall foraging range as the Minimum Convex Polygon (MCP) encompassing all GPS locations obtained for each bird (WORTON 1989).

We made the same calculations for the birds of “Group 2”.

The nocturnal roosting places were defined by taking the coordinates acquired during every night (from 20:00 to 06:00) and were used for roosting for more than 3 inconsistent days. Furthermore, we considered that locations less than 300 m away from one another are the same roosting place.

In order to compare the movements of the birds and the occupied territories during the different parts of the year, we divided the four seasons based on the winter and summer solstices (21.06 и 22.12)

and the spring and autumn equinox (20.03 и 23.09), although we were observing immature birds, this separation coincides with the life-cycle of the vultures (hatching eggs during the winter, raising young during the spring and summer, chick independence from September to December).

We calculated 50% and 95% home range and the daily distance covered by every bird for those periods.

The birds were tracked for a different period of time and during different seasons. For the seasonal dynamics we removed seasons with less than 40 days with data. Unfortunately, we had only one winter of the birds from Group 1, when we were able to track a vulture OX and we did this analysis for all the vultures – Group 1 and Group 2 together.

We split the year again, this time in two parts: from 21 March to 22 September (spring-summer) and from 23 September to 20 March (autumn-winter); to compare the difference in vulture movement in the half-year with a longer daylight from that with a shorter one.

Results

The seven transmitters from Group 1 sent 37,397 daily GPS coordinate locations. Average for a transmitter is $5,342 \pm 3,787$ (range 1,002–10,782). The tracking period for the birds on average is 237 ± 152 days (range 48–425), but due to technical reasons (broken files during data transmission or lack of GSM network coverage, resulting in file transition failure and loss), the acquired data on average is 195 ± 131 days (range 30–418). The average number of coordinates per day is 28.5 ± 10.4 (range 16–47).

In total, the vultures flew over 33,796 km, mean for vulture $4,828 \pm 3,426$ km (range 648–7,874).

All data for the griffon vultures from Group 1 and Group 2 are given in the Table 1.

Daily movement

The average distance of the daily flights is 25 ± 10.5 km (range 11–42.5), where the maximum distance covered in a single day from the birds from Group 1 is 190.9 ± 75.1 km (range 95–312.2) and Group 2 is 295.2 ± 67.5 (range 222–378.2).

Home Ranges Estimation

The total area occupied by all seven vultures from Group 1 calculated as Minimum Convex Polygon (MCP) is $30,190 \text{ km}^2$, which includes the whole of Southwest Bulgaria, the Eastern part of Macedonia and parts of Northern Greece. Average area of MCP for all vultures in Group 1 is $9,494 \pm 7,243 \text{ km}^2$ (range

Table 1. Tracking data, home-range, daily movement parameters and nocturnal roosting places of 12 Eurasian griffon vultures tracked by GPS satellite telemetry in Bulgaria.

Tag	Origin of the bird	Transmitter attachment and weight	Start – End date	Received GPS coordinates	Tracking Period, days	Days with data	Distance traveled, km	Daily distance, mean ± standard deviation	Median daily distance, km	Daily distance (min - max), km	Minimum Convex Polygon (MCP) area, km ²	Core areas (within 50% UD isopleths) km ²	Home range area (within 95% UD isopleths) km ²	Nocturnal roosting places
Group 1														
OX	Reintroduced	Wing attachment 33 g	15.07.2016 02.06.2017	10,782	323	230	9,767	42.5 ± 50.4	21.7	0.3 – 254.45	11,948	207	2,673	10
C-G48	Reintroduced	Backpack 90 g	06.05.2012 22.06.2012	1,002	48	30	648	21.6 ± 32.3	9.3	0 – 119.9	1,337	10	106	3
12-F64	Reintroduced	Backpack 90 g	02.05.2015 29.06.2016	9,180	425	418	6,313	15.1 ± 27.1	6.5	0 – 312.2	9,316	16	145	13
K-B37	Reintroduced	Backpack 90 g	27.07.2012 13.12.2012	1,825	140	115	1,261	11.0 ± 17.9	3.6	0 – 95.0	2,208	12	166	4
U-B31	Reintroduced	Backpack 90 g	23.06.2012 19.09.2012	2,899	88	88	2,770	31.5 ± 39.2	14.9	0 – 171.4	6,451	26	829	2
M-B17	Reintroduced	Backpack 90 g	30.06.2012 09.08.2013	7,275	406	282	7,874	27.9 ± 34.5	14.5	0 – 207.2	22,518	46	1,164	15
9	Reintroduced	Backpack 90 g	15.04.2015 29.11.2015	4,434	229	202	5,164	25.6 ± 35	13.1	0 – 175.8	12,682	57	763	9
mean ± standard deviation														
Group 2														
B2A	Balkan population	Backpack 90 g	22.07.2015 20.08.2016	6,499	396	285	8,165	28.6±44.1	7.9	0 – 236.6	24,143	1,591	7,490	4
3-B93	Balkan population	Backpack 90 g	26.06.2014 06.10.2015	7,183	468	444	15,144	34.1±55.4	12.4	0 – 345.7	127,206	6,367	72,849	9
H1	Reintroduced	Wing attachment 33 g	08.03.2017 08.06.2017	6,929	93	93	5,006	53.8±53.4	37	0.5 – 292.6	7,621	34	332	3
K5M	Reintroduced	Wing attachment 33 g	08.06.2017	7,015	136	136	6,434	47.3±53.8	30.1	0.4 – 378.2	6,845	46	277	2
K77	Reintroduced	Backpack 90 g	31.10.2014 07.06.2017	9,490	951	800	18,438	23.0±33.1	10.1	0 – 222	107,886	847	7,916	12
mean ± standard deviation														
All vultures (Group 1 and Group 2)														
mean ± standard deviation														
30.1±12.7 234.3±87.2 28,347±42,439 772±1,826 7,893±20,645														

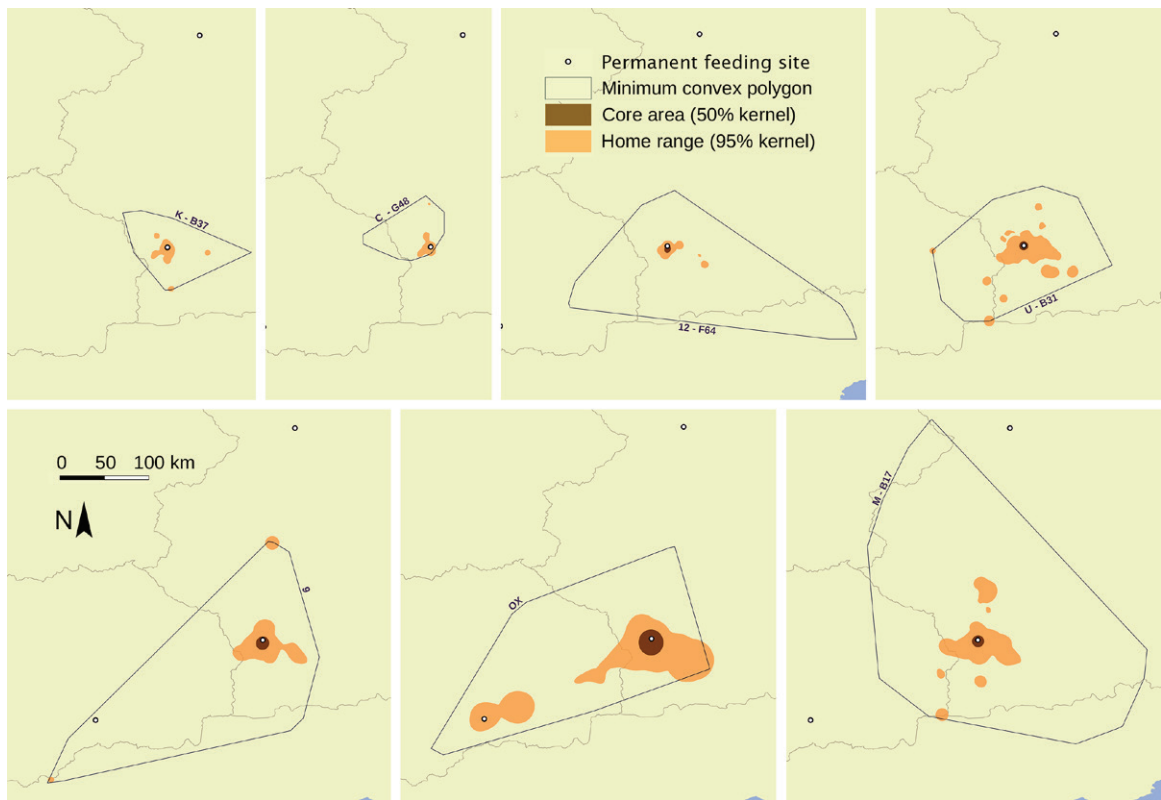


Fig.1. Home-ranges of Griffon Vultures from Group 1, including MCP, Core area - 50% kernel and home-range 95% kernel and the existing vulture feeding sites.

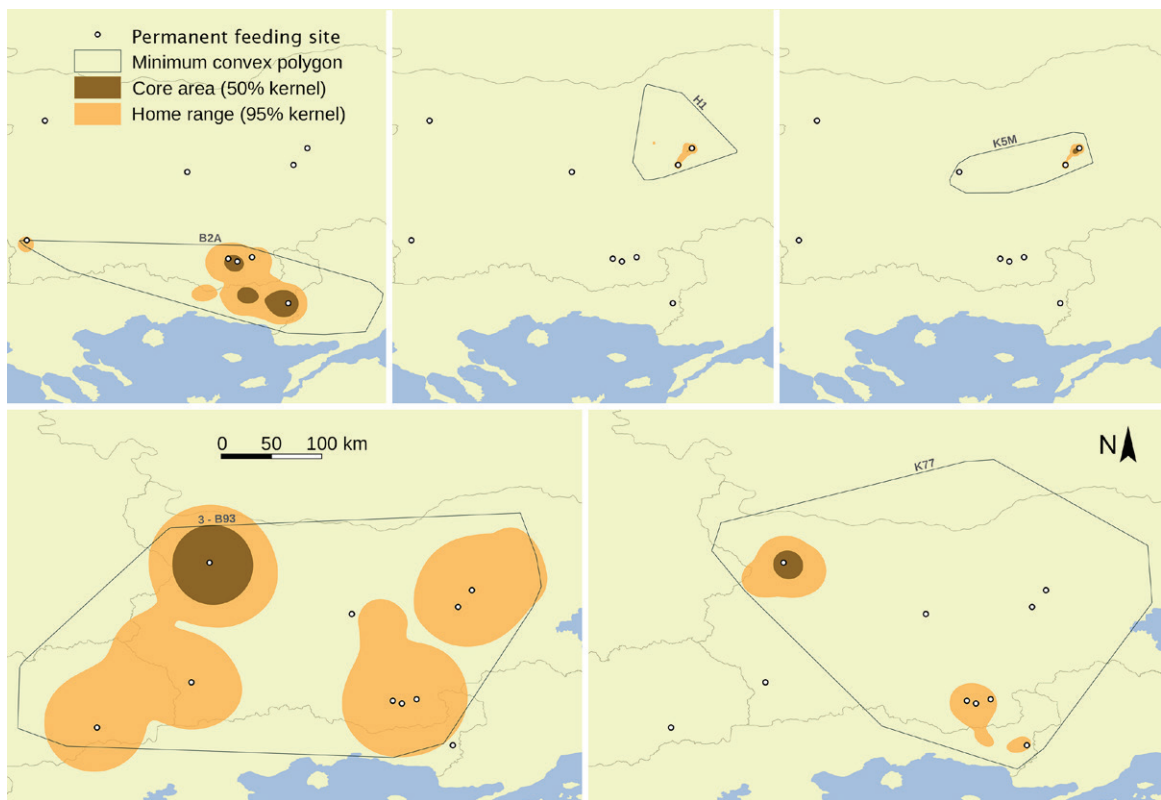


Fig. 2. Home-ranges of Griffon Vultures from Group 2, including MCP, Core area - 50% kernel and home-range 95% kernel and the existing vulture feeding sites.

Table 2. Seasonal tracking data, daily movement and home-range of twelve Eurasian griffon vultures (Group 1 and Group 2) tracked by GPS satellite telemetry in Bulgaria.

Season	Mean of Daily distances (mean± standard deviation), km	Core areas (within 50% UD isopleths), (mean± standard deviation), km ²	Home range area (within 95% UD isopleths), (mean± standard deviation), km ²
Spring	40.3±19.8	2,513±5,726	11,840±26,741
Summer	38.2±18.5	2,159±5,691	10,049±23,729
Autumn	10.4±7.4	217±540	1,036±2,557
Winter	20.4±9.8	3,727±7,435	18,388±33,458
Spring – Summer	39.6±19	1,842±5,279	10,113±26,085
Autumn – Winter	13.5±7.1	717±1,662	5,301±13,335

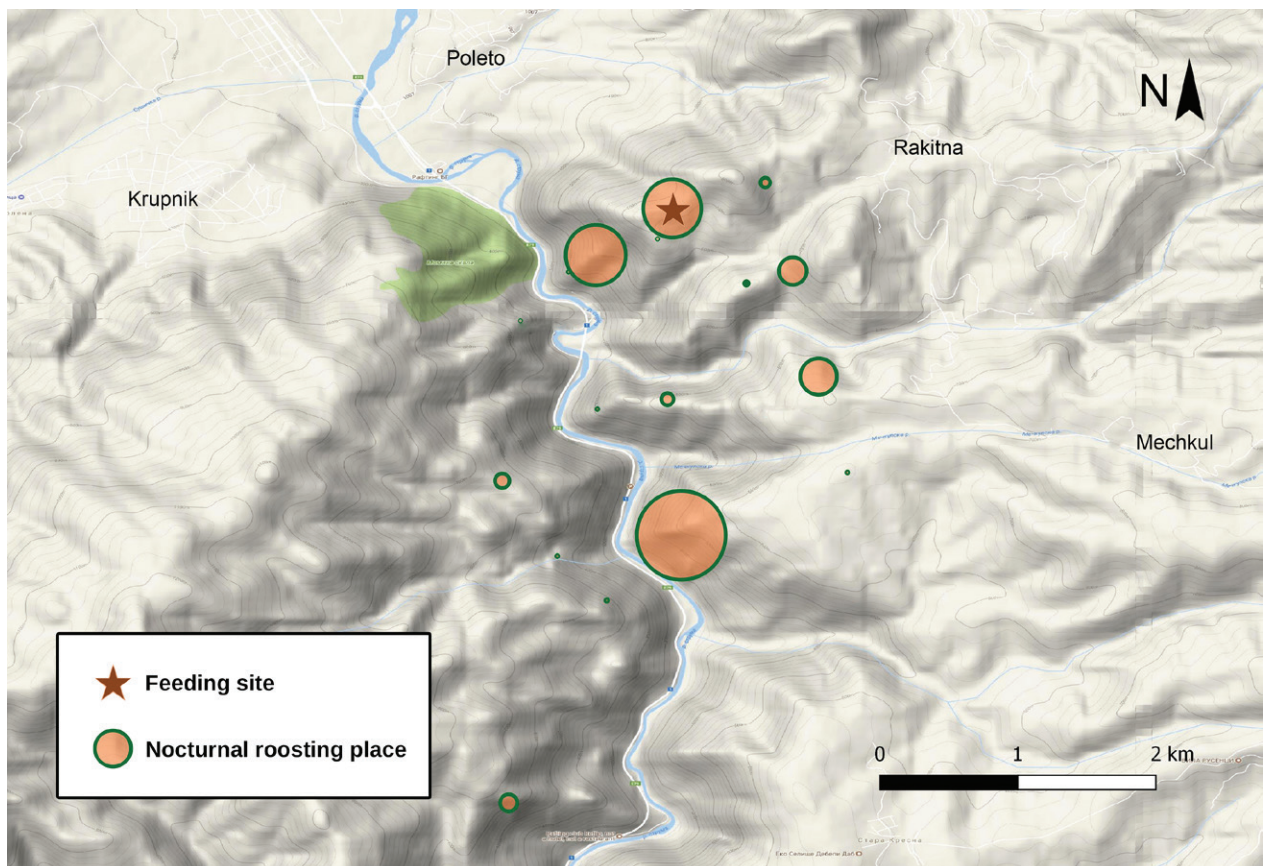


Fig. 3. Map of nocturnal roosting places of Griffon Vultures of Group 1 in the Kresna Gorge and the vulture feeding site. The size of the circle is proportional to the use of the roosting site by the vultures.

1,337–12,682) and 57,740±58,150 (range 6,845–127,206) km² for Group 2. Mean area of the home range (95% kernel) and core area (50% kernel) for Group 1 was 835±810 km² (range 106–2,673) and 53.4±70 km² (range 10–207), respectively.

Seasonal dynamics

No seasonal differences in core area size (according to 50% kernel) (Kruskal-Wallis test: $H(3, N=40) = 5.228902, p=0.1558$) were observed, while there was seasonal differences in home-range size (according

to 95% kernel) (Kruskal-Wallis test: $H(3, N=40) = 9.258590, p=0.0260$), and in average distance of the daily flights between seasons (Kruskal-Wallis test: $H(3, N=40) = 19.44866, p=0.0002$).

The analysis showed that during the spring-summer half of the year, the griffon vultures travel about three times longer distances per day than in the other half (autumn-winter). One of the vultures K77, crossed significant distances during the winter of 2015, which increased the average score for this period of the year for all birds. In contrast, all other

vultures had larger areas of kernel 50 and 95% in the spring-summer season. Despite the huge distances that K77 flew in the winter, as with other birds, its daily distances are much larger in the spring-summer season.

Nocturnal roosting places

The vultures used multiple nocturnal roosting places (Fig 3.), the most commonly used were on average seven for a bird (7 ± 5 , range 2–15). In the Kresna Gorge, there is only one vulture feeding site and the average distance in a straight line to most used roosting places is 2.6 ± 2.2 km (range 0.9–6.1 km).

Discussion

This study provides a first preliminary insight of the territory use of the reintroduced and native to Balkans immature griffon vulture in four vulture areas (Kresna Gorge, Vrachanski Balkan, Eastern Rhodopes and Kotlenska Planina-Sinite Kamani) in Bulgaria with emphasis on Southwest Bulgaria with centre the Kresna Gorge. The northern part of the Kresna Gorge, where the vulture feeding site is found, together with the nearby cliffs and 400 kV pylons is the core zone of the newly established colony in the area. Flights of the soaring birds are becoming easier in warmer months and the griffon vultures move to Pirin National Park, Rila National Park and to lesser extent Maleshevska Mts. and FYR of Macedonia, and sometimes make large-distant and short-time excursions of 190.9 ± 75.1 (range 95–312.2) km a day. However, roosting is rarely happening outside the usual few sites, and feeding outside the vulture restaurant in the Gorge or any other such specialized site in Bulgaria, FYROM and Greece was rare. Exception is the sojourn of the entire colony of griffon vultures from Kresna Gorge in the treeless zone of Pirin National Park, where each summer, together with summering guest birds from other colonies are feeding on carcasses of free ranging cattle.

For more remote flights, the vultures used the mountains' ridges in the area, as well as the high hills. They clearly avoided the lowland intensively cultivated areas in the Struma Valley, and elsewhere in Bulgaria, Greece and FYR of Macedonia, which was also observed for the Black Vultures in Dadia National Park in Greece (VASILAKIS et al. 2005). Probably the absence of thermal lifts affects negatively the selection of these areas for foraging, along with the intensive human presence.

Seasonal movement data showed that the flight length is greater in summer and spring and much smaller in winter, this is related to the shorter length

of the day and the worse conditions for flying, and the concentration of even non-breeding vultures around breeding pairs that begin to prepare for the following season.

Each core area (50% kernel), for all tracked birds, encompasses the vulture restaurant and all the most commonly used roosting sites and the radius of 15 km around them. The distance of 14–15 km around the main colony as the most used is mentioned in a number of other studies (GARCÍA-RIPOLES 2011, GIL et al. 2009, XIROUCHAKIS & ANDREOU 2009).

Compared to the study in Spain, our results match the overall median foraging range, calculated as MCP (7,419 km²). Median daily distances ranged around 3 to 40 km in both studies. For the 95% and 50% kernel contours, medians are smaller in Bulgaria. This might be attributed to feeding sites network density, which is bigger in Teruel and Castellón Provinces in Spain – average distance among them of 71.53 km (n=16), while in Bulgaria and the nearby Greece and FYR of Macedonia it is 192.7 ± 100.4 (range 9–407) km (n=10). The birds then concentrate their movements around them, which reduces the size of the kernels, although the distances that birds fly every day are the same in Spain and Bulgaria.

This gives us a proof that the national and pan Balkan network of vulture restaurants is playing an important role for Balkan native and reintroduced griffon vulture population. Furthermore, this greatly supports the concept of GROZDANOV et al. (2018) for the need of establishment of a network of Vulture Safe Areas (VSA), where in relatively small areas the full spectrum of threats for the species could be addressed and mitigated. In such areas through maintenance of permanent feeding sites, the vultures might be concentrated and kept in safe environment, while avoiding threats like poisoning and electrocution, which are: 1. acting on vast territory; 2. unpredictable in space and time; and 3. hardly controlled in short-term. The vultures will then move among them and keep staying in the VSAs, using them as safe stepping stones during their migrations and sojourn in across the Balkans.

Out of the known vulture restaurants in Bulgaria, FYR of Macedonia and Greece, the vultures rarely stayed overnight on-passage and never were feeding with exception of few places that should be given priority for application of urgent vulture conservation measures and to secure them as VSAs instead playing roles of ecological traps. These are Kaymakchalan Peak on the border between Greece and FYR of Macedonia; Pirin National Park in Bulgaria; the Valley of Krumovitsa River

and the hills to the west of it in Eastern Rhodopes in Bulgaria; the area between the Dadia National Park and Kompsatos River valley in Greece, with centre around the village of Esochi.

The lack of a much higher sample size, the limited duration of the transmitters' batteries and the lack of adult individuals constitute limitations preventing us from deeper analyses.

Ongoing research projects will grant complementary information about breeding individuals and inter-sexual and inter-age differences that will improve our understanding of the spatial ecology and behaviour of the griffon vulture in Bulgaria and Balkans.

Conclusions

We are now aware that effectively, a colony of griffon vultures could be protected by concentrating conservation efforts in an area 15 km radius of a vulture restaurant in complex with suitable roosting/breeding sites.

It seems that strategically placed and permanently supplied vulture restaurants, may concentrate large numbers of griffon vultures in a relatively small and able to control areas. This, in combination with implementation of site based conservation activities, may buffer the impact of any hardly controlled and acting on large scale threats, such as poisoning and electrocution.

The natural instinct of the griffon vultures to travel long distances is not necessarily related with taking food outside their well known areas. This conservatism together with the gregariousness of the species may be used for its conservation. The only serious problem for this approach appears, when the deadly threat (poisoning, electrocution, direct persecution etc.) appears in the core of the presumed Vulture Safe Area – thus turning it into a deadly ecological trap. This increases the level of responsibility of the managers of any VSA. However, the sole role of each such area may be reduced if their number and density is increased and the vultures have more such sites to move along and sojourn.

Ethics Statement: The study was not specifically approved by an ethical committee as a permit for equipping vultures with loggers was provided as part of the license of team members of the NGO Fund for Wild Flora and Fauna (FWFF), according to the Ministry of Environment and Waters applying the Bulgarian Biodiversity Law for allowing the owners of a licence to capture and handle birds of protected species and mark them (with rings or any other device like GPS units).

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References

- BAHAT O., HATZOFFE O., KAPLAN A. & WOODLEY B. 2001. Foraging range and movements of Griffon vultures (*Gyps fulvus*) in Israel, as determined by satellite tracking. Proceedings of the 4th Eurasian Congress on Raptors. Doñana Biological Station, Raptor Research Foundation, Seville, pp. 11–12.
- BAHAT O., KAPLAN A., BAIDATZ Y., KAPLAN L., CHOSHNIK I. & HOUSTON D. 1993. Radio-tracking a juvenile Griffon Vulture (*Gyps fulvus*) in the north of Israel. Preliminary results. Israel Journal of Zoology 39: 47–77.
- CALENGE C. 2006. The package adehabitat for the R software: a tool for the analysis of space and habitat use by animals. Ecological Modelling 197: 516–519.
- CRAMP S. & SIMMONS K. (eds.). 1980. The Birds of the Western Palearctic. Vol. 2. Oxford – London – New York: Oxford University Press. 695 p.
- DEMERDZHIEV D., HRISTOV H., DOBREV D., ANGELOV I. & KURTEV M. 2014. Long-term Population Status, Breeding Parameters and Limiting Factors of the Griffon Vulture (*Gyps fulvus* Hablizl, 1783) Population in the Eastern Rhodopes, Bulgaria. Acta Zoologica Bulgarica 66 (3): 373–384
- DEMERDZHIEV D., STOYNOV E., KURTEV M. & YANKOV P. 2007. Griffon Vulture (*Gyps fulvus*). – In: YANKOV P. (ed.). Atlas of Breeding Birds in Bulgaria. Bulgarian Society for the Protection of Birds, Conservation Series, Book 10. Sofia, BSPB, pp. 134–135.
- FIEBERG J. 2007. Kernel density estimators of home range: smoothing and the autocorrelation red herring. Ecology 88: 1059–1066.
- FULLER M. R., MILLSAUGH J. J., CHURCH K. E. & KENWARD R. E. 2005. Wildlife radiotelemetry. In: BRAUN C. E. (Ed.): Techniques for wildlife investigations and management, pp. 377–417. The Wildlife Society, Bethesda, USA.
- GARCÍA-RIPOLLÉS C., LÓPEZ-LÓPEZ P., & URIOS V. 2011. Ranging behaviour of non-breeding Eurasian Griffon Vultures *Gyps fulvus*: a GPS-telemetry study. Acta Ornithologica 46: 127–134.
- GIL J. A., LAGARES J. L. & ALCÁNTARA M. 2009. Radio-telemetry of the Eurasian Griffon Vulture (*Gyps fulvus*) in the Eastern Iberico System (Aragón – Spain). Teruel 92: 137–164.
- GRIESINGER J. 1998. Juvenile dispersion and migration among Griffon Vultures *Gyps fulvus* in Spain. In: CHANCELLOR R. D., MEYBURG B.-U. & FERRERO J. J. (Eds): Holarctic Birds of Prey. ADENEX-WWGBP, pp. 613–621.
- ELOSEGUI J. & ELOSEGUI R. 1977. Displacements of Pyrenean Eurasian Griffon Vultures (*Gyps fulvus*). Munibe 1–2: 97–104.
- KOCHERT M. N., STEENHOF K. & MORITSCH M. Q. 1983. Evaluation of patagial markers for raptors and ravens. Wildlife Society Bulletin 11: 271–281.
- KOSTADINOVA & GRAMATIKOV (eds.) 2007. Important Bird Areas in Bulgaria and Natura 2000. Bulgarian Society for the Protection of Birds, Conservation Series, Book 11. Sofia, BSPB.
- MAECHLER M., ROUSSEUW P., STRUYF A., HUBERT M. & HORNIK K. 2013. Cluster: Cluster Analysis Basics and Extensions. R Package, Version 3.4.0.

- MICHEV T., POMAKOV V., STEFANOV V. & YANKOV P. 1980. Colony of the Griffon vultures (*Gyps fulvus*) in Eastern Rhodops. *Ekologiya* (Sofia) 6: 74-79. (In Bulgarian).
- NESBITT S. A. 1979. An evaluation of four wildlife marking materials. *Bird-Banding* 50: 159.
- PESHEV H., STOYNOV E., GROZDANOV A. & VANGELOVA N. 2015. Re-introduction of Griffon Vulture (*Gyps fulvus*) in Kresna Gorge, South-west Bulgaria. *Fund for Wild Flora and Fauna, Conservation Series – Book 3*. Blagoevgrad.
- PESHEV H., STOYNOV E., VANGELOVA N. & GROZDANOV A. 2017. Re-introduction of Griffon Vulture *Gyps fulvus* in Kresna Gorge of Struma River, Bulgaria, Annual Report 2016, Fund for Wild Flora and Fauna, Blagoevgrad.
- QGIS D., QGIS GEOGRAPHIC INFORMATION SYSTEM. Open source geospatial Foundation project. 2015.
- QGIS DEVELOPMENT TEAM, 2009. QGIS Geographic Information System. Open Source Geospatial Foundation. URL <http://qgis.osgeo.org>
- STEINIGER S. & HUNTER A. J. S. 2012. OPENJUMP HORAE—A free GIS and toolbox for home-range analysis. *Wildlife Society Bulletin*, 36: 600 – 608. doi: 10.1002/wsb.168
- THE JUMP PILOT PROJECT. 2008. OPENJUMP GIS - The free and open source Java-based desktop GIS. Available from <http://www.openjump.org/>. (Accessed January 2009)
- VASILAKIS D., POIRAZIDIS K. & ELORRIAGA J. 2005. Breeding season range use of a Eurasian Black Vulture *Aegyptius monachus* population in Dadia National park and adjacent areas, Thrace, NE Greece. In: HOUSTON D.C. & PIPER S.E. (Eds): *Proceedings of the International Conference on Conservation and management of Vulture Populations*. 14-16 November 2005, Thessaloniki, Greece. Natural History Museum of Crete & WWF Greece. p. 176.
- WORTON B. J. 1989. Kernel methods for estimating the utilization distribution in home-range studies. *Ecology* 70: 164 – 168.
- XIROUCHAKIS S. M., ANDREOU G. 2009. Foraging behaviour and flight characteristics of Eurasian griffons *Gyps fulvus* in the island of Crete, Greece. *Wildlife Biology* 15: 37–52.
- YANKOV P. & PROFIROV L. 1991. Contemporary state of the Griffon Vulture (*Gyps fulvus* Hablizl) population in Bulgaria. *BAS. Sofia, Bulgaria. Ekologiya* (Sofia) 24: 44-52. (In Bulgarian).

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