Terrestrial Ecology and Behaviour
Research Article

ACTA ZOOLOGICA BULGARICA
Acta zool. bulg., 66 (3), 2014: 373-384

Long-term Population Status, Breeding Parameters and Limiting Factors of the Griffon Vulture (*Gyps fulvus* Hablizl, 1783) Population in the Eastern Rhodopes, Bulgaria

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Abstract: The Griffon Vulture in Bulgaria declined during the first half of the 20th century, from widespread and abundant to localised and very rare. In the 1970s the species was on the brink of extinction, represented by probably few scattered pairs in northeastern Bulgaria and less than 10 pairs in the south of Bulgaria, where one population, common to Bulgaria and Greece, survived in the Eastern Rhodope Mountains. Here we report the results of a 25-year long survey (1987-2011), which documents the steady increase in the population from 10 pairs distributed in 2 colonies, to 56 pairs in 7 colonies. During the study period, 450 juveniles fledged from totally 646 occupied nests, with mean breeding success of 0.77±0.14 and mean productivity of 0.71±0.16, indicating average values for Europe. The main limiting factor is the mortality after consumption of illegally set poisoned baits, targeted against carnivores, followed by shooting, collision and exhaustion. The human-wildlife conflict in large areas and the increasing illegal use of poison baits in Greece are extremely hard to handle with. As a main conservation action for managing the Griffon Vultures we recommend the implementation of large-scale diverse public awareness campaign targeted at schools, kindergartens, governmental institutions, stock breeders, hunters and local communities.

Key words: Population status, breeding, limiting factors, Griffon Vulture, Bulgaria

Introduction

The *Gyps* vultures represent a scavenger guild composed of 8 species distributed in the Old World and specialised in feeding exclusively on carcasses of medium and large-sized mammals (Johnson *et al.* 2006). Of them, only the Griffon Vulture (*Gyps fulvus* Hablizl, 1783) is breeding in Europe (but also in Asia and until recently in North Africa). Its distribution in Europe, which in the past stretched north up to Germany and Poland, is currently restricted to the Mediterranean, with a population of more than 25 000 pairs (>95% of which in Spain), where it breeds in the Iberian Peninsula, the south of France, the Alps, the Apeninnes, the Balkans, Crimea and Caucasus (Cramp, Simmons 1980, Ferguson-Lees, Christie 2001).

In the Balkans, the Griffon Vulture was widely distributed and breeding in all countries across the peninsula in the 19th century (Cramp, Simmons 1980). In Bulgaria, until the first quarter of the 20th century, the species had a wide distribution throughout the country, being reported as numerous in many areas (Reiser 1894). It was recorded as breeding in most large mountain ranges, namely Stara Planina (throughout), Rila, Pirin, Vitosha, and the Rhodopes, as well as the Provadiya-Royak plateau, but also in the lowlands and on cliffs at the Black Sea coast (*e.g.* Cape Kaliakra) and along the Danube River (Demerdzhiev *et al.* 2007, Stoyanov 2010). At that time probably more than 1000 pairs bred in Bulgaria.

For only about several decades after the end of the 19th century, the Griffon Vulture in Bulgaria changed its status from widespread and abundant to very rare (Patev 1950, Demerdzhiev *et al*. 2007). The first large decline probably occured in the years of the First World War, when, as suggested, the decrease in the vulture populations was due to frequent shooting by soldiers (Boetticher 1927, Stoyanov 2010). Subsequently, during 1950s and 1960s, a massive campaign to exterminate the then called „pest" carnivores, mainly wolves and foxes, by use of poisoned baits, was conducted at national level, which resulted in the complete population crash of the Griffon Vulture as a breeding species in the country (Nankinov 1981, Stoyanov 2010). In effect, in the 1950s the species was reported as very rare (Patev 1950, Bijleveld 1974), while during the 1960s, the last known breeding colonies at that time, at Nevsha, Liuliakovo and Kotel, were lost, and the species was considered extinct as a breeder (Robel *et al.* 1972, Baumgart 1974, Hudson 1975).

However, there were records of some isolated pairs in areas very rarely visited by ornithologists, such as the Kotlenska Mountain (part of the East Stara Planina Mountains). At that location one pair was recorded breeding in 1971 (Donchev 1974). In Ludogorie (northeastern Bulgaria), a non-breeding pair was observed around a nesting cliff as late as 1983 (Spiridonov 1988), which is the latest report on a recorded pair in Northern Bulgaria.

In 1978, the species was rediscovered as a breeder in the Eastern Rhodopes, when an occupied nest was found, and a total of 29 vultures was observed (Michev *et al.* 1980). At that time, at least 8-11 pairs were reported from the Greek part of the mountain (Skartsi *et al*. 2009). In 1979 two nests were recorded on the same cliff, while in 1980 a nest with a juvenile about 20 km west of that location was registered (Yankov 1981). During 1980–1987 breeding on minimum 5 different cliffs along the Arda River (between Kardzhali and Madzharovo) was documented, but no systematic monitoring was undertaken (Yankov, Profirov 1991, Hristov 1997, Profirov, Niagolov 1984). The aim of the current publication is to present and analyse the distribution, population development, breeding performance and limiting factors for the native Griffon Vulture population in Bulgaria in the period 1987-2011.

Material and Methods

Study area and field survey methods

The Griffon Vulture breeding population was monitored annually for a period of 25 years between 1987 and 2011 in the Eastern Rhodope Mountains, Bulgaria. This low mountain area is characterised by a big diversity of habitats and a human population with a low density, mainly occupied in agriculture and livestock breeding. The area holds the highest diversity of breeding raptors in Bulgaria (23 species) and is inhabited by a total number of 171 breeding bird species (Stoychev *et al*. 2004a). All of the discovered griffon nests were located on cliffs along the Arda River and its tributaries between the villages of Zvezdelina and Borislavtsi. All suitable cliffs in the area were surveyed for occupied nests.

Within the study area (Fig. 1), the bulk of the survey work was carried out in two main areas: 1) the region of Madzharovo town (41°38'N 25°51'E) and 2) the Studen Kladenets Reservoir and its surroundings (41°37'N 25°32'E). More distant cliffs (located up to 6 km south of the Arda River), which offered suitable nest sites or were occupied at least once during the study period, were also annually checked. Occasionally before 2003, or regularly as part of the study on Egyptian Vulture (*Neophron percnopterus* Linnaeus, 1758), which started afterwards, dozens of other (mostly smaller) cliffs were checked in the rest of the Eastern Rhodopes.

The monitoring was implemented each year during January – August, with at least three visits to every cliff. The first visit was conducted between the 10th February and 20th March to record the number of incubating pairs and pairs that were not started breeding. The second visit took place during the period 15th April – 5th May in order to check the number of new pairs that had started breeding and to record new pairs that were missed, as well as to establish the number of pairs failed during incubation or after hatching. The third visit was implemented in June for recording the number of juveniles in nests before fledging and the new pairs that had failed. After 2003, a fourth visit was implemented in July – early August to establish the final number of fledged juveniles. We used almost exclusively the method of observation from an elevated viewpoint (Bibby *et al.* 1999). All observations were made on rainless days with good visibility at distance of 300 to 800 meters from the particular cliff in order to avoid disturbance. Viewing scopes with a magnification of 20 x and 20-60 x were used for the observation.

In accordance with some other surveys (Sarrazin *et al*. 1996, del Moral, Marti 2001, Lopez-Lopez *et al*. 2004, del Moral 2009), a cliff was considered as a Griffon Vulture colony when it was occupied by at least two pairs, at a distance of at least one kilometer from the neighboring occupied cliff. The pairs that occupy nests situated at a distance of more than 1 km from a neighboring pair or colony were considered isolated pairs.

For every nest a record of its location, the position and type of the nest substrate (niche or ledge) was noted. Other parameters recorded were: 1. number of occupied nests (all nests occupied by breeding and non-breeding pairs); 2. number of breeding pairs (pairs that were observed incubating); 3. breeding success (fledged juveniles per incubating pairs); 4. productivity (fledged juveniles per occupied nest); and 5. hatching success (hatchlings per incubating pair). The criteria for counting non-breeding pairs (pairs that did not lay eggs) was observing that both birds in the pair were attached to a particular niche/ledge of the cliff suitable for breeding, where nest may or may not be present, and engaged in at least two of the following behaviour types: courtship flights, mutual preening, copulation, nest building, and defence of the immediate vicinity of the chosen nest site from conspecifics. A juvenile was considered fledgling if it was aged at least 125 days old (Cramp, Simmons 1980). During 2004-2011, when it was possible, the age of the birds in the pairs was recorded according to Blanco *et al*. (1997).

Supplementary feeding with domestic livestock carcasses and offal from slaughter houses was implemented mainly at four feeding stations in the Bulgarian and Greek part of the Eastern Rhodopes, namely Madzharovo, Studen Kladenets, Pelevun (Bulgaria) and Dadia (Greece).

Statisitcal analyses

The pairs were divided into three categories according to their age structure: 1) adult pairs – consisting of two birds in adult plumage; 2) mixed pairs – one of the birds is an adult, the other an immature; 3) immature – both birds are in immature plumage. During the statistical analyses to test the relationship between the breeding success and age of the pair, group 2 and 3 were merged together and compared with group 1.

Statistical analyses were implemented with the program „Statistica for Windows, Release 7.0" (StatSoft Inc. 2004).

The data were analysed for normality of the distribution using the Shapiro-Wilk test (Shapiro *et al*. 1968). This test calculates the value of the statistics W, with null hypothesis HO assuming normality of the data distribution. For meaningful values of W ($p < 0.05$), HO is rejected and to prove normality of distribution, the value of W must not be significant ($p > 0.05$). When the data were not normally distributed, they were transformed by the function log (x+1) (Fowler, Cohen 1992). Results with $p < 0.05$ [$\alpha = 5\%$] were considered significant.

One-way ANOVA analysis was used to test the statistical validity of the differences in the productivity, hatching success and breeding success in both age groups. To identify differences in the breeding performance according to different nest substrates Friedman ANOVA, Kendall Coefficient of Concordance and Mann-Whitney U Test were used.

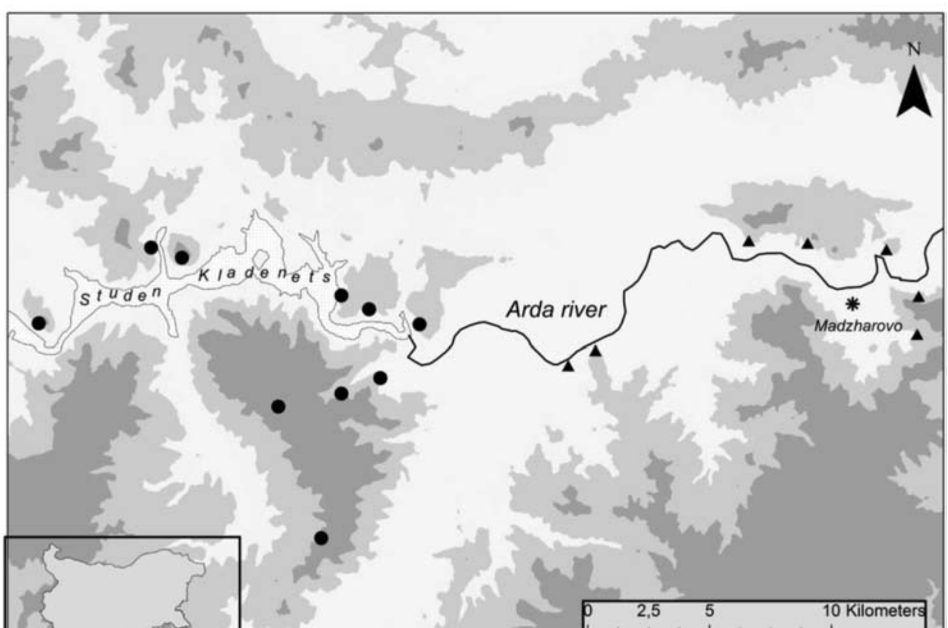

Fig. 1. Distribution of breeding cliffs used by Griffon Vultures in the Eastern Rhodopes (● Studen Kladents breeding cliffs; ▲ Madzharovo breeding cliffs)

Results

Population development

From 1987 to 2011 the Griffon Vulture breeding population in the Eastern Rhodopes increased from 10 to 56 pairs and expanded its breeding range (Fig. 2).

During the mentioned period there were two notable declines, the first from 1988 to 1991, when the population that bred only in Madzharovo area dropped from 18 to 10 pairs. The second, in 1996-1998, resulted in a smaller population decline – from 18 to 14 pairs. The population was more or less stable for 9 years during 1998-2006, while a big steady increase occured for 6 years after 2006, when the pairs almost doubled – from 30 to 56.

During 1988-1992, the Griffon Vulture breeding range was confined only to the region of Madzharovo. The breeding range expanded westwards when one pair (in 1993) and two pairs (in 1994) were found breeding on a cliff in the area of Studen Kladenets Reservoir, at a distance of 22 km west of the nearest breeding cliffs in Madzharovo (Hristov 1997, 2003). In the next two years breeding was not registered, but in 1997-1998 three pairs bred each year, while from 1999 a steady increase in the breeding pairs started in the area of Studen Kladenets Reservoir, reaching a maximum of 32 pairs in 2011. From a total of 17 breeding cliffs used by the Griffon Vultures in the study period, four were regularly used in the first 5 years of the study period, while 15 cliffs were used during the last five years.

Nest site

In the Eastern Rhodopes the Griffon Vultures were always recorded breeding on big cliffs along the Arda River valley (> 50 m high and > 100 m long), where the highest density of large cliff formations in the mountain is concentrated. Since 2009, with the big increase of the population, the vultures started occupying nests on smaller and lower edge parts of the main cliff complexes (single cliffs up to 30 meters high and wide) (n=4), with one of the nests only at about 25-30 m above an asphalt road. The number of colonies and isolated pairs increased during the study period. The position of the nests showed that those in the south, southwest, and west were most preferred.

Breeding performance

During 1987-2011, 646 occupied territories were registered and a total of 450 juveniles fledged. The mean breeding success for the period 1987-2011 was 0.77 ± 0.14, while the mean productivity was 0.71 ± 0.16 (Fig. 3). The highest breeding success and productivity (n = 1) was established in 1987 while the lowest breeding success/productivity (n = 0.33) were registered in 1988.

The breeding performance of the Griffon Vultures in Madzharovo and in the area of Studen Kladenets Reservoir did not differ significantly ($F = 0.14$, $p = 0.72$), (Fig. 4). The mean productivity of the vultures from Studen Kladenets (0.67 ± 0.14) was slightly higher than in Madzharovo (0.62 ± 0.21). Similarly, the mean breeding success at Studen Kladenets (0.84 ± 0.12) was also slightly higher than

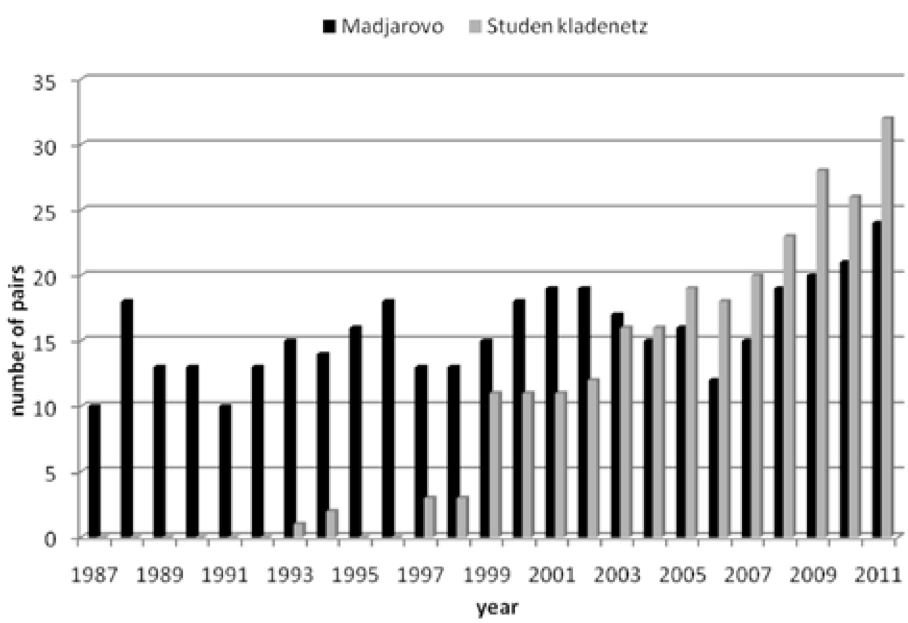

Fig. 2. Comparison between the population dynamics of the Griffon vulture breeding groups in the areas of Madzharovo and Studen Kladenets Reservoir, during 1987-2011

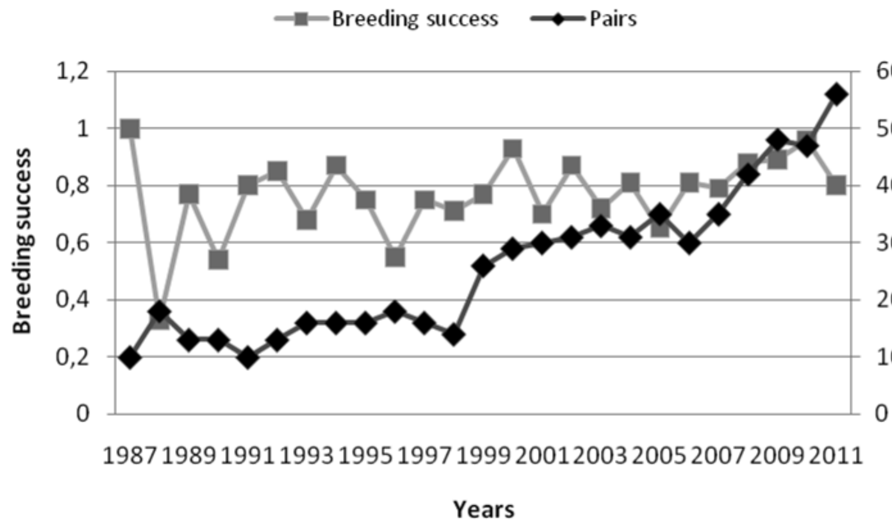

Fig. 3. Trend in the breeding population number and breeding success of Griffon vultures in the Eastern Rhodopes during 1987-2011

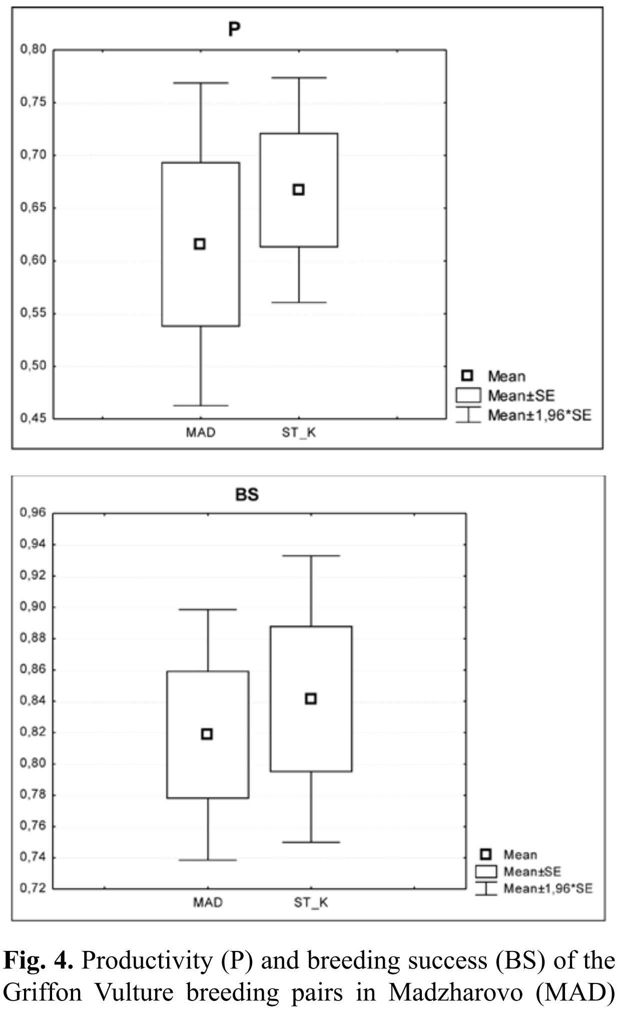

Fig. 4. Productivity (P) and breeding success (BS) of the Griffon Vulture breeding pairs in Madzharovo (MAD) and in the area of Studen Kladenets Reservoir (ST_K)

in Madzharovo (0.82±0.11), while the mean hatching success was the same in both groups (0.89±0.12).

The correlation between the breeding success and the age of the birds in the pair was measured

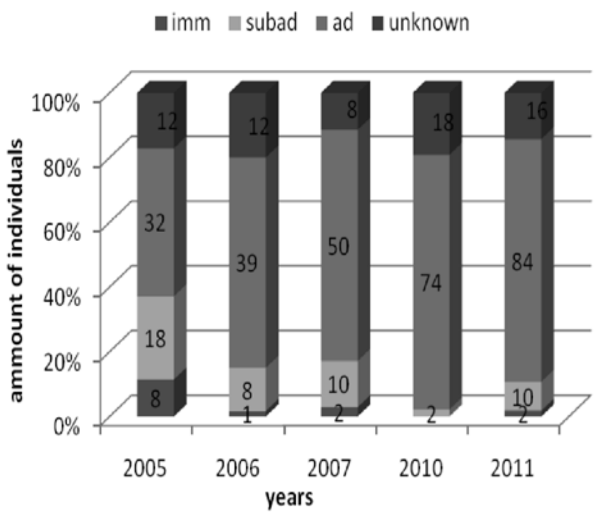

Fig. 5. Age structure of the breeding Griffon Vultures

in 93 pairs. The adult pairs had significantly higher breeding success compared with the pairs that had one or both partners in immature plumage ($Z = 1.97$, $p = 0.05$), with a mean breeding success of 0.78 ± 0.42 (n = 51) in the adult pairs and of 0.6 ± 0.5 in the second group (n = 42). The percentage of the adult birds in the breeding population increased significantly from 46% in 2005 to 75% in 2011 (Fig. 5).

The type of nesting substrate (niche or ledge) did not affect significantly the breeding success ($Z = 1.2$, $p = 0.13$; n = 93), but pairs breeding in niches had slightly higher breeding performance. Similarly, the nest exposition did not significantly affect the breeding success ($\chi^2 = 9.18$, $p = 0.16$).

The supplementary feeding to support the Griffon Vulture population intensified after 1987. The quantity of food provided yearly averaged 4-7 tones during 1987-1999 and increased to 10-15 tones

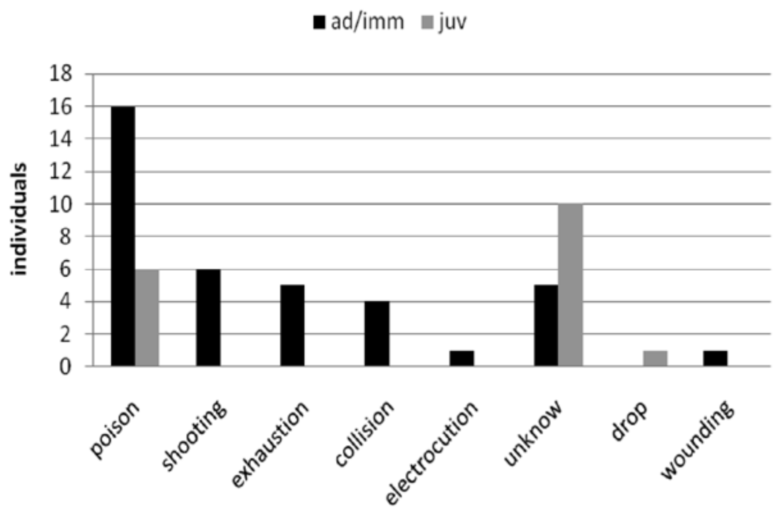

Fig. 6. Mortality of Griffon Vulture (n = 55) between 1979 and 2011

during 2000-2007, reaching a maximum of 30 tones during 2007-2010.

Mortality factors

During 1979-2011, mortality data was collected for 38 adult and immature Griffon Vultures (Fig. 6).

Almost half of the birds (42.1%, n = 16) died from poisoning, 15.79 % (n = 6) were shot, while the vultures that died from collision or electrocution and exhaustion had equal numbers, reaching totally 13.16 % (n = 5). In one case the reason for the death was injury, while 13.16% died from unknown causes. Additionally, data for the mortality of 17 juveniles in nests before the time of fledging was collected. Most of the juveniles, 58.82 % (n = 10), died from unknown reasons, while 35.29% (n = 6) were poisoned (Fig. 6).

Discussion

Population development

When in 1978 a breeding colony with at least 29 birds was discovered in the Eastern Rhodopes, it was suggested that the colony was new and had formed probably in the past 6-7 years (Michev *et al*. 1980). However, hardly any ornithological work was conducted in the region before 1978 and Demerdzhiev *et al*. (2007) suggested that the species might have never gone extinct as breeder from the Eastern Rhodopes, which is also supported by observations from local people (authors, unpubl. data).

The observations prior to 1987 might have underestimated the true size of the population and the large population increase afterwards may be partially the result of the increased survey effort. The frequency and dates of survey are crucial for the proper recording of all pairs, since the single counts of nesting vultures detect 30-80% of pairs, depending on the survey date (Martinez *et al*. 1997). Most probably in years prior to 1987, some pairs were not recorded because of the irregularity of the visits, incomplete coverage of the area, early low level of experience of the observers with the species, and the low quality of the equipment used for observations. Yankov, Profirov (1991) also suggested that breeding of isolated pairs could have occured occasionally in the area of Studen Kladenets Reservoir, but remained undocumented.

Breeding performance

The mean breeding success recorded in our survey (0.77) is above the average for Europe, being higher than that in Massif Central, France (reintroduced population) (0.57); Croatia (0.6); Macedonia (0.66); Spain (0.67); Northeast Portugal (0.69); French Alps (0.7); Crete island, Greece (0.74); and Cyprus (0.74) (Sarrazin *et al.* 1996, Grubač 1997, Pavokovič, Susič 2006, Terrasse 2006, van Beest *et al*. 2008, del Moral 2009, Xirouchakis 2010), but lower than that in Serbia (0.89) (Marincovič, Orlandič 1994). Breeding success, very simillar or the same as in Bulgaria, was registered in French Pyrenees (0.76), Spanish Pyrenees (0.77), and Sardinia (0.77) (Arroyo *et al*. 1990, Leconte, Som 1996, Aresu, Schenk 2005).

Breeding success in the group-living birds may be related to colony size (Hunt *et al*. 1986, Barbosa *et al*. 1997, Brunton 1997, 1999, Weaver, Brown 2005). In Griffon Vultures it was reported that colonies of intermediate size are doing comparatively better than larger or smaller ones (Leconte 1985, Arroyo *et al.* 1990). Similarly, Xirouchakis (2010) showed a density-dependent effect in smaller colonies, which have higher breeding success, compared with larger colonies. Our survey does not show a decline in the breeding success with the increase in the number of pairs, which may imply that the population has still not approached the saturation levels (Fernandez *et al.* 1998). However, in long-lived raptor populations, the term carrying capacity should be treated with caution, considering its variability according to fluctuations, mainly in the food availability and demographics.

The higher breeding success of the Griffon Vultures in the area of the Studen Kladenets Reservoir, compared with that at Madzharovo, may be attributed to the higher livestock densities in the region (Stoychev *et al.* 2004 b, 2005), which is also supported by the observations that the Griffon Vultres breeding in the region of the Studen Kladenets Reservoir almost never visit Madzharovo during the supplementary feedings, while very often the opposite happens (authors pers. obs.). The survey on the "human-carnivore" conflict in the Eastern Rhodopes found out that 92% (n = 144) of the wolf kills of livestock, which was also subsequently eaten by the vultures, were in the region of the Studen Kladenets Reservoir (Angelov *et al.* 2005).

Many species of large raptors, including Griffon Vultures, were recorded breeding as subadults (Newton 1979, Blanco, Martinez 1996). In our survey, during the period 2005-2011 the percentage of adult birds in the pairs increased significantly. In Spain Blanco *et al.* (1997) found that the percentage of adult birds that take part in the reproduction varies from 84% to 88%, and adult pairs (73%) prevail over the mixed pairs (23%), while Lopez-Lopez *et al.* (2004) recorded 61.6% of the birds to be adult. Breeding of the non-adults within the population is determined by two main factors: 1. Increased adult mortality enables younger birds to breed replacing dead adults (Balbontin *et al.* 2003, Ferrer 2001, Ferrer *et al.* 2003); and 2. Increased resource availability encourages non-adult breeders (Wyllie, Newton 1991, Brommer *et al.* 1998). In our survey we recorded a population decline during 2005-2006 (35 to 30 pairs), which suggests an increased mortality in that period. This might have resulted in the very high percentage of immatures in the breeding population, which subsequently decreased in parralel with the increased age of the birds and high survival. Unfortunately, we do not have data prior to 2005 and cannot confirm this hypothesis. We suppose that the subsequent very high population growth of 53.6% during 2006-2011 (from 30 to 56 pairs) may be the result, as suggested by Blanco *et al.* (1997), of the good feeding conditions and the increased immature and adult survival during the period, which enabled immatures to recruit in the population.

The age of partners in the territorial pairs affects significantly the breeding performance of the population (Forslund, Part 1995, Sanchez-Zapata *et al.* 2000). Immatures have lower breeding potential owing to their lower frequency to start breeding and tendency to produce smaller clutches and broods (Margalida *et al.* 2008). As expected, we found significantly lower breeding success in the mixed and immature pairs, compared with adult pairs.

In Griffon Vultures, nest site characteristics were shown to variably affect the breeding success (Fernandez *et al.* 1998, Lopez-Lopez *et al.* 2004). In our study we did not find significant relationship between the nest substrate (niche or ledge) and exposition, and the breeding performance. Donazar (1993) argued that there was generally no preference for a specific nest orientation by Griffon Vultures and that patterns observed were likely dictated by the mountain range orientation. Probably, the large size of Griffon Vultures protects them against adverse weather conditions (Fernandez *et al.* 1998), which in the study area is characterised by a relatively mild winter. At the end of the study period, a few pairs started occupying low and smaller cliffs for breeding, which may be considered as a sign of an increasingly healthy population.

Limiting factors

In species with extreme K-selected life history strategies, adult mortality may have significant consequences because population stability demands high adult survival rates (Meretsky *et al.* 2000). In all European countries, the massive campaign for eradication of the then called „pest" wild carnivores occured till the 1970-1980s and had a devastating effect on scavenging raptors, particularly due to the widespread use of poisoned baits (Bijleveld 1974). This occurred in Bulgaria most intensively in the 1950s and 1960s, bringing the Griffon Vulture to the brink of extinction (Yankov, Profirov 1991, Stoyanov 2010). In neighboring countries, during these years the poisoning severely reduced and, in some countries, lead the Griffon Vulture population to extinction (Handrinos 1985, Marinkovic *et al.* 1985, Simic 2000). In the following decades, the poisoning was continuously reported as the main mortality factor threatening the Griffon Vulture populations across Europe and the Mediterranean (Tewes 2002, Slotta-Bachmayr *et al.* 2004). Similarly, in Bulgaria, in spite of prohibiting the use of poisoned baits in the late 1960s, this remained the main threat and during the study period, we found the poisoning as the main mortality factor for the species in the Eastern Rhodopes. The highest recorded mortality because of poisoning occurred in 1996 when 5 adult, 1 subadult and 5 juveniles were found dead (Hristov 1997). In Greece, the two main decreases that had ocurred before 2002, were in the 1980s and after 1994, which most likely resulted in more than a 50% loss of the population, while the species decline coincided with the reappearance of the wolf (Tewes 2002, Xirouchakis, Tsiakiris 2009).

Survival along the migration flyway and in wintering areas may significantly affect the populations of long-lived birds (Newton 2008). In September-October is the bulk of the juveniles and second-calendar Griffon Vultures fledged in the Eastern Rhodopes. They leave the natal area and migrate southeast, presumably through the Bosphorus and Dardanelles, and return in February-April (authors, pers. obs.). The current level of knowledge based on the wing-tagged and ringed birds, points Israel as an important part of the wintering range, where 14 birds tagged on the Balkans (3 of them from the Eastern Rhodopes) were observed during winter (O. Hatzofe *in litt*.). However, in the rest of the Middle East, migrant Griffon Vultures are known to winter, augmenting the local populations, *e.g.* in Southern Turkey and Saudi Arabia (Vaassen 2001, Jennings 2010). However, it is unknown to what extent the birds from the Eastern Rhodopes winter there. Because of poisoning, a severe decline in the Griffon Vulture population in Taurus region of South Turkey was reported to have occurred during 1996-1998 (Vaassen 2001), while in Israel the population halved in only five years during the 1990s (Shirihai 1996). Many regions in the Middle East countries were considered dangerous for the large birds of prey due to very high incidence of shooting at raptors, but recently positive trends were observed (Tucker, Goriup 2005). We suggest that the lack of increase in the Eastern Rhodopean population during the 1990s may partially be result of the worsening conditions along the migratory pathway and in the wintering grounds in Israel, Turkey, and possibly their neighboring countries.

Secondary reasons for mortality are: the shooting, electrocution, collision, and starvation. In Bulgaria shooting was a major factor contributing to the population decline most notably in the first half of the 20th century (Stoyanov 2010). According to our knowledge, the last Griffon Vulture to be lethally shot was in 1990 (Yankov, Profirov 1991). Subsequently, shooting showed a tendency to decline, probably as a result of the legal protection in place since the 1970s.

All electrocuted birds and birds killed by collision were found in the vicinity of medium and high-voltage power lines (110, 220 kV). In large raptors, electrocution may be concentrated in hotspot areas (Angelov *et al*. 2012) and in some cases may cause up to 5 % mortality, in particular to the Griffon Vulture populations (Hatzofe 2010). Research for the finding of dead birds under power lines has never been conducted in the Eastern Rhodopes and mortality due to electrocution is probably underrepresented. Some commonly used pole constructions of the 20 kV power lines in Bulgaria are particularly hazardous for the birds, with raptors being the most common victims (Stoychev, Karafeizov 2004, Demerdzhiev *et al*. 2009). However, the wild Griffon Vultures in the Eastern Rhodopes do not have the habit for perching on power lines, since they have been very rarely observed doing this (authors, pers. obs.).

The victims of exhaustion due to various factors are mainly young birds. The causes are different: inexperience, prolonged bad climatic conditions or trauma. This may lead to a stay in areas outside of the breeding range of the species and being unable to find conspecifics and (or) becoming unable to find natural food, which may result into starvation. The cases in which the cause of mortality was not found involve mainly juveniles that died in the nests before fledging and birds that were found in a state of decomposition which had not allowed implementation of further post mortem analyses.

The Griffon Vulture is a species highly vulnerable to collision with wind turbines (Barrios, Rodriguez 2004, 2007, Lucas *et al*. 2008, Carrete *et al*. 2012). There are no wind turbines in operation in the Eastern Rhodopes (though there are ongoing investment proposals); however, the existing wind turbines (more than 800 in 2012) in the Greek part of the mountain were proven to cause mortality among Griffon Vultures (Carcamo *et al*. 2009, 2011). The proliferation of the wind energy industry and its cumulative effect on given populations by causing even only a small increase in mortality, when combined with other threats, may significantly shorten the time to extinction. In accordance with the recent findings showing that the high susceptibility of *Gyps* sp. vultures to wind farms collisions is related to their specific flight behavior and physiological factors in the birds' vision, we also suggest that wind farms should be kept apart from the vulture breeding areas. This measure should be a priority line, especially in cases of isolated subpopulations with low or decreasing numbers of breeding pairs (Barrios, Rodriguez 2004, Martin *et al*. 2012).

Conservation implications

The Griffon Vulture colonies in the Bulgarian and

Greek part of the mountain are very closely related and interdependent (Skartsi *et al*. 2009). This is not surprising, since *Gyps* sp. vultures are known as being able to travel up to 150 km daily in order to forage successfully (Houston 1976, Pennycuick 1983, Bahat, Kaplan 1995). During a large part of the year the area of Dadia holds a congregation of tens of mostly non-breeding immatures, increasing during autumn and winter, with maximum of 112 birds counted in autumn 2002 (Skartsi *et al*. 2009).They feed mostly at the feeding station there and originate from all the colonies in the Eastern Rhodopes in Bulgaria and Greece (authors, unpubl. data). Another area, which is very important for non-breeding Griffon Vultures is the valley of the Kompsatos (64 km west-northwest from Kirki and 51 km south-southwest from the Studen Kladenets Reservoir), where the vultures are constantly present and up to 30 birds have been observed. In March 2012 the biggest Griffon Vulture colony in mainland Greece (17-20 pairs in 2007 and 11 pairs in 2011), located at the Nestos gorge (Azmanis *et al*. 2009), in the Greek part of the Western Rhodopes, was completely extirpated or abandoned by the birds after a major illegal poisoning incident targeted at wolves (L. Sidiropoulos *in litt.*). Griffon Vulture colonies are known to be able, in some specific cases, such as disturbance or sharp decline in the food availability, to move completely from the breeding cliff at up to tens of kilometers away in the next breeding season (Shirihai 1996). One such case was the reappearance of the Griffon Vulture as a breeder in Dadia in 1989 (3 pairs started breeding), after more than 10 years of absence, which coincided with the decline in the colonies at Madzharovo from 18 to 13 pairs and the lowest breeding success ever recorded of 0.33 in the previous year. The subsequent disappearance of the colony in Dadia in 1995 might have been connected with the presence of the new colony of Griffon Vultures that was discovered in the area of Studen Kladenets Reservoir in 1998, approximately 75 km away (Hristov 2003, Skartsi *et al*. 2009). Similarly, the new colonisation of the colony in Dadia in 2007 was preceded by a population decline in Bulgaria.

At present the nearest breeding site to the colonies in the Eastern Rhodopes (the Bulgarian and Greek part), is at a distance of 270 km to the west, at Demir Kapija, Republic of Macedonia (M. Velevski *in litt*.). The observations of individually marked Griffon Vultures during the last three decades have shown that the Eastern Rhodopes in both countries serve as important stopover area for migrating, wintering and dispersing immatures from the Western Balkans, mainly Croatia, Serbia and Macedonia (Susic 2000), where the population size is about three times larger than that in the Eastern Rhodopes.

The use of poison baits against carnivores has long been identified as the main threat for many vulture populations across Europe (Bijleveld 1974, Tewes *et al*. 2004). Elsewhere in Europe, strengthening of the regulation and control of poisonous pesticides on the market (Noer, Secher 1990, Hernandez, Margalida 2008), together with implementation of public awareness campaigns, have already been recommended as measures to decrease the illegal use of poisons affecting vultures (Cortes-Avizanda *et al*. 2009). Success in decreasing this mortality factor seems to be highest in the areas, where conservationists have constant presence (*e.g.* vulture visitor centers) and live within the core breeding range of the vultures, communicating where they can on daily basis with local communities (authors, pers. obs.). Partial success in limited geographical areas has been achieved by strengthening of the regulations for selling of pesticides, involvement of the police and training of dogs to detect poisoned baits, or by compensation schemes. However, since these measures are dependent on political and economic factors, they are not sustainable and their eventual stop may cause high and uncontrolled proliferation of the poisoning. To our knowledge, nowhere persistent, long-term and methodologically sound community awareness work has been undertaken, covering the whole range of the given vulture subpopulation, falling within the "carnivore-human conflict" area. Importantly, it must be noted that the badly designed and implemented community awareness campaigns may have even a negative influence on the target species. The illegal use of poisons against carnivores and the continuing proliferation of wind farms construction are the two main negative factors currently affecting the Griffon Vulture in the Bulgarian and Greek parts of the Eastern Rhodopes as well as the Egyptian and Cinereous Vulture (*Aegypius monachus* Linnaeus, 1766). Taking into account the location of the colonies in the Bulgarian and Greek part of the mountain in the light of the ongoing steep decline of the population in Greece and the ecological features of the species, such as an extremely large home range and moving of colonies from one site to another at a distance of tens of kilometers (Shirihai 1996, Bahat *et al*. 2001), we suggest that the Eastern Rhodopean population of the Griffon Vulture in Bulgaria and Greece, to be considered as one distinct subpopulation and always treated as a whole unit in planning of future research and conservation activities.

Acknowledgments: The work during the study period was funded by the Bulgarian-Swiss Biodiversity Conservation Program, Fraknfurt Zoological Society, Black Vulture Conservation Foundation, DBU, European Association of Zoos and Aquaria, OPE. We would like to thank Nedko Nedyalkov, Stoycho Stoychev, Stefan Avramov, Volen Arkumarev, Vladimir Dobrev, Tsvetomira Yotsova, Nikolay Terziev, Mariana Valcheva, Vladimir Trifonov, Borislav Borisov, Sanie Mümün, Yordan Minchev, Krali Kralev, Georgi Gerdzhikov, Dimitar Plachiiski, Georgi Popgeorgiev, Atanas Demerdzhiev, Petar Yankov, Georgi Georgiev, Ivayla Klimentova, Emil Yordanov, Ivan Ivanov, Elena Bozhinova, Aleksandar Bozhinov, Svetlana Miteva, Milan Bakalov, and Albena Kurteva who took part in the field work. Without their assistance this survey would not be possible.

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Received: 04.06.2013
Accepted: 24.02.2014