THE DADIA–LEFKIMI–SOUFLI FOREST NATIONAL PARK, GREECE: BIODIVERSITY, MANAGEMENT AND CONSERVATION

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Population trends and conservation of vultures in the Dadia–Lefkimi–Soufli Forest National Park

Theodora Skartsi, Dimitris Vasilakis and Javier Elorriaga

Before 1970, all four vulture species of Europe nested in the Dadia–Lefkimi–Soufli Forest National Park (DNP), but the Bearded Vulture *Gypaetus barbatus* disappeared in that year. DNP is the sole nesting place of the Eurasian Black Vulture *Aegypius monachus* in Greece and the Balkans. Since 1970, Griffon Vultures *Gyps fulvus* have twice abandoned, and re-colonized, their nesting cliffs in DNP. Considerable numbers of Griffon Vultures concentrated in the DNP, especially during dispersal periods, even in years when they did not breed there. Individuals from other Balkan colonies were also seen there all year round. The Black Vulture and the Griffon Vulture are the main consumers of the supplementary food provided at a feeding station, a management measure that increased juvenile survival. Both the number of nesting pairs and maximum counts of Egyptian Vulture *Neophron percnopterus* at the feeding station have declined strongly after 1994 even though the number of occupied nesting territories has not changed dramatically. Seasonal restrictions on logging, strict protection of most nest sites, and minimisation of illegal hunting have no doubt all contributed to the conservation of the vulture populations, but more protection measures are needed to ensure their long-term survival.

Keywords: European vultures, population trends, supplementary feeding station, vulture conservation

Introduction

Animals appear to survive in the environments in which they live today only because these environments tend to be similar to those of the past (Begon et al. 2006) and because they meet their needs. Vultures, being specialized scavengers with a long lifespan, require vast areas of unspoiled habitat (Cramp and Simmons 1980, Heredia 1996). They feed on sparse, patchily distributed food resources and travel extensively during foraging (Maretsky and Snyder 1992). Nowadays, unspoiled habitats are becoming increasingly rare in Europe. As a result, vultures, once widespread across the continent, have undergone dramatic declines, which has led to their extinction in many regions. In the past, the Dadia–Lefkimi–Soufli Forest National Park (hereafter DNP) and the broader region of the eastern Rhodopi mountain range hosted all four European vulture species (Cramp and Simmons 1980), but currently only three of them occur there.

The above-mentioned region is situated in the south-eastern foothills of the Rhodopi massif and is shared between Greece and Bulgaria. The area consists of numerous primary and secondary ridges and hills, separated by wide longitudinal depressions and river valleys (Yordanova 2004). Geographical, historical, socio-economic and political factors have contributed significantly to its isolation. It is one of the most under populated and underdeveloped parts of Greece and Bulgaria. For centuries, the inhabitants have relied on extensive stock-raising practices for a living (Stoychev et al. 2004). Shepherds habitually burnt dense vegetation areas periodically and Pomac shepherds in particular pollarded oaks and stored the branches in piles ("mastirikia") up in the trees for food for their livestock during the winter (Varvounis 1997). These practices led to the formation of open woodland with meadows and scattered mature oak and beech trees. Combined with the area's relief, which consists of larger and smaller valleys and cliffs, such landscapes provide favourable soaring conditions for vultures and their detection of food (Stull 1988); they also provide suitable nesting sites. Similar land practices were applied in DNP until the 1970s when

the Forest Service implemented a systematic forest management for timber exploitation, trying to transform the forest from an open to a closed one. Fortunately, because of timely protection measures, landscape features such as mature forests and low infrastructure development have been maintained and with it the breeding populations of vultures.

Trends in Greek vulture populations

The four vulture species residing on the Balkan Peninsula have shown negative population trends over the last decades, in contrast to their recovery in south-western and central Europe. However, some local populations are stable or even show a slight increase, thanks to the intensive conservation efforts of international, national and local non-governmental organizations and institutions.

All four vulture species used to be abundant in Greece (Handrinos 1985). Throughout the 19th and by the turn of the 20th century, they were widely distributed all over the mainland and occurred on several of the islands. Compared with the situation today they were much more common (Handrinos and Akriotis 1997). At present, the Bearded Vulture *Gypaetus barbatus* is considered extinct on the Greek mainland, although single individuals have been seen occasionally in the Pindos and Pinovo Mountains and in DNP. Its main stronghold, as in the past, is Crete (Handrinos and Akriotis 1997), where conservationists from the Natural History Museum of Crete (NHMC) and the Hellenic Ornithological Society (HOS) have made joint efforts to safeguard its survival. The Griffon Vulture *Gyps fulvus* population has declined dramatically and it is estimated that more than half of its colonies on the mainland have disappeared (Bourdakis et al. 2004). However, in Crete due to the long-term traditional grazing activity and the low impact of poison use on the population (Xirouchakis et al. 2000) Griffon Vulture breeding populations have been maintained. Similarly, the Egyptian Vulture *Neophron percnopterus*, once common in certain areas, has experienced a large population decline (by 44–60%) and the population presently numbers no more than c. 100–140 breeding pairs (Bourdakis et al. 2006). This species appears to have a negative population trend globally – an annual decline rate of 35% was recently detected on the Indian subcontinent (Cuthbert et al. 2006), which holds around 50% of the global population (del Hoyo et al. 1994, BirdLife 2004). Following the recent dramatic decline in the world population of this species and after a suggestion by Cuthbert et al. (2006), its status in the IUCN Red List has been changed from "Vulnerable" to "Endangered" (http://www.iucnredlist.org).

Following a dramatic shrinkage of its Greek range and a concurrent decrease in numbers throughout the post-war decades, the Eurasian Black Vulture *Aegypius monachus* is now confined to the DNP. Detailed information on this species is presented in the next chapter of this volume.

Trends in the vulture populations of Dadia National Park

The vulture monitoring programme at the Dadia feeding station, run by local wardens from 1987 to 1993 and by the local WWF team during the last 14 years, has made it possible to follow the four vulture species' population development closely. It is assumed that the annual maximum counts of vultures at the feeding station provide good indices of their overall population sizes in the broader area around the park. However, this depends on the specific biological characteristics (territoriality, foraging behaviour, dispersal pattern, etc.) of each vulture species.

Bearded Vulture

In the past, at least two pairs of Bearded Vulture occurred in the Evros region. One pair nested on the cliff of Kapsalo at the edge of the strictly protected area but disappeared after the construction of the road leading to the top of this hill in 1971 (Adamakopoulos et al. 1995). The second pair nested outside the DNP on the top of the Sapka cliff at the border between the Rhodopi and Evros prefectures. One of this pair disappeared after the construction of the road leading to the top of the cliff in the 1970s. The other was still observed in the Sapka area until 1995–1996. This individual was last observed in DNP in winter 1995 when it was seen feeding at the vulture feeding station and also when mobbing a Black Vulture around Kapsalo. In 2002, a Bulgarian ornithologist observed an individual flying close to the Gibrena hill (M. Dimitrov, pers. comm.).

Griffon Vulture

During the 1960s, the population of Griffon Vultures outnumbered that of Black Vultures in the Evros region. The species nested on the Kapsalo cliffs until the

mid-1970s and in the southern part of the Evros prefecture until 1985 (Hallmann 1990, Adamakopoulos et al. 1995). In 1979, 8–11 breeding pairs were reported in the entire Evros prefecture. It was hypothesized that many Griffon Vultures moved to Bulgaria after 1985, following the establishment of artificial feeding programmes in the south-eastern part of the Bulgarian Rhodopi Mountains.

In 1989, the Griffon Vultures re-colonized the Kapsalo cliffs (Fig. 1) where they nested until 1995, when they inexplicably abandoned the area again. Their disappearance from Kapsalo might have been connected with the presence of a new Bulgarian colony discovered at Studen Kladenetz in 1998, approximately 75 km away (Stoynov 2001). During the period 1990–2007, Griffon Vultures were numerous in DNP and used the area for roosting and foraging. The largest concentrations were observed during autumn and winter at the Dadia feeding station. Immature birds occurred there throughout the year, while the numbers of adults and juveniles increased after the breeding season. The maximum number observed was 112 individuals in autumn 2003 (Fig. 1). In 2007, three pairs of Griffon Vultures again colonized the Kapsalo cliffs and bred successfully.

There has been an additional Griffon Vulture colony in the Evros prefecture, south of DNP, but there is no historical information about it. The staff of WWF Greece's Dadia Project have monitored it irregularly from 1994 and annually from 2003. It is a small colony consisting of 3–5 pairs, which nest on low cliffs in the forest lowlands of Kirki, 35 km from the Dadia feeding site.

Observations of marked Griffon Vultures, ringed in Dadia by the WWF team during 2003–2004, suggest

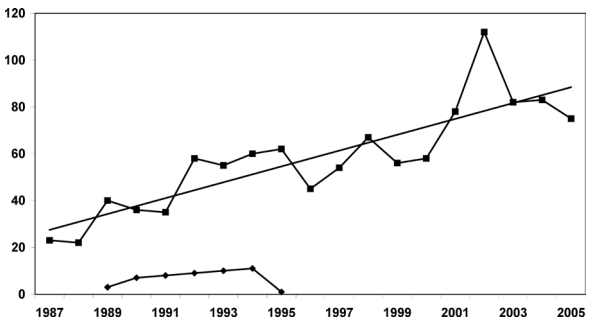

Fig. 1. Annual maximum number of Griffon Vultures visiting the Dadia feeding station (upper curve with regression line) and number of breeding pairs in DNP (lower curve) during 1987–2005. The increase in the number of Griffon Vultures at the feeding station is highly significant ($Y = -6700.44+3.39X$, $R^2 = 0.73$, $P < 0.001$).

that the Griffon Vulture populations of the Rhodopi Mountains (Greek and Bulgarian parts) are closely interconnected. Marked individuals have been observed breeding in the two Bulgarian colonies, Madjarovo and Studen Kladenetz, situated 69 km to the north and 79 km to the northwest of the Dadia feeding station, respectively. Together these colonies consisted of 35 breeding pairs (Stoychev et al. 2005). Marked individuals have also been observed in the Nestos Gorge colony 127 km west of the Dadia feeding station; this colony consists of 17 breeding pairs (Jerrentrup and Efthimiou 2006). Marked immature birds originating from these neighbouring colonies have been observed to feed at the Dadia feeding station on a regular basis and to roost in the colony at Kirki.

Observations of marked juvenile and immature birds from colonies further away, such as ones in Croatia and Serbia, are regular at Dadia throughout the year. According to the results of a programme of ringing nestlings carried out for more than ten years in Croatia, all juvenile birds leave their breeding areas at the end of August or in the first half of September along two main routes: NW to the Austrian and Italian alps and SE to the Balkans, Greece, Bosporus and the Middle East and, based on one observation, Africa (Susic 2000). The Griffon Vulture has been considered both as resident and a partial migrant (Cramp and Simmons 1980), but is, according to our studies and similar studies in Spain, definitely a "medium-distance" migrant (Criesinger 1996) or even a "long-distance" migrant (Susic 2000, Terrasse 2006). DNP is situated on the SE route and migrating birds benefit from the feeding site and other food sources in the area.

Erratic or nomadic movements of juvenile, immature and non-breeding adult birds also occur during spring and summer (Terrasse 2006). In addition to the above-mentioned movements of Griffon Vultures from the neighbouring colonies of Nestos, Kirki and Bulgaria, sporadic observations of immature birds from more distant colonies have been made in DNP from March to September. For example, in September 2005, a Griffon Vulture from France which was observed at the Dadia feeding station had returned to its place of origin 45 days later. Observations of marked birds suggest that the Griffon Vultures observed in the Dadia area (and also those that occasionally breed there) originate from nearby colonies within the Evros prefecture and also from colonies further away in the Balkans and the east. The increasing annual maximum number of individuals (Fig. 1), recorded mainly in autumn–winter, can be related to the stabilization or even increase of the

breeding populations through protection efforts made throughout the Balkans during the last decade. These autumn–winter counts can be considered as good indices of the population inhabiting the DNP and the wider Evros area. However, they should be used with caution considering the extent of juvenile and immature dispersal in this species.

Egyptian Vulture

The population of Egyptian Vultures has decreased significantly from 17 breeding pairs in 1978 to 9–10 in 2003 (Hallmann 1979, Poirazidis 2003, Schindler et al. 2003). During this period, the number of pairs was estimated at 20–25 in 1987 (Vlachos 1989), 12 in 1989 (Adamantopoulou and Androukaki 1989), 5–6 in 1991–1993 (Papageorgiou et al. 1994) and 10–14 in 1993–1994 (Adamakopoulos et al. 1995).

In all years, the highest concentration of Egyptian Vultures was observed at the feeding station during late August – early September (Fig. 2). It can be argued that these concentrations may be used as an index of the population of the DNP and the wider area, even though the Egyptian Vultures also visit the open rubbish dump close to the town of Soufli but in low numbers due to the irregular food availability there. The highest number ever recorded at the feeding station was 48 individuals in 1988, and the second highest, 38 individuals in 1997. Since then total numbers have decreased, even though the number of breeding pairs did not change dramatically after 1994.

Eurasian Black Vulture

In 1979, the Dadia–Lefkimi–Soufli forest complex was one of the last refuges for the Eurasian Black Vulture in Greece and SE Europe. At that time the population was considered to be under risk of extinction due to the intensive forest management aiming at wood exploitation. The population was estimated at 4–5 active pairs and a total of 26 individuals (Hallmann 1979). Seven years later, in 1985, the population was estimated at 15 pairs (Handrinos 1985). After the establishment of the feeding station in 1987, almost daily counts of birds visiting it have been carried out. During the period 1987–1993 there was a remarkable increase of both breeding pairs and number of individuals, and during the following years the population seemed to be stable (Fig. 3). More detailed information on the population parameters can be found in the next chapter of this volume. It is important to mention that the Black Vulture re-colonized Bulgaria in 1993 (Iankov 1998), with one successful breeding recorded close to Studen Kladenetz, followed by an unsuccessful attempt in 1994 (Marin et al. 1998). In 2003, a new successful breeding was recorded in the same region (Tewes et al. 2004, H. Hristov pers. comm.). In 2000, a permanent group of 14–18 birds occurred in the region of the Biala Reka River close to the Greek border; these birds were considered part of the Dadia colony (BSBCP 2000). In the last few years a small group (less than 10 individuals) has been observed at Studen Kladenetz (Hristov et al. 2004).

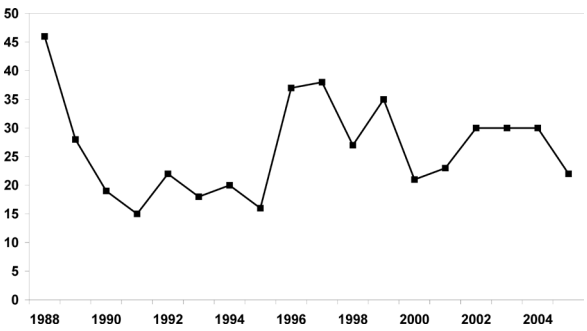

Fig. 2. Annual maximum number of Egyptian Vultures visiting the Dadia feeding station during 1988–2005.

Past and present limiting factors, and conservation measures

According to Handrinos (1985) the main factors causing the decrease of the Greek vulture populations during the period 1960–1980 were: (a) habitat fragmentation

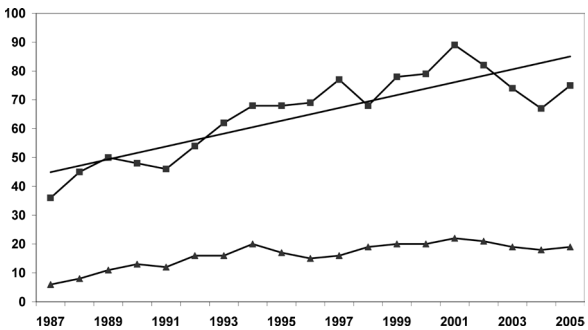

Fig. 3. Annual maximum number of Eurasian Black Vultures visiting the Dadia feeding station during 1987–2005 (upper curve with regression line) and number of breeding pairs in DNP. Numbers at the feeding station increased significantly during the period ($Y = -4385.73+2.23X$, $R^2 = 0.74$, $P < 0.001$).

due to the development of public works such as roads (national, provincial and forest roads), which caused severe changes in their feeding habitats, (b) disturbance of nesting sites by road construction that gave access to unspoiled natural forest areas for timber exploitation, (c) urbanization resulting in the abandonment of rural areas and the subsequent natural regeneration of forest on traditional grazing lands as free-stock farming and transhumance were abandoned – all factors that reduced the vultures' food sources, (d) intensive use of poison, mainly strychnine, to control mammals and birds considered as "vermin" at the time, (e) illegal hunting for taxidermy purposes or, simply, because of negative attitudes to these birds and (f) lack of legal protection and of awareness among authorities and the public.

Changes similar to those just described also affected the landscape in the Evros region in the 1970s, but the early initiatives to protect the Dadia–Lefkimi–Soufli forest complex saved this area from the destructive development projects of that period. The declaration of the Dadia Protected Area in 1980 kept a large core area undisturbed, while a much larger buffer zone was given the area status as "partially protected." Compared with the surrounding areas, the unspoiled Dadia Protected Area benefited the conservation of vultures. According to the protection decree, human-induced disturbance (logging, hunting) was excluded from the vultures' most important breeding sites. In the following years, several projects focused on the conservation of the vultures, the most important being the long-term project of WWF Greece. By 1993, this project supported and promoted fundamental activities, such as monitoring and management, research and the raising of public awareness. The latter aimed at reinforcing the involvement of local people, decision makers and authorities.

Hunting may be a disturbance in the vultures' nesting habitats but is no longer a cause of mortality. During the last 20 years, the illegal persecution of birds of prey has been minimal in the DNP and the surrounding area. Only one Black Vulture has been found shot (in 2006 in Rhodopi prefecture next to the Sapes village). The open season for hunting hare and wild boar overlaps the reproductive period of Black and Griffon Vultures by no more than 20 days (1–20 January) and only affects areas outside the strictly protected zone of DNP. The effect of this hunting is considered small because (a) Black Vultures do not visit their nests frequently until February and (b) the cliff-nesting Griffon Vultures, although starting to incubate during the hunting season, are well protected from humans because their nests are inside the strictly protected zone where hunting is not permitted.

Within the vultures' nesting areas, forest operations such as logging, building and maintenance of forest roads, etc. are only undertaken outside the breeding season, a practice that the Forest Service has followed since 1994, encouraged by WWF Greece. Since 2006, a law has incorporated both this practice and the seasonal restrictions on forest operations in the nesting habitats of raptors.

The construction of a national road across the eastern border of the DNP in the 1990s did not affect the important vulture habitats, and the network of regional roads has not expanded much. However, a network of roads has been created all over the forest inside the buffer zone, aimed at fire prevention and forest exploitation. Despite the lack of maintenance of forest roads in the last five years and the destruction of many secondary and blind roads, the network of forest roads gives access to most forest areas.

Before 1993, the Forest Service and the Hunting Clubs legally used cyanide-poisoned baits to control fox populations. After the prohibition of the use of poisoned baits in 1993, illegal baiting with pesticides to kill foxes resulted in the death of many vultures. In comparison with previous years, incidents of vultures being poisoned in this way increased after 1993. Although the illegal use of poisoned baits is less frequent than in other Greek areas, its consequences may be very severe for the limited population of Black Vultures. Anti-poisoning campaigns have always been part of WWF conservation projects and have included both local and national activities aiming at raising the awareness of authorities and local people. In 2005–2006, a WWF educational material was distributed in all secondary schools in the Evros prefecture inviting students to participate actively in a campaign against the use of poisoned baits.

The efficiency of guarding the DNP has recently decreased because of diminished budgets of the responsible public authorities, such as the Forest Service and the recently established National Park authority.

In 1994, an ecotourism scheme was developed in the Dadia village to provide alternative sources of income for the local people to compensate for the income lost through restrictions on logging. It was later used as a model for the eco-development of other villages in the DNP and in other protected areas of Greece. This scheme was based primarily on giving tourists an opportunity to watch vultures at the feeding station and it focused on the Black Vulture as a priority, flagship species. Tourist activities have been designed in such a way that they do not disturb the vultures' nesting and feed-

ing habitats. Throughout the years, many inhabitants of DNP have been involved in this scheme and have been made aware of the value of protecting raptors.

In the wider foraging area of the vultures, the landscape has gradually changed since the 1990s. Forest exploitation for wood and keeping free-grazing livestock are no longer profitable. Nor can small-scale agriculture support families. This has caused rural depopulation, especially in the Pomac district, which again indirectly threatens the vultures' future. The abandonment of traditional livestock husbandry practices will continue and will affect the vultures through food shortage and habitat alteration. EU programmes aiming to support rural economies have not been exploited on such a scale as to invigorate the local economy and keep the young people in the countryside. Additionally, in the last five years, new roads have been laid and nationwide infrastructure projects, such as extensive wind farm development, are being established in the mountainous area of the Pomacs, significantly altering a traditional landscape unspoilt for centuries and thus increasing the mortality risks for vultures. These socio-economic conditions and the ensuing landscape changes will mean that the future presence of breeding vultures cannot be guaranteed without constantly adapting the management plans to meet these changes.

The ongoing monitoring of vulture populations generated questions about what factors limit them. Specific research has been promoted by WWF in order to assess the impact of different factors on the vulture populations and especially on the Black Vulture (see next chapter). This applied research aims to implement specific measures by the managers of the DNP (Poirazidis et al 2006).

Supplementary feeding: a long-term management measure for vultures

As for other birds, the availability of sufficient food is an important factor for the vulture populations and can strongly influence how often the birds reproduce (Newton 1979, Hiraldo 1983). In the DNP, poor food availability was early considered as an important limiting factor, especially for the small population of Black Vultures. This scarcity of food was caused by (a) a decrease in numbers of free-grazing animals, (b) low availability of dead domestic animals due to obligatory interment, (c) fewer domestic animals dying because of improved veterinarian monitoring, (d) prohibition of open-air slaughtering and (e) low density of wild ungulates (Grant and Vlachos 1985, Adamakopoulos et al. 1995).

For these reasons, a supplementary feeding programme was launched with the establishment of a feeding station in 1987 (Handrinos and Hallman 1984) and was supported by different national and European financial sources. It is currently funded and implemented by the local environmental office of the Evros Prefecture in the village of Dadia, with the scientific support of WWF Greece.

The main bird visitors at the feeding station are the three European vulture species, i.e. the Black Vulture and the Griffon Vulture, which are the main consumers, and the Egyptian Vulture. Some other raptors benefit from the food, especially in winter. The most common are Golden Eagle *Aquila chrysaetos*, Imperial Eagle *Aquila heliaca*, White-tailed Eagle *Halliaeetus albicilla*, Greater Spotted Eagle *Aquila clanga* and Black Kite *Milvus migrans*. The Steppe Eagle *Aquila nipalensis* occurs very rarely and on occasions between 1992 and 1994, a Bearded Vulture was seen. Smaller scavengers, such as Ravens *Corvus corax* and Hooded Crows C*orvus corone cornix*, are regular visitors at the feeding station. Foxes, wolves, domestic dogs and, rarely, jackals, benefit from the food, which before 2002 was sometimes provided outside the fence surrounding the station.

Food is provided at the station once a week in the form of dead animals offered by farmers, slaughter houses, cattle farms and pig farms. In the 1980s, domestic animals used in farming and wood-cutting operations were abundant in the Evros area and were a food source for the feeding station. Nowadays, mainly pig and cattle carcasses from commercial farms are provided (Table 1). Dead goats and sheep are rarely brought in since farmers abandon them where found. About 20–30 tonnes of food have been provided yearly during the last decade, an amount that has varied depending on the availability of carcasses from the farms.

There were suggestions that when large-sized carcasses (cows, sows) were provided, the vultures did not consume them and as a result, the use of this type of food is nowadays avoided. In other instances, it has been confirmed that the vultures prefer natural corpses found elsewhere to those provided at the feeding station, such as goats from wolf attacks, foxes, sheep dogs, martens and badgers, even when the last are found as traffic victims on provincial roads. Vultures also seem to prefer remains from the open-air slaughterings undertaken during the traditional Pomac festivals.

Until recently, the majority of feedings were made at the Dadia feeding station as it fulfilled the EU regula-

Table 1. Food provided (kg) during the period 1988-2006 within the framework of the supplementary feeding programme in DNP.

Year	Cattle	Horses	Pigs	Goats	Slaughter remains	Other	Total
1988	850	4350	200	215	2150	0	7765
1989	2620	6970	0	285	1400	540	11815
1990							
1991	2350	7670	5320	1050	1010	35	17435
1992	1630	6170	0	366	2140	30	10336
1993	2820	5170	1500	75	3240	0	12805
1994	2110	3590	9650	295	2260	30	17935
1995	5295	7150	3530	2745	1930	0	20650
1996	9180	4820	5830	330	2020	0	22180
1997	11190	6070	2720	960	350	0	21290
1998	7510	5610	17520	790	300	0	31730
1999	10000	4770	16050	410	0	0	31230
2000	15600	5950	4800	970	0	0	27320
2001	5730	2180	12650	250	0	0	20810
2002	22900	3200	6580	100	0	0	32780
2003	10880	1830	10645	185	0	0	23540
2004	8610	4335	16820	440	0	0	30205
2005	7470	2050	18159	530	0	0	28209

tions of such activities, such as presence of fencing, etc. (EU regulations 2003/322 and 2005/830). However, to satisfy the continuous flow of tourists for vulture-watching, the need was created to supply food very frequently. This in turn resulted in many vultures being concentrated in one and the same place. To counterbalance this, after 2003 two new feeding stations were established in the buffer zone of the DNP that also obey the EU restrictions (Liarikos 2006). The creation of this network of feeding stations aimed at dispersing the vultures and decreasing competition between them. The long-term goal is to improve the breeding success of the Black Vultures by promoting a more natural pattern of foraging.

Although the tourist demand for vulture-watching at the Dadia feeding station is high, the feeding network started to work gradually with food being provided at random intervals, but sometimes simultaneously, at the new stations. So far, we can conclude that (a) vultures use the new stations, (b) divide themselves between stations when these have food available simultaneously, (c) some juveniles and immatures may visit both stations when food is available simultaneously and (d) Black Vultures detect food at the new feeding stations earlier than do Griffon Vultures, which concentrate in large numbers later in the first day of feeding or in the following day. These results agree with the aims of the new feeding scheme and show the soundness of this practice, which should be expanded in the future both within the DNP and in adjacent areas where vultures forage.

In addition to that practiced in the DNP, a long-term supplementary feeding was started in the eastern Rhodopi, SE Bulgaria, in 1984, at first irregularly but after 1989, on a regular basis. From 1994 this was part of a vulture conservation programme (Hristov and Stoynov 2002). Two feeding stations, one in Madjarovo and one in Studen Kladenetz, are run regularly and one in Pelevun irregularly. Considering the high number of adult Griffon Vultures observed at the DNP feeding stations outside the breeding season, this wider feeding network probably supports the breeding Griffon Vulture populations of SE Bulgaria and NE Greece (Nestos and Evros). However, the importance of this network lies primarily in increasing the survival of juvenile and immature Griffon Vultures from neighbouring and distant colonies until they reach maturity. Observations of marked juvenile and immature Griffon Vultures from Croatia, Serbia and Israel as well as from the DNP indicate the importance of the feeding stations for their

survival, especially in autumn and winter. In contrast, the breeding population of Black Vultures in DNP is supported mostly by the Dadia feeding stations and less by the Bulgarian ones, where their presence is limited to a few birds (Hristov et al. 2004) except at the feeding station closest to the Greek border (Pelevun). This feeding station, when in operation, gathers a significant number of Black Vultures; for example, 42 individuals were observed in 2000 (Marin et al. 2007). The survival of juvenile Black Vultures after fledging and during their first winter is certainly enhanced by the Dadia feeding stations, a conclusion that has been confirmed by the monitoring of marked individuals.

However, according to population data from 1984 to 1994 the presence of the Dadia feeding station had no marked effects on the population of Egyptian Vultures with the exception of an improved survival rate of young, especially in nests containing two eggs (Vlachos et al. 1998). A decrease in egg hatching during this period appears to have been caused by disturbance at nests situated outside the strictly protected zone or by competition with other species, such as Eagle Owl *Bubo bubo*, Lanner Falcon *Falco biarmicus* and Raven (Vlachos et al. 1998, Levy 1990). The limited effect of the feeding station on the population of this species is confirmed by data from 1995 to 2005, when the population decrease became clearly visible. Egyptian Vultures are present at the feeding station in low numbers during the breeding season, but in high numbers during the post-breeding period in late August – early September. During this period, juvenile individuals join the sub-adult and adult birds. Egyptian Vultures usually appear at the feeding station early in the morning and in late afternoon when the two larger vultures, Griffon Vulture and Black Vulture, are few in number. The Egyptian Vulture's low use of feeding stations has also been noticed in France, where it is present only shortly after the spring migration and absent during breeding (Terrasse 1985). The lack of clear effects of feeding stations on this species' population trend might be explained by the fact that Egyptian Vultures can feed on alternative foods, such as small vertebrate carrion, and that it may sometimes attack live prey (Donázar 1993, Negro et al. 2002, Liberatori and Penteriani 2001). The significant decrease in the area of forest clearings in DNP, from 25% in 1973 (not including agricultural land) to 9% by 2001 (Triantakonstantis et al. 2006), may have influenced prey abundance and hence limited the availability of alternative food sources for the Egyptian Vulture. This change in landscape structure may have contributed to the species' negative population trend.

Conclusions

The four European vulture species, i.e. the Bearded, Black, Griffon and Egyptian Vultures have long been present in DNP, but fairly systematic data on their population dynamics have been collected only during the last 20 years. These data represent a period in which natural and residential areas changed slowly and only localized alterations in the DNP took place; the latter might have affected isolated pairs of Black or Egyptian Vultures.

Long-term conservation activities in DNP have secured the presence of three of the vulture species. The successful protection of these species from persecution and the exclusion of humans from their nesting habitats were considered important for their survival. In contrast, the Bearded Vulture disappeared before the conservation efforts yielded results, so it is not known whether its limited population could have recovered. Future recovery may be difficult without re-introduction, as observations of this species have been extremely few during the last decade.

During 1994–1995, the breeding population of Black Vultures stabilized, that of Griffon Vultures was absent and that of Egyptian Vultures declined. A variety of factors might have affected these population trends, probably different for each species, but some might have been common to them, e.g. poisoning, a threat identified as one of the most important causes of vulture deaths in most Balkan countries (Tewes et al. 2004). In 2007, 11 years after the last observation of breeding pairs, Griffon Vultures re-colonized their former nesting cliffs, an event that may be connected to the species' biology rather than to conservation measures. Abandonment and re-colonization of breeding sites by Griffon Vultures have been observed in Croatia (G. Susic pers. comm.), with a 5-year interval between the two events. In neither this nor the Dadia case was there any obvious cause behind the abandonment.

Supplementary feeding has been critical for the preservation of the vultures in DNP but has not contributed to an appreciable increase in their numbers. Nor has it affected the foraging behaviour of the vultures, which continue to forage in an area wider than the DNP (Vasilakis et al 2008). However, there is a gap in our knowledge of potential natural food sources in this wider area and to what extent these can cover the vultures' needs. The main role of the feeding project has always been to provide supplementary food and not to satisfy the vultures' total energy requirements. For the management of the vultures it is crucial to study the

food availability in the DNP and in the wider Greek and Bulgarian areas, taking into account the supplementary feedings, the populations of wild ungulates, of medium-sized mammals, and free-grazing domestic animals. Based on the results of such studies, the future supplementary feeding scheme could potentially be given a different structure for the benefit of the vultures. Not only food quantity but also food quality should be studied. As mentioned above, a large proportion of the supplementary food originates from farms practicing intensive livestock breeding. Considering that three species of *Gyps* vultures on the Indian subcontinent collapsed because of medicine residues in domestic cows (Risebrough 2004, Green et al. 2004) and that increased mortality rates of Black Vultures might have been caused by antibiotic residues in livestock carcasses (Lemus et al. 2008), a specific study of the quality of the provided food is required.

In conclusion, conservation efforts within the boundaries of DNP are not adequate to safeguard vulture populations because their foraging areas extend over a much wider area, characteristics of which have remained unchanged for a long time. However, recent rural depopulation and landscape alteration are threatening the future of the vulture populations.

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