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

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Eurasian Black Vulture: the focal species of the Dadia–Lefkimi–Soufli Forest National Park

Theodora Skartsi , Javier Elorriaga and Dimitris Vasilakis

Since 1988, the only breeding population of the Eurasian Black Vulture in Greece and the Balkans is that of the Dadia–Lefkimi–Soufli Forest National Park (DNP). The protection of its nesting sites and the establishment of a supplementary feeding station may have contributed to an increase in number of breeding pairs in the period 1987–1993. Thereafter, the number of breeding pairs remained stable but breeding success decreased. Mortality because of poisoning has adversely affected population parameters, as adults were more poisoning-prone than immatures and juveniles. The DNP constituted just over 14% of the birds' estimated total foraging area of more than 3000 km^2. Adults seemed to depend much less on the feeding station than did young birds and foraged all over that area. This put them at risk of consuming unsafe food. The availability of suitable nesting areas, such as mature trees on steep slopes, appeared not to limit the population. Neither the level of genetic diversity nor the presence of polychlorinated biphenyls (PCBs) and organochlorine pesticides (OCs) in their tissues seem so far to have affected the population adversely.

Keywords: *Aegypius monachus*, nesting habitats, breeding rates, conservation

Introduction

The protection of the Dadia forest complex was motivated by the presence of breeding, wintering and migrating birds of prey. In 1980, the Eurasian Black Vulture *Aegypius monachus*, Griffon Vulture *Gyps fulvus*, Imperial Eagle *Aquila heliaca* and White-tailed Eagle *Haliaeetus albicilla* were selected as the most important among the breeding species in the area, and the extent of the established protected area was based on the distribution of their nests. At the time, the Black Vulture had already been a breeding species for decades, whereas the other three species had only been breeding for shorter periods within what today are the boundaries of the Dadia–Lefkimi–Soufli Forest National Park (hereafter called DNP). As a consequence, the Black Vulture became the park's centre of attention. Since then, its uniqueness and vulnerability have been used to promote the management and protection not only of this but also of other raptors and their habitats, as well as to promote ecotourism and local development. Thus, the Black Vulture can be considered as the focal or umbrella species of the DNP and the wider area of Evros and Thrace. If met, its requirements for size, type and quality of breeding and foraging habitats can ensure the survival of other important raptors and the preservation of important habitats and landscapes (Lambeck 1997, Armstrong 2002).

In the early 1980s, data on the species' population size were collected, but these were not based on a systematic annual monitoring. However, an annual monitoring scheme of Black Vulture breeding activity was established in 1987. Between 1987 and 1993, the monitoring was carried out by the local wardens Kostas Pistolas and Petros Babakas (Ministry of Environment) in collaboration with Ben Hallmann (Black Vulture Conservation Foundation) and individual researchers.

In 1993, WWF Greece took over and has been carrying out the monitoring to the present day, in collaboration with the above mentioned wardens, who now comprise the Environmental Office of the Evros Prefecture. Together with the monitoring of pelicans in Prespa National Park, Amvrakikos Wetlands and Kerkini Lake National Park (Doxa et al. 2006) this scheme can be considered as one of the few long-term monitoring schemes of birds in Greece.

In addition to the monitoring of the Black Vultures' breeding activity, since 2003 both intensive investigations of threats to their population and a population study have been conducted by WWF Greece. Monitoring and research combined have provided reliable data that have allowed us to suggest and implement well-founded management measures. This long-term work establishing a connection between monitoring and management can provide a model for other protected areas with priority species.

The global distribution and conservation status of the Black Vulture

The Black Vulture breeds in Spain, France (reintroduced population), Bulgaria, Greece, Turkey, Armenia, Azerbaijan, Georgia, Ukraine, Russia, Uzbekistan, Kazakhstan, Tajikistan, Turkmenistan, Kyrgyzstan, Iran, Afghanistan, the north of India and Pakistan, Mongolia and mainland China. It may breed occasionally in Portugal, Former Yugoslav Republic of Macedonia (F.Y.R.O.M.) and Albania. Its global population is estimated at 7,200–10,000 pairs, with 1,700–1,900 pairs in Europe and 5,500–8,000 pairs in Asia. In Europe, populations are increasing in Spain (minimum 1,500 pairs), Portugal and France, and are stable in Greece and F.Y.R.O.M. However, numbers are decreasing in Armenia, Azerbaijan, Georgia, Russia, Turkey and Ukraine. Overall, the European population underwent a large increase between 1990 and 2000, possibly by more than 30%. Much less information is available regarding the population trends in Asia, where the bulk of the global population resides (BirdLife International 2006).

The species is classified globally as "Near Threatened" according to the IUCN's Red List (IUCN 2007), as "Rare" (SPEC1) in Europe (BirdLife International 2004) and as "Endangered" in Greece (Karandinos and Legakis 1992). It is included in the Annex I of the EU Bird Directive and in the Appendix II of the Bern, Bonn and CITES Conventions.

Historical records in Greece and neighbouring areas

Black Vultures were once widespread all over mainland Greece and on some islands, e.g. Kythira, Lefkada and probably Rhodes. In Crete, they were recorded until the 1940s and occasionally in the 1970s. In the 1980s, small groups of up to 3–4 individuals were detected outside the breeding season, wintering for successive years in the areas of Messolonghi and Delphi (Handrinos and Akriotis 1997). During the same period, two breeding populations existed in Greece, one at Mt. Olympus (two pairs) and one in DNP. Since 1988, when the species ceased breeding at Mt. Olympus (Hallmann 1993), DNP has remained the stronghold of the species in the Balkan Peninsula. The re-colonisation of the Eastern Rhodopes in Bulgaria has been possible due to this population (Iankov 1998). Thus, in the last five years, 1–2 pairs have bred, although unsuccessfully, in Studen Kladenetz (Iankov et al. 2007a), while wintering birds have been observed in Studen Kladenetz (Hristov et al. 2004) and Madjarovo (Iankov et al. 2007b). The species is present in Turkey where the national population is estimated at 300–400 pairs (BirdLife International 2004). The nearest known breeding population to DNP (approximately 400 km) is in Turkmenbaba Mountain, in north-western Turkey, where 26 pairs breed (Yamac 2004). Through captures, marking and telemetry, researchers at the two sites, Dadia and Turkmenbaba, have been trying to establish whether there is a connection between these two populations, but so far this has not been confirmed. The Black Vulture has also been included in a list of migrating birds, based on 20 years' data of sporadic observations at Marmara Ereglisi, but it is not clear whether the authors refer to spring or autumn migration (Zalles and Bildstein 2000).

During the last decade, few observations of Black Vultures have been made in the mainland and islands of Greece. One individual was recorded in 1998 and 2002 in Acheron Gorge, Souli area, NW Greece (Cameron 1998, Jennings 2002). One immature bird was observed in 1999 and 2000 in Iraklia, Naxos island (HOS 2006) and one juvenile at Lasithi, Crete (HOS 2007). In 2004, an adult observed several times in Kaimaktsalan Mt. (Sidiropoulos 2004) was considered to be a member of the limited non-breeding population of F.Y.R.O.M. The species occurs in the Komsatos river valley, in Rhodopi Prefecture, where occasional annual observations have confirmed its presence (Panagiotopoulou et al. 2006). Satellite-telemetry data (WWF

Greece, unpublished) have shown that these individuals have originated from the DNP population.

Nesting habitat and breeding behaviour

The distribution of Black Vulture nests within the boundaries of DNP has followed the same pattern over the last 12 years. Nests have been grouped within three distinct nuclei, which are divided between zone A (area of nature protection) and zone B (buffer zone) of the park (Fig. 1). In 1997–1998, one previously successful pair used a slope between the two parts of zone A, but the proximity of the nest to a forest recreational area with much disturbance during spring resulted in breeding failure in the following year (1999). Since then, no pair has bred in this area. In general, within each of the three nuclei the spatial distribution of nests has changed between years, but it is not known whether the same breeders move between valleys or whether they have just selected neighbouring trees in the same valley. Data from three years of our marking programme (2004–2006) showed that four breeders used the same nest, one breeder used two nests close to each other, whereas one used two nests close to each other for two

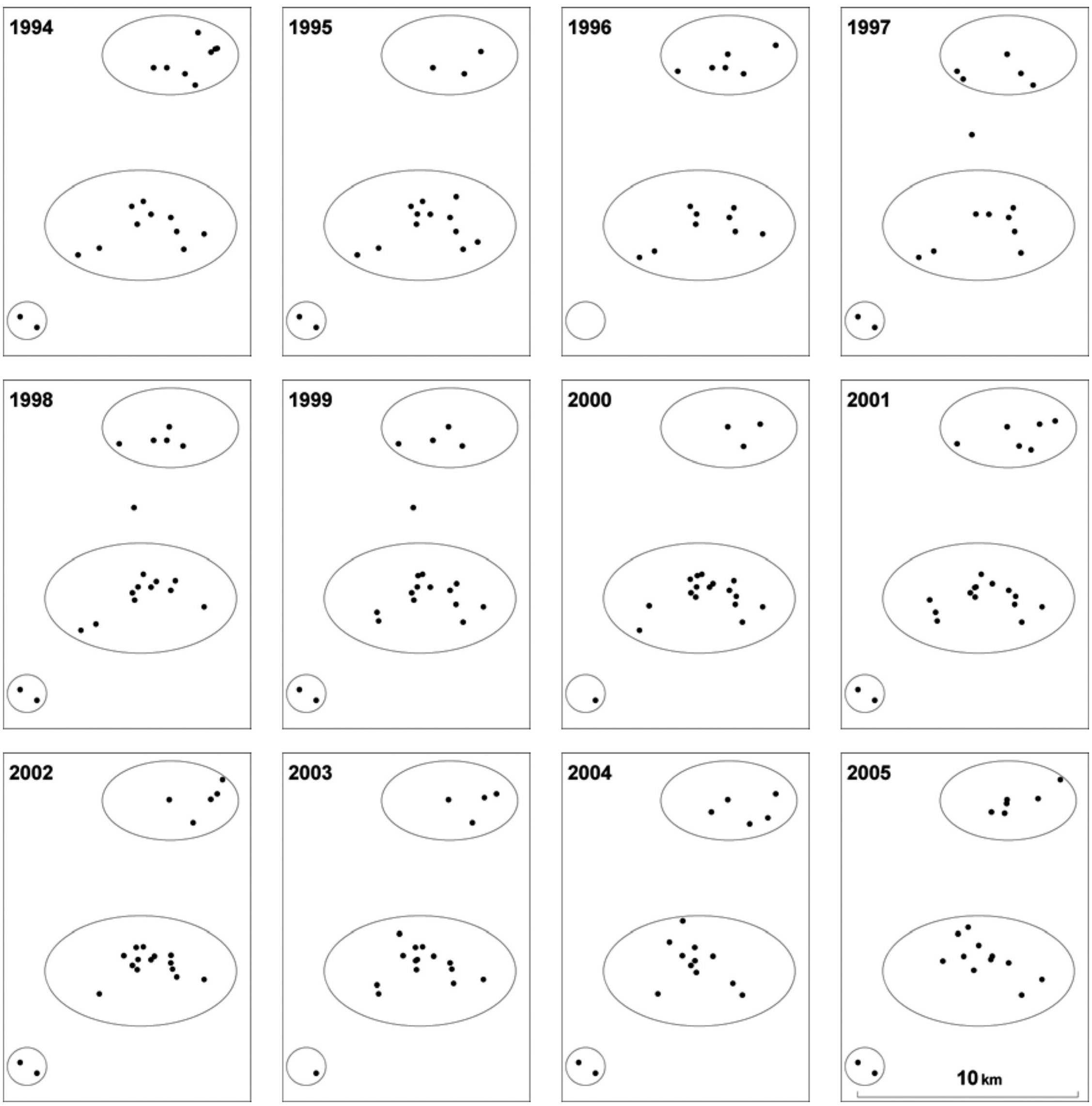

Fig. 1. The spatial distribution of Black Vulture nests during 1994 – 2005.

years then moving to a different valley in the third year. These preliminary data suggest that the species shows fidelity to the nest (Cramp and Simmons 1980) or valley, but more data are needed to make inferences on the breeders' distribution pattern.

In the last 12 years, most occupied nests have been found in zone A (average 68.4%). Following the declaration of the Dadia National Park in 2006, zone A was expanded to include the slopes near the Black Vultures' nesting areas. Since then, only a few nesting areas with active pairs remain outside zone A.

Poirazidis et al. (2004) studied the suitability of nesting areas in the Park and concluded that: (a) available nesting areas did not differ from known nesting areas, (b) most suitable nesting habitat was found in zone A, but the south-western part of zone B was also suitable, (c) when pine trees were excluded from the analysis but all other tree species were considered as potential nesting trees, a large area in the southwest of the park appeared to be suitable on the condition that isolated mature oak trees (the only potential nest-tree apart from pine) were protected, and (d) the availability of nesting sites was not a limiting factor.

Vegetation modelling showed that Black Vultures might not be confined to pure pine forests only but could also nest in mixed pine-oak stands or in broadleaf forests with isolated mature pines. The key requirement was the occurrence of mature nest-trees (mean diameter at breast height, DBH, of 50 cm and mean height of 11.5 m) and not the type of nest-tree or kind of surrounding forest. Exposure was not an important factor. However, most Black Vulture nests were situated in an extensive internal valley, where the microclimatic conditions were not greatly affected by the strong northerly winds in winter. Steep slopes and high elevations appeared to be additional key factors for nest-site selection (Poirazidis et al. 2004).

Nests are built on top of trees, with the majority placed in the middle of the crown but others near the edges. There are nests that have been used for 10–13 successive years and nests used for only 1–2 years (WWF Greece, unpublished). Old nests have material added each year and so reach huge size. According to Cramp and Simmons (1980), nests can be up to 300 cm in diameter and 200 cm in height. Sometimes, after long use, such nests become damaged, resulting in parts of the nest missing. None the less, in many cases such nests continued to be used, with the risk that the chick might fall down. Because such damaged nests are vulnerable to destruction by snow and wind, they may cause incubation failure or nestling loss. In the DNP colony, two cases where a nest containing an egg has fallen down have been recorded in late winter, and four such cases with nests containing a nestling have been recorded in July–August. All of the four nestlings found on the ground were rescued by WWF staff: two of them, fed by their parents, were put back on their reconstructed nests and the other two, which were at the limit of starvation, were rehabilitated successfully.

In DNP, Black Vultures occupy their nests in February. At this time of year they display over the nesting area and construct or restore their nests. By the end of the month, a small number of pairs start incubating. In March, the majority of pairs begin to incubate, only a few starting in early April. Hatching takes place between the middle and end of May and the nestling period lasts until the end of August. This phenology is similar to that of the colony in Lozoya Valley in Spain (de la Puente 2006). Even after fledging in September, when marked juveniles have been observed at the feeding station, they still use their nests.

Both parents share the reproductive responsibilities from incubation to the fledgling period (WWF Greece, unpublished, Cramp and Simmons 1980). After hatching of the egg, one member of the pair stays on the nest taking care of the hatchling. By the end of June, when the chick is half-grown, the parents visit the nest itself only to feed their chick, mostly roosting in the surrounding trees, from which they can monitor their nest (WWF Greece, unpublished).

In addition to effects of weather and nest condition, other threats that may affect the reproductive success of the Black Vulture colony in DNP are: (a) loss of parents (possibly poisoned during the nestling period) causing the chick to starve (three records), (b) forest fires forcing breeders to abandon their egg (one record; even though their nest tree was not burnt, the birds abandoned because of a 3-day long presence of firemen), (c) disturbance by large eagles such as Golden Eagle *Aquila chrysaetos*, Imperial Eagle and White-tailed Eagle during the incubation period, forcing the vultures to defend their nest or to mob the eagle (five records; in all of these the vultures successfully warded off the eagles) and (d) chick injured in the nest (two cases) or dead from having consumed stones (one case).

Monitoring of population parameters

The long-term annual monitoring of the breeding activity of the species in DNP has involved three population parameters: the number of breeding pairs, their breeding success, and the total number of individuals. However, after 15 years of continuous monitoring (1987–2001), we concluded that the population remained stable and our only concern was the possibility of a sudden collapse. The annual monitoring alone was not adequate to predict the population's future. Therefore, in 2003, we initiated specific studies of a number of parameters, including genetics, health, home range, survival rate, population size and causes of mortality, alongside the continued annual monitoring. Some of these studies have been accomplished, while others are still in progress.

The annual monitoring methodology was specified in the first edition of the Monitoring Plan of DNP (Poirazidis et al. 2002), evaluated in 2006 (Poirazidis et al. 2006) and specified once again in the second edition (Poirazidis et al. 2007).

According to the results of the monitoring, over the years 1987–2005 the number of breeding pairs ranged from six (recorded in 1987) to 22 (recorded in 2001) with an average of 16.21 ± 4.44 pairs (Skartsi et al. 2008) (see Fig. 3 in the preceding chapter of this volume). Even though there was a significant increase in the number of breeding pairs during these 19 years (linear regression, $F_{1,17} = 39.359$, $p < 0.001$), two distinct periods could be identified where the breeding trend changed: (a) during 1987–1993 when the number of breeding pairs showed a significant increase ($F_{1,5} = 60.355$, $p < 0.01$) and (b) during 1994–2005 when the number of breeding pairs remained stable ($F_{1,10} = 1.598$, $p > 0.05$).

The total number of individuals was estimated during the autumn and winter (October–February) of the same years, the time of year when maximum numbers were present at the feeding site. The mean number of individuals was 65 ± 14.6, and the maximum number recorded on any single occasion during this period was 89 individuals on 11 January 2001 (see Fig. 3 in the preceding chapter of this volume). Between 1987 and 2005, a significant increase in the total number of individuals was found ($F_{1,17} = 47.52$, $p < 0.001$).

Breeding success ranged from 53% in 2003 to 95% in 1994 (Table 1) for the period 1994–2005, when data for all reproductive phases were available. The average value for this period was 72% ± 12% and showed a significant decrease ($F_{1,10} = 5.072$, $p < 0.05$) over the same period.

According to the mortality data collected by WWF Greece both within and outside the boundaries of DNP, 25 Black Vultures were found dead, three sick or injured (after being rehabilitated, they were released) and two permanently disabled kept in captivity during the period 1994–2005 (Skartsi and Poirazidis 2002, Skartsi et al. 2003, Elorriaga et al. 2004, Elorriaga et al. 2005). Of the 25 vultures found dead, 14 were confirmed to have died from poisoning, four from accidents such as drowning in water deposits, six from unidentified causes (4 found in a decayed state, 2 relatively fresh) and one from natural causes such as old age. Of the 14 poisoned birds, 12 (86%) were adult individuals. These vultures died because they had consumed carcasses of dogs, foxes, martens and badgers, the main victims of poisoning in our area. These mammals had consumed poisoned baits, which according to the toxicological analysis of

Table 1. Breeding status of Black Vulture in the Dadia NP during 1994-2005.

	No. of occupied nests	No. of incubating pairs	No. of hatchlings	No. of fledglings	Breeding success[1], %
1994	20	20	19	19	95.00
1995	20	17	15	15	83.23
1996	18	15	10	10	66.66
1997	21	16	10	10	62.50
1998	19	19	14	13	68.42
1999	21	20	16	16	80.00
2000	24	20	15	15	75.00
2001	26	22	17	14	63.64
2002	26	21	18	16	76.19
2003	27	19	15	10	52.63
2004	25	18	16	13	72.20
2005	27	19	15	12	63.10

[1] No. of pairs producing a fledgling/no. of incubating pairs × 100.

the dead vultures, had contained compounds such as Carbofuran, Methomyl and Methamidophos (Antoniou et al. 1996, Skartsi and Poirazidis 2002, Skartsi et al. 2003, Elorriaga et al. 2004). Besides Black Vultures, one Griffon Vulture *Gyps fulvus*, two Egyptian Vultures *Neophron percnopterus* and one Golden Eagle were found poisoned.

Mortality rate showed two peaks, during 1995–1997 and 2003–2004, with nine and 11 individuals, respectively, dying. This mortality most likely explains the decrease in number of incubating pairs, total number of individuals and, probably, breeding success in these two periods (see Fig. 3 in the preceding chapter of this volume, Table 1, and below). In both periods of high mortality, extensive poisoning had taken place. In particular in 2003, when the lowest breeding success was recorded, two instances of poisoning occurred during the nestling/fledging period when two Black Vultures, one immature and one adult, were found poisoned next to the border of DNP. Simultaneously, relatively large nestlings were found dead and the nests abandoned by the parents.

High adult mortality may be reflected in the number of immature breeders that has recently been present in the Black Vulture population of DNP. During the last few years (Table 1), immature birds have been involved in breeding activities, as confirmed by the monitoring of marked individuals. The considerably higher number of occupied nests compared with number of incubating pairs observed in the last three years (Table 1) may also be attributed to the presence of immature breeders in the population. This may be a warning signal of a potential population decline, as was the case for the Spanish Imperial Eagle *Aquila adalberti*: the proportion of immature breeders in the population was particularly high during the period of its population decline (Ferrer et al. 2003).

Some results of specific research programmes

Range use and movements

During foraging, Black Vultures search for food in an area much wider than DNP, visiting the western parts of Thrace and the mountainous areas of southeastern Bulgaria. Their home ranges include thinly populated areas where traditional stock-raising practices are still common. During the autumn of 2005, two marked individuals, one adult and one juvenile, were observed at a feeding station in Studen Kladenetz, Bulgaria (Bulgarian Society for Bird Protection, unpublished), 75 km away from Dadia. The next morning one of them was seen at the feeding site in Dadia so had likely made this tour in one day. During such trips, Black Vultures visit traditional nesting grounds (Marin et al. 1998) also used by other vulture species, such as the Griffon Vulture and the Egyptian Vulture (Stoychev et al. 2004, Tewes et al. 2004).

Since 2004, WWF Greece researchers have been studying the movements of Black Vultures in collaboration with BSPB-BirdLife and Green Balkans, using telemetry techniques. Both radio and satellite transmitters are being used on a sample of birds of different age classes. The study area covers the Evros mountainous area and the south-eastern Rhodopes in Bulgaria. According to Vasilakis et al. (2008), Black Vultures search for food in an area of over 3000 km^2, one seventh of which is the DNP (Fig. 2). This result suggests that, although the vultures use the feeding stations quite intensively (Elorriaga et al. 2005), they may not have become habituated to them, and their normal foraging behaviour may not have been affected.

The pattern of range use of different individuals showed high variability within and between breeding and non-breeding seasons, probably depending on age class and breeding status. However, there were no statistically significant differences with respect to home range size between adult and immature individuals either within or between the two seasons. In contrast, juveniles used a significantly smaller area than adults during the non-breeding season, probably due to their inexperience forcing them to be attached to the natal area.

Similar results have been obtained from the census of marked birds at the feeding stations. Adult birds were less regular visitors than juveniles and immature birds (Elorriaga et al. 2004, Elorriaga et al. 2005). Therefore, both telemetry and marking results show that, during foraging, adults may risk their lives by consuming unsafe food found outside DNP. This may explain the high adult mortality.

The area used by the vultures showed an eccentrically spaced pattern around the colony with a prevailing northwesterly orientation (Fig. 2). Taking into account the topography and land use to the east and southeast of the study area, this may be explained as an avoidance of the intensively cultivated lowland areas, where the absence of thermal lifts and the intensive human presence make these areas unattractive for foraging. It is possible that physiographic factors influence not only the selection of breeding habitat (Poirazidis et al. 2004, Morán-López et al. 2006a) but also the selection of foraging habitat.

Genetic study

A study of the genetic diversity and population structure has been accomplished in collaboration between WWF Greece and the Natural History Museum of the University of Crete. The study included the Dadia population, but also a population from Spain, three populations from Caucasus and one from Mongolia, thus comprising samples from throughout most of the geographical range of the species.

The sex ratio of the Dadia population was almost equal (53 samples; Poulakakis et al. 2008); mtDNA exhibited a very low degree of diversity both between and within all populations, as the number of polymorphisms found was very small. Although the level of variability in the mitochondrial genome was low, no evidence of genome-wide genetic erosion existed, since nuclear diversity exhibited normal levels. Despite the low mtDNA variability, the small number of substitutions revealed a clear geographic pattern of population structure. The two European populations formed a sister group, whereas birds from Caucasus were closer to the Mongolian populations, together comprising a group distinct from the European populations. No signatures of a genetic bottleneck were detected in the nuclear genome, indicating that the demographic bottleneck during the 20th century was neither critical nor long-lasting enough to impact on the nuclear genetic variation at the species level (Poulakakis et al. 2008).

The microsatellite and mitochondrial data provided strong evidence that historical isolation has led to the differential accumulation of mutations in Balkan and Iberian populations. This, together with their genetic

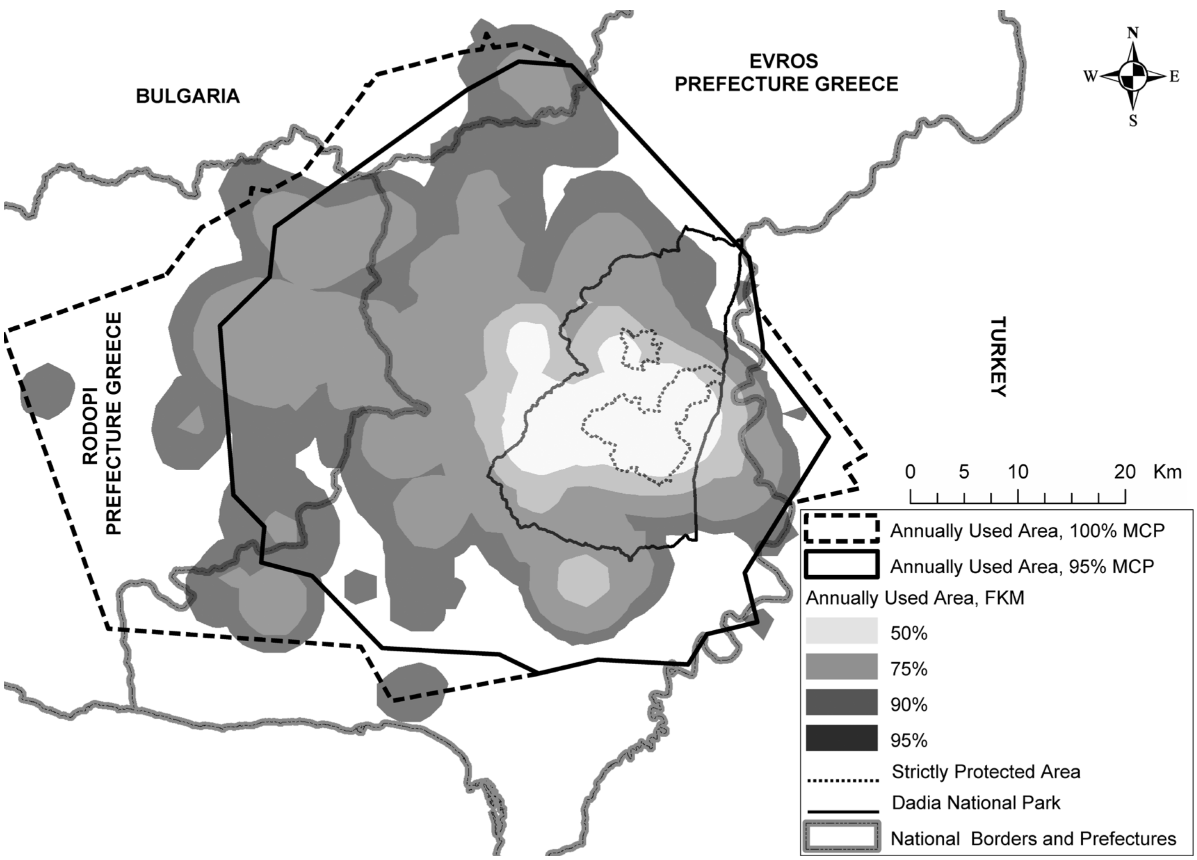

Fig. 2. Overall area occupied by radio-tagged Eurasian Black Vultures *Aegypius monachus* during their annual life cycle (breeding and non-breeding season), as determined by superimposing the individual home ranges (n=10). Hatched line indicates 100% MCP estimates; solid line indicates 95% MCPs; graduated shaded polygons show the utilization distributions for fixed FKM.

divergence from the eastern populations, means that they make a major contribution to the total genetic diversity of the species. Consequently, management strategies should aim to preserve the existing diversity of the Balkan and Iberian populations and, if the goal is to preserve genetic distinctiveness and ongoing evolutionary processes, introductions of birds should be discouraged.

Effect of environmental contaminants on Black Vultures

The presence of polychlorinated biphenyls (PCBs) and organochlorine pesticides (OCs) was measured in 2006 in a sample of 30 Black Vultures within the framework of collaboration between WWF Greece, the Aristotelian University of Thessaloniki and the University of Ioannina. Comparing the residue levels detected in Dadia Black Vultures with those reported in the literature to affect birds of prey negatively (Van Wyk et al. 2001, Gómara et. al. 2004, Hela et al. 2006), shows that residue levels at Dadia appear to be too low to have any negative effects (Goutner et al. unpublished). Comparisons between Black Vulture age-classes indicated significant differences between adults and nestlings in the levels of PCB 28, PCB 52, PCB 101 and PCB 118, and between nestlings and immatures in the levels of PCB 101. No differences were detected between older age-classes (Goutner et al., unpublished).

Ageing Black Vultures using moulting pattern

Moulting patterns were used to age Black Vultures in the hand. Birds were trapped and marked at two sites, DNP and Rascafria, Spain. It was possible to identify birds in their first, second, third, fourth and fifth calendar year, from the moulting pattern of flight feathers, mainly the primaries (de la Puente and Elorriaga 2004).

Conservation achievements

In the last 14 years, the key conservation goal in the DNP, i.e. to conserve the Black Vulture, has been achieved thanks to the efforts of WWF Greece in collaboration with local authorities (Evros Prefecture and Soufli Forest Service). The protection of nesting sites from forest operations has been improved. In addition, no logging has been realized in some forest stands suitable for nesting, where the number of mature trees is limited. The decrease of illegal hunting of raptor species in the park and in the Evros area has affected bird survival positively. The control of forest fires and of the flow of visitors has safeguarded the species' crucial nesting areas from ravages and disturbance. After the proposed zoning of DNP (Adamakopoulos et al. 1995), only a few nesting sites have remained outside zone A, the strictly protected zone. The results of the research carried out by WWF Greece points to a bright future for the population of Black Vultures in the area with regard to nest site availability, genetic diversity and the vultures' levels of organochlorine pesticides and polychlorinated biphenyls. As mentioned above, the number of breeding pairs and the total number of individuals appear to remain stable, but the level of adult mortality probably prevents the population from increasing.

The long-term operation of the vultures' feeding station has not led to an increase in the Black Vulture population. It has certainly affected post-fledging and juvenile survival but cannot guarantee adult survival. In the north of Spain, the creation of feeding sites did not contribute to the observed increase in the number of colonies and pairs of Griffon Vulture, since there had always been food available in nature; the population recovery was rather attributed to the cessation of human-induced mortality (Donázar and Fernández 1990). In our study area, we do not consider that food available in nature can maintain Black Vulture and Griffon Vulture populations. Hence, limited food availability in nature and high adult mortality can be considered as important limiting factors of the Black Vulture population in the area. These factors are merely balanced by the conservation activities and supplementary feeding, which together help to maintain the current population.

With respect to the persistence of the vulture population, one must take into account that large carrion-eating raptors are extremely sensitive to increased mortality, especially of adult birds, so that populations may crash when there is widespread persecution (Donázar and Fernández 1990, Donázar 1993). The population of these long-lived and non-migratory raptors depends on three main factors: adult survival, non-adult survival and productivity. Population changes are most sensitive to variation in adult survival (Gilbert et al. 2002). If the vultures are unable to adjust their reproductive rate to compensate for losses of adults, the population will inevitably start to slide towards extinction (Houston 1996).

Poisoning has always been an important mortality factor that constrains the Black Vulture population and if poisoning is common and widespread it can provoke a severe population decrease. In this light, it is really alarming that a new mortality factor has recently made its appearance in the area: the wind farms. The future national wind-farming plan for Thrace predicts a considerable number of wind turbines within the Black Vultures' home ranges (Fig. 2), which may increase the risk of collisions with the rotors or collisions/electrocutions with electrical pylons and wires (Barrios and Rodriguez 2004, Bevanger 1998). It is disappointing that achievements of long-term conservation efforts may be threatened or even thwarted by a new development project where, once again, the local environmental priorities have not been taken into account. For a long-term conservation project such as the WWF Greece Dadia project, such environmentally oriented development projects (e.g. production of 'green' energy) introduce conservation challenges that need to be solved.

Conservation challenges

Conservation of the Black Vulture population is the major aim in the management of DNP and the adjacent regions. The species has predominance over the rest of the raptor species present in the area by its uniqueness, rareness and sensitivity and is of international concern and focus. The long-term monitoring and conservation activities, as well as the long-term tourist development of the area, which is based on vultures, keep being focused on the Black Vulture and specify the DNP as the forest of vultures rather than the forest of raptors.

The focal role of the species has helped gradually to alter the political and social priorities, but not necessarily the financial priorities and, in particular, the national ones: environmental priorities have to be negotiated every time a large-scale project promises economic development to the area. To maintain the Black Vulture as the focal species in DNP and the adjacent areas appears to be essential in order to: (a) conserve the mountainous and hilly habitats of the Evros and Rhodopi regions and (b) promote a sustainable development of the region.

Regarding the future protection of the Black Vulture, it is of high priority to secure current conservation achievements, such as the protection of nesting sites from forest operations, tourist activity, road construction and forest fires. Supplementary feeding should be continued at least until the establishment of a long-term project aimed at restoring natural food resources.

Annual monitoring should be continued to provide data for the evaluation of population trends. Initiatives such as the rescue and rehabilitation of injured birds can secure the survival of certain individuals, which is valuable for a population of small size such as the one in DNP. A systematic study of mortality rates should be made, as this is a significant parameter for the assessment of population trends of long-lived and sensitive species (Newton 1979, Akcakaya et al. 1999). Death causes could then be identified and suitable management measures taken.

In particular, a systematic anti-poisoning strategy should be promoted at the local and national levels. This would help improve monitoring of poisoning events, the implementation of relevant laws, the involvement and sensitization of stakeholders and finally the control of the poisoning itself. Regarding the future wind-farm establishment, a sophisticated planning of the localization of wind turbines and associated pylons, wires and electrical stations must be carried out in collaboration with the authorities involved to minimize the risks for vulture collisions. Even though no dead vultures were found during the two years of monitoring by WWF Greece at the existing wind-farms (Ruiz et al. 2006), there is always a collision risk and this risk increases at large wind-farms (Barrios and Rodriguez 2004). Six times the number of presently existing wind turbines (160 turbines) will be established in the Rhodopi/Evros region, as predicted by the national planning for renewable energy. A long-term monitoring of bird casualties at the wind-farms should be established in order to identify the most dangerous turbines and to propose specific measurements to avoid their impact.

The availability of suitable nesting habitat in the wider area of the Greek and Bulgarian Eastern Rhodopes should be studied, based on the DNP modelling (Poirazidis et al. 2004), to identify where new colonies might become established in these areas. In particular, the number of breeding pairs of the DNP population should be increased, but without controlling mortality, this goal is not so realistic.

In conclusion, the Black Vulture of DNP appears to be a species whose conservation is highly dependent on the management of human activities, which involves long-term planning and institutionalization of the protection activities.

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References

Adamakopoulos, T., Gatzogiannis, S. and Poirazidis, K. (eds). 1995. Specific Environmental Study of the Dadia Forest Special Protection Area. Parts A+B, C. – WWF-Greece, Ministry of Environment, Ministry of Agriculture, ACNAT. WWF-Greece, Athens. (In Greek.)

Akcakaya, R. A, Burgman, M. A. and Ginzburg, L. R. 1999. Applied Population Ecology, principles and computer exercises using Ramas Ecolab 2.0. – Sinauer Associates, Inc., Sunderland, Massachusetts.

Antoniou, V., Zantopoulos, N., Skartsi, Th. and Tsoukali-Papadopoulou, H. 1996. Pesticide poisoning of animals of wild fauna. – Vet. Hum. Toxicol. 38: 212–213.

Armstrong, D. 2002. Focal and surrogate species: Getting the language right. – Conserv. Biol. 16: 285–286.

Barrios, L. and Rodriguez, A. 2004. Behavioural and environmental correlates of soaring-bird mortality at onshore wind turbines. – J. Appl. Ecol. 41: 72–81.

Bevanger, K. 1998. Biological and conservation aspects of bird mortality caused by electricity power lines: a review. – Biol. Conserv. 86: 67–76.

BirdLife International 2004. Birds in Europe: population estimates, trends and conservation status. – BirdLife Conservation Series No.12, BirdLife International, Cambridge, UK.

BirdLife International 2006. Species factsheet: *Aegypius monachus*. – Downloaded from http://www.birdlife.org on 11/10/2006.

Cameron, C. 1998. Birdwatching in North West Greece – May 1998. Downloaded from http://www.birdtours.co.uk/tripreports/Greece/nwgreece/index.htm

Cramp, S. and Simmons, K. E. L. (eds). 1980. The Birds of the Western Palearctic. Vol. II. – Oxford University Press, Oxford.

De la Puente, J. and Elorriaga, J. 2004. Ageing of Eurasian Black Vulture (*Aegypius monachus*) using the moult. – In: Contributions of the International Symposium on the Black Vulture *Aegypius monachus*, 21–23 October 2004, Cordoba, Junta de Andalucia, Spain, Consejería de Medio Ambiente.

De la Puente, J. 2006. Effect of monitoring frequency and timing on estimates of abundance and productivity of colonial Black Vultures *Aegypius monachus* in Central Spain. – In: Houston, D. C. and 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 and WWF Greece, Athens, pp. 31–40.

Donázar, J. A., 1993. Los buitres ibéricos. Biología y conservación. – J. M. Reyero Ediciones, Madrid.

Donázar, J. A. and Fernández, C. 1990. Population trends of the Griffon Vulture *Gyps fulvus* in Northern Spain between 1969 and 1989 in relation to conservation measures. – Biol. Conserv. 53: 83–91.

Doxa, A., Theodorou, K., Robert, A., Hatzilakou, D., Catsadorakis, G., Naziridis, Th. and Crivelli, A. 2006. Demographic analysis of pelicans' populations in Greece. – Book of abstracts, 3rd Congress of the Hellenic Ecological Society and Hellenic Zoological Society: "Ecology and conservation of biodiversity", 16–19 September 2006, Ioannina University, Ioannina, Greece. (In Greek.)

Elorriaga, N. J., Skartsi, Th. and Vasilakis, D. 2004. Black Vulture and Griffon Vulture monitoring in the National Park of Dadia–Lefkimi–Soufli Forest. – Annual Technical Report 2004. WWF Greece, Athens.

Elorriaga, N. J., Skartsi, Th. and Vasilakis D. 2005. Black Vulture and Griffon Vulture monitoring in the National Park of Dadia–Lefkimi–Soufli Forest. – Annual Technical Report 2005. WWF Greece, Athens.

Ferrer, M., Penteriani, V., Balbontín, J. and Pandolfi, M. 2003. The proportion of immature breeders as a reliable early warning signal of population decline: evidence from the Spanish imperial eagle in Doñana. – Biol. Conserv. 114: 463–466.

Gilbert, M., Virani, Z. M., Watson, T. R, Oaks, J. L., Benson, C. P., Khan, A. A., Ahmed, S., Chaudhry, J., Arshad, M., Mahmood, S., and Shah, Q. 2002. Breeding and mortality of Oriental White-backed Vulture *Gyps bengalensis* in Punjab Province, Pakistan. – Bird Conserv. Int. 12: 311–326.

Gómara, B., Ramos, L., Gangoso, L., Donázar, J. A. and González, M. J. 2004. Levels of polychlorinated biphenyls and organochlorine pesticides in serum samples of Egyptian Vultures (*Neophron percnopterus*) from Spain. – Chemosphere 55: 577–583.

Hallmann, B. 1993. Greece: The conservation project. – In: European Black Vulture Conservation Project Annual Report 1991–1992. Frankfurt Zoological Society, Frankfurt.

Handrinos, G. and Akriotis, T. 1997. The Birds of Greece. – Christopher Helm, London.

Hela, D. G., Konstantinou, I. K., Sakellarides, T. M., Lambropoulou, D. A., Akriotis, T. and Albanis, T. A. 2006. Persistent organochlorine contaminants in liver and fat of birds of prey from Greece. – Arch. Environ. Contam. Toxicol. 50: 603–613.

HOS (Hellenic Ornithological Society). Evaluation Committee of Ornithological Observations 2006. Annual Report 2005. Downloaded from: http://rarities.ornithologiki.gr/gr/eaop/annual_reports.htm

HOS (Hellenic Ornithological Society). Evaluation Committee of Ornithological Observations 2007. Annual Report 2006. Downloaded from: http://rarities.ornithologiki.gr/gr/eaop/annual_reports.htm

Houston, D. C. 1996. The effect or altered environments on vultures. – In: Bird, D., Varland D. E. and Negro, J. J. (eds). Raptors in human landscapes. Academic Press, London, pp. 327–335.

Hristov, H., Demerdzhiev, D. and Stoychev, S. 2004. Status of the Black Vulture in Bulgaria and BSPB/BirdLife conservation activities. – In: Contributions of the Proceedings of the International Symposium on the Black Vulture *Aegypius monachus*, 21–23 October 2004, Cordoba, Junta de Andalucia, Consejería de Medio Ambiente, Spain.

Iankov, P. 1998. Conservation of the Black Vulture (*Aegypius monachus*) in Bulgaria. – In: Tewes, E., Sánchez, J. J., Heredia, B. and van Bijleveld, L. M. (eds). International Symposium on the Black Vulture in South Eastern Europe and Adjacent Regions, Dadia, Greece, 15–16 September 1993. FZS/BVCF, Palma de Mallorca, pp. 43–45.

Iankov, P., Hristov, H. and Barov, B. 2007a. Studen Kladenetz. – In: Kostadinova, I. and Gramatikov, M. (eds). 2007. Important Bird Areas in Bulgaria and Natura 2000. Bulgarian Society for the Protection of Birds, Conservation Series, Book 11. BSPB, Sofia, pp. 160–163.

Iankov, P., Hristov, H., Barov, B. and Kurtev, M. 2007b. Madzharovo. – In: Kostadinova, I. and Gramatikov, M. (eds). 2007. Important Bird Areas in Bulgaria and Natura 2000. Bulgarian Society for the Protection of Birds, Conservation Series, Book 11. BSPB, Sofia, pp. 164–166.

IUCN 2007. 2007 IUCN Red List of Threatened Species. Downloaded from www.iucnredlist.org

Jennings, J. 2002. A Report from birdtours.co.uk Parga area of North western Greece. Downloaded from http://www.birdtours.co.uk/tripreports/Greece/mainland3/greece-sept02.htm

Karandinos, M. and Legakis, A. (eds). 1992. The Red Data Book of Threatened Vertebrates of Greece. – Hellenic Zoological Society and Hellenic Ornithological Society. WWF Greece, Athens.

Lambeck, R. J. 1997. Focal species: a multi-species umbrella for nature conservation. – Conserv. Biol.11: 849–857.

Marin, S., Rogev, A. B., Christov, I. and Sarov, M. 1998. New observations and nesting of the Black Vulture (*Aegypius monachus.* L.) in Bulgaria. – In: Tewes, E., Sánchez, J. J. Heredia, B. and van Bijleveld, L. M. (eds). International Symposium on the Black Vulture in South Eastern Europe and Adjacent Regions, Dadia, Greece, 15–16 September 1993. FZS / BVCF Palma de Mallorca, pp. 47–50.

Morán-López, R., Guzmán, J. M. S., Borrego, E. C. and Sánchez, A. V. 2006a. Nest-site selection of endangered cinereous vulture (*Aegypius monachus*) populations affected by anthropogenic disturbance: present and future conservation implications. – Anim. Conserv. 9: 29–37.

Newton, I. 1979. Population Ecology of Raptors. – Poyser, London.

Panagiotopoulou, M., Bourdakis, S., Sidiropoulos, L., Vasilakis, D. and Skartsi, Th. 2006. The importance of Komsatos valley (Xanthi and Rhodopi prefectures) for the conservation of vultures in Thrace. – Book of abstracts, 3rd Congress of Hellenic Ecological Society & Hellenic Zoological Society: "Ecology and conservation of biodiversity", 16–19 September 2006, Ioannina. (In Greek.)

Poirazidis, C., Skartsi, Th. and Catsadorakis, G. 2002. Monitoring Plan for the Protected Area of Dadia–Lefkimi–Soufli Forest. 1st edn. – WWF Greece, Athens.

Poirazidis, K, Goutner, V., Skartsi, Th. and Stamou, G. 2004. Modeling nesting habitat as a conservation tool for the Eurasian Black Vulture (*Aegypius monachus*) in Dadia Nature Reserve, northeastern Greece. – Biol. Conserv. 118: 235–248.

Poirazidis, K., Skartsi, Th., Vasilakis, D., Gatzogiannis, S. and Catsadorakis, G. 2006. Monitoring plan of the Protected Area of Dadia–Lefkimi–Soufli Forest. Synopsis and evaluation of results for the period 2000–2005. – WWF Greece, Athens. (In Greek.)

Poirazidis, K., Skartsi, Th., Vasilakis, D., Gatzogiannis, S. and Catsadorakis, G. 2007. Monitoring Plan of National Park of Dadia–Lefkimi–Soufli Forest. 2nd edn. – WWF Greece, Athens. (In Greek.)

Poulakakis, N., Mantziou, G., Antoniou, A., Parmakelis, A., Skartsi, Th., Vasilakis, D., Elorriaga, J., de la Puente, J., Gavashelishvili, A., Ghasabyan, M., Katzner, T., McGrady, M., Batbayar, N., Fuller, M. and Natsagdorj, T.2008. Conservation genetics and population history of the near threatened Eurasian Black Vulture *Aegypius monachus* (Falconiformes; Accipitridae). – Biol. J. Linn. Soc. 95: 859–872.

Ruiz, C., Poirazidis, K. and Schindler, S. 2006. Impacts on Wind Farms on Birds in Evros and Rhodopi, Greece: Preliminary results. – In: Houston, D. C. and 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, Athens, p. 157 .

Sidiropoulos, L. 2004. Transboundary monitoring and public awareness actions of 4 Vulture species and their habitats in the mountain range of Aridea (Greece) and Kavadartzi (F.Y.R.O.M.). – Technical report to BVCF/ FZS 2004.

Skartsi, Th. and Poirazidis, K. 2002. Management plan of Black Vulture population in the Protected Area of Dadia–Lefkimi–Soufli Forest. – WWF Greece, Athens. (In Greek.)

Skartsi, Th., Vasilakis, D. and Elorriaga, J. 2003. Black Vulture and Griffon Vulture Monitoring in National Park of Dadia–Lefkimi–Soufli Forest. – Annual Technical Report, WWF Greece, Athens.

Skartsi, Th., Elorriaga, J. and Vasilakis, D. 2008. Population size, breeding rates and conservation status of Eurasian Black Vulture in the Dadia National Park, Thrace, NE Greece. – J. Nat. Hist. 42: 345–353.

Stoychev, S., Hristov, H., Iankov, P. and Demerzhiev, D. 2004. Birds in the Bulgarian part of the Eastern Rhodopes. – In: Beron, P. and Popov, A. (eds). Biodiversity of Eastern Rhodopes (Bulgaria and Greece). 1st edn. National Museum of Natural History and Pensoft Publishers, Sofia, pp. 881–894.

Tewes, E., Terrasse, M., Sánchez, J. J., Fremuth, W. and Frey, H. 2004. Action Plan for the recovery and conservation of vultures on the Balkan Peninsula: activities and projects during 2002 and 2003. – In: Chancellor, R. D. and Meyburg, B.-U. (eds). Raptors Worldwide. Proceedings of the VI World Conference on Birds of Prey and Owls. WWGBP / MME, Budapest, Hungary, pp. 147–175.

Van Wyk, E., Bouwman, H., Van der Bank, H. ,Verdoorn, G. H. and Hofmann, D. 2001. Persistent organochlorine pesticides detected in blood and tissue samples of vultures from different localities in South Africa. – Comp. Biochem. Physiol. 129: 243–264.

Vasilakis, D. P, Poirazidis, K. S. and Elorriaga, J. N. 2008. Range use of a Eurasian Black Vulture (*Aegypius monachus*) population in the Dadia National Park and the adjacent areas, Thrace, NE Greece. – J. Nat. Hist. 42: 355–373.

Yamac, E. 2004. Studies on the Cinereous Vulture (*Aegypius monachus* L.). Population Biology in Turkmenbaba Mountain, Eskisehir, Turkey. – PhD thesis, Science Institute, Anadolou University, Turkey.

Zalles, J. I. and Bildstein, K. L. (eds). 2000. Raptor Watch: A global directory of raptor migration sites. – BirdLife Conservation Series No.9. BirdLife International, Cambridge, UK and Hawk Mountain Sanctuary, Kempto, PA, USA.