

At the crossroads from Asia to Europe: spring migration of raptors and black storks in Dadia National Park (Greece)

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Migrating raptors and black storks (*Ciconia nigra*) were studied in Dadia National Park, Greece, during spring 2003–2005. Vantage points and transects were used to evaluate magnitude, phenology, local variation and direction. We observed 23 species and 2030 individuals, including 715 common buzzards (*Buteo buteo*), 547 black storks and 136 short-toed eagles (*Circaetus gallicus*). Species-specific migration peaks were detected, starting in the second half of March, e.g. common buzzard, short-toed eagle, black stork, and ending early May, e.g. Levant sparrowhawk (*Accipiter brevipes*), red-footed falcon (*Falco vespertinus*), honey buzzard (*Pernis apivorus*). Most raptors were observed in the Evros valley, which may function as a migration corridor. The average direction of passing raptors was north. Species' proportions and phenology in the study area were similar to those in neighbouring Bosphorus and Marmara Flyways. Further migration monitoring should be established in the area, which will provide important information not least to inform wind farm development location.

Keywords: raptor migration; birds of prey; Thrace; Bosphorus; Dardanelles

Introduction

More than half of the Palaearctic raptor species are migratory with wintering grounds in southern Europe or Africa (Génsbøl 1997). Although some small raptor species cross the Mediterranean Sea in considerable numbers (e.g. Beaman and Galea 1974; Agostini and Logozzo 1995; Lucia et al. 2011), larger species tend to avoid crossing large water bodies (Richardson 1978) and form concentrations at the Straits of Bosphorus and Gibraltar (Bildstein 2006; Newton 2010). Recent studies show that different migration routes are adopted for spring and autumn migration (Panuccio 2011; Panuccio et al. 2011, 2012; Agostini et al. 2012). It is considered that raptors enter the Balkans in spring via the Bosphorus (Newton 2010; Üner et al. 2010), Crete, Antikythira and the Peloponnese (Lucia et al. 2011) and the Adriatic Flyway, i.e. Italy and the Strait of Otranto (Premuda et al. 2004, 2008; see also Denac et al. 2010). Alternative entry points in the close vicinity of the Bosphorus are the Dardanelles and Marmara Flyways via the Kapıdağ Peninsula, but peer-reviewed publications from these areas are scarce (Zalles and Bildstein 2000; Dochy 2006; Tuncali 2010).

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Spring migration studies in southeast Europe are rare and often focus on single species, such as the honey buzzard (Agostini et al. 2012) or the short-toed eagle (Panuccio et al. 2012), information on the spring migration of raptors crossing the Bosphorus, the most important migration bottleneck in this region, is insufficient (Newton 2010). Spring migration studies that include the entire raptor community usually cover only one season. At the Bosphorus, Üner et al. (2010) observed 47,000 raptors in spring 2006, and at Kapıdağ Peninsula, Tuncalı (2010) observed 6720 raptors and 50,000 other soaring birds during spring 2008. Denac (2010) observed 1710 migrating raptors in western Slovenia during spring 2010 but her surveys focused strongly on the honey buzzards and were only completed during May.

In Greece, little is known about raptor migration. Recent studies mainly deal with single species (Agostini et al. 2012; Kassara et al. 2012; Panuccio et al. 2012, 2013), Lucia et al. (2011) observed 797 migrating raptors at Antikythira Island in the Aegean Sea during 2007 and 2008, but further migration surveys of the entire raptor community are rare (but see Handrinos and Akriotis 1997; Panuccio et al. 2011). This is a particular issue in northeast Greece, where, due to the close proximity to the Strait of Bosphorus, it is assumed that many birds migrate but at the same time the area is the focus of considerable large-scale wind farm development (Vasilakis et al. 2011). Here, the last spring migration survey occurred probably in 1987, when De Nobel et al. (1990) observed 2831 migrating raptors during non-systematic surveys in the area of Porto Lagos.

In this study, we examined the spring migration of raptors and black storks in Dadia-Lefkimi-Soufli Forest National Park (hereafter Dadia NP) in Thrace, north-east Greece during three consecutive seasons, i.e. 2003, 2004 and 2005, as part of the systematic raptor monitoring conducted in the reserve (Poirazidis et al. 2009, 2010b, 2011a). Using 24 vantage points and 10 road transects, the study area was systematically sampled and the flights of migratory birds were mapped, to: (1) monitor the numbers and proportion of passing individuals, (2) evaluate the migration phenology of the most frequent species, (3) detect optimal migration spotting points in the study area and (4) determine the direction of migratory raptor species.

Material and methods

Study area

Dadia NP (41°13' N, 26°23' E) is situated in the Evros Prefecture of Thrace, Northeastern Greece, at the crossroads of migration flyways that connect southeast Europe with Asia Minor (Figure 1). It is part of the European Green Belt (Zmelik et al. 2011) and was declared a reserve in 1980 and a National Park in 2003. Dadia NP hosts a forest complex extending over 427 km², including two zones of strict protection (Catsadorakis and Källander 2010) and is characterized by valleys and hills covered by extensive oak and pine forests as well as a variety of other habitats such as cultivations, fields, pastures, torrents and stony hills (Poirazidis et al. 2004; Schindler et al. 2008). The reserve is considered a local hotspot of biodiversity (Kati et al. 2004, 2010; Poirazidis et al. 2010a), and breeding grounds of a unique assemblage of birds of prey (Poirazidis et al. 2010b, 2011a) including the last breeding colony of Eurasian black vulture (*Aegypius monachus*) in the Balkans (Skartsi et al. 2008; Vasilakis et al. 2008).

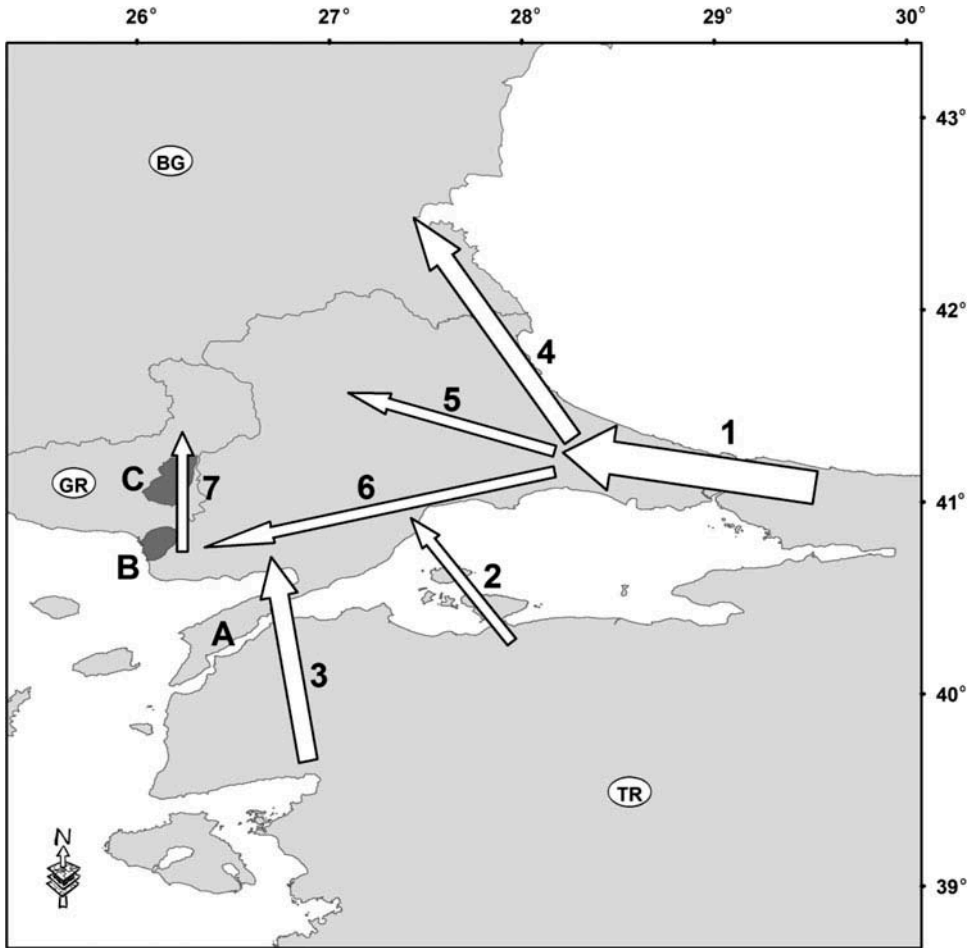


Figure 1. Dardia National Park (GR) at the crossroads from Asia to Europe. Letters refer to locations mentioned in the text, A: Dardanelles (TR), B: Evros Delta (GR/TR), C: Dardia NP (GR). Arrows symbolize the main raptor migration routes in spring, 1: Bosphorus (TR), 2: Marmara Flyway (TR), 3: Dardanelles (TR), 4: Black Sea coast (TR/BG), 5: Hypothetical flyway connecting Bosphorus with Central Bulgaria, 6: Flyway connecting Bosphorus and the Evros Delta (TR), 7: Flyway from the Evros Delta northwards along the western fringe of the Evros river floodplain (GR).

Raptor monitoring in the Dardia-Lefkimi-Soufli National Park

Conservation research and evidence-based conservation management have a long and successful history in the Dardia NP (Poirazidis et al. 2004, 2011b; Catsadorakis and Källander 2010; Schindler et al. 2011). The Systematic Raptor Monitoring programme started in 2000 and was fully implemented from 2001 to 2005 (Poirazidis et al. 2009, 2011a). The main aim was the monitoring of territorial raptor species during the breeding period, and an average of 23.8 ± 1.3 raptor species and 320.9 ± 15.5 territories were detected each year, implying an average density of 76.6 territories/100 km² (Poirazidis et al. 2011a).

As the Systematic Raptor Monitoring was designed for the monitoring of raptor breeding territories, five surveys were carried out each year from March to July, to ensure that each species was monitored when indications of presence and reproductive behaviour were most evident (Poirazidis et al. 2009). The same sampling scheme was applied each year: 5 h per month from each of 24 vantage points and 10 road transects (Figure 2). This implies a total of 170 h of survey per month (Poirazidis et al. 2009, 2011a). Colonial vulture species (griffon vulture *Gyps fulvus* and Eurasian black vulture) were excluded, whereas black storks were included, because of their ecological similarities with raptors. At the beginning, the Systematic Raptor Monitoring focused only on the local birds, but from 2003 until 2005 migrating individuals were also systematically recorded. Based on individual flight behaviour we distinguished between local, probably local, probably migratory and migratory birds. The final classification of each flight to the above categories was done during the territory estimation (Poirazidis et al. 2009) using all available data (records, territories, habitats, etc.) to minimize classification error. For this study, we used only records that were finally considered “migratory” or “probably migratory” and calculated for each species the total number of migrating individuals observed and mean \pm SD per year. To demonstrate migration phenology, we calculated for the most abundant species the number of migrating individuals for each third of the months March until May. We present the phenological pattern (1) averaged per survey day to account for weather-related differences in survey intensity and (2) averaged per year to avoid overestimation for periods with predominantly bad weather conditions and rather concentrated migration during a few days of good weather. Binoculars and telescopes were used for the surveys and all observations were mapped with a symbolic arrow marking the point where they were detected, their route through the sampling site, and the point where we lost their track.

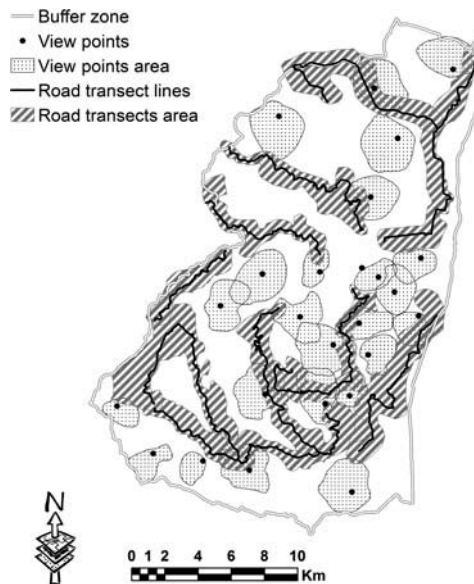


Figure 2. Sampling units of the systematic raptor monitoring in Dadia National Park.

Detection and end points were used to calculate the flight direction for each individual, which was subsequently summarized for the most abundant species.

Results

During the 3 years of systematic spring migration monitoring, we detected 2030 migratory individuals. Of these 715 (238.3 ± 80.7 per year) were common buzzards and 547 (182.3 ± 40.4) were black storks. The remaining 768 individuals consisted of 21 raptor species (Table 1), mainly short-toed eagles (totally 136; 45.3 ± 8.0 per year), Eurasian sparrowhawks (*Accipiter nisus*; 124; 41.3 ± 18.5), honey buzzards (114; 38.0 ± 23.3) and Levant sparrowhawks (93; 31.0 ± 23.5). The overall number of individuals changed from 739 (in 2003) to 662 (in 2004) and 629 (in 2005). This decrease was mainly related to lower numbers of common buzzards and black storks, whereas several other species (i.e. Eurasian and Levant sparrowhawks, honey buzzards and red-footed falcons) were observed in the highest numbers in 2005 (Table 1).

The phenology of migrating raptors and black storks in the study area showed two peaks: the most pronounced one during the second half of March, and a lower peak during the first 10 days of May (Table 2). The first peak was caused by common buzzards, black storks, short-toed eagles and Eurasian sparrowhawks, but the second peak was mainly related to migrating honey buzzards, Levant sparrowhawks, red-footed falcons and Eurasian hobbies. Most of the other less abundant migratory species, including marsh harriers (*Circus aeruginosus*) and lesser spotted eagles (*Aquila pomarina*), peaked during April in the study area (Table 2).

The majority of migratory raptors were observed from vantage points close to the lowland area of the River Evros, bordering Turkey. The vantage points with the best performance yielded an average of 8.7 species and 53.7 individuals per year (Figure 3). The average flight direction of all detected migrating individuals ($n = 2030$) was 359° , i.e. north (Figure 4). Only minor species-specific differences were noticed. For example, common buzzard (1°), and short-toed eagle (3°) tended to migrate very precisely northwards, Levant sparrowhawk (345°) and honey buzzard (347°) showed a very slight deviation towards the west and lesser spotted eagle (10°) and Eurasian hobby (9°) towards the east.

Discussion

Magnitude of migration

Due to strong differences in spatial coverage and sampling effort, comparing absolute numbers between migration studies should be treated with caution. That being said, it is considered that the Dardia NP is an important area for migratory raptors during the spring, with absolute numbers in the same order of magnitude as those recorded at the local bottlenecks of Antikythira Island (Aegean Sea; Lucia et al. 2011) and Breginjski Stol (northwest Slovenia; Denac 2010), but 10 and 70 times lower than at the major bottleneck at Kapidaž Peninsula (Tuncalı 2010) and the Bosphorus (Üner et al. 2010), respectively. Due to the shortcomings of the sampling strategy and to further reasons for underestimation, such as topography and weather (Denac 2010; Panuccio 2011), we must assume that the real numbers of the entire spring migration passing over Dardia NP are higher than those presented in this study. The area

Table 1. Number of migrating individuals detected during the systematic raptor monitoring in the Dadia NP. The proportion of individuals (%) only considers raptor species, not the black stork.

Species		2003	2004	2005	Total	Mean	SD	%
Common buzzard	<i>Buteo buteo</i>	268	300	147	715	238.3	80.7	48.2
Black stork	<i>Ciconia nigra</i>	201	210	136	547	182.3	40.4	–
Short-toed eagle	<i>Circus gallicus</i>	53	46	37	136	45.3	8.0	9.2
Eurasian sparrowhawk	<i>Accipiter nisus</i>	41	23	60	124	41.3	18.5	8.4
Honey buzzard	<i>Pernis apivorus</i>	31	19	64	114	38.0	23.3	7.7
Levant sparrowhawk	<i>Accipiter brevipes</i>	15	20	58	93	31.0	23.5	6.3
Marsh harrier	<i>Circus aeruginosus</i>	40	6	16	62	20.7	17.5	4.2
Red-footed falcon	<i>Falco vespertinus</i>	12	3	42	57	19.0	20.4	3.8
Eurasian hobby	<i>Falco subbuteo</i>	13	7	12	32	10.7	3.2	2.2
Lesser spotted eagle	<i>Aquila pomarina</i>	15	4	10	29	9.7	5.5	2.0
Eleonora's falcon	<i>Falco eleonora</i>	7	11	11	29	9.7	2.3	2.0
Hen harrier	<i>Circus cyaneus</i>	7	2	10	19	6.3	4.0	1.3
Common kestrel	<i>Falco tinnunculus</i>	10	3	4	17	5.7	3.8	1.1
Montagu's harrier	<i>Circus pygargus</i>	9	0	3	12	4.0	4.6	0.8
Booted eagle	<i>Aquila pennatus</i>	1	2	6	9	3.0	2.6	0.6
Pallid harrier	<i>Circus macrourus</i>	3	0	4	7	2.3	2.1	0.5
Osprey	<i>Pandion haliaetus</i>	4	0	3	7	2.3	2.1	0.5
Egyptian vulture	<i>Neophron percnopterus</i>	4	2	0	6	2.0	2.0	0.4
Black kite	<i>Milvus migrans</i>	2	1	2	5	1.7	0.6	0.3
Northern goshawk	<i>Accipiter gentilis</i>	2	0	2	4	1.3	1.2	0.3
Steppe eagle	<i>Aquila nipalensis</i>	0	3	0	3	1.0	1.7	0.2
Lesser kestrel	<i>Falco naumanni</i>	0	0	2	2	0.7	1.2	0.1
Greater spotted eagle	<i>Aquila clanga</i>	1	0	0	1	0.3	0.6	0.1
Total		739	662	629	2030	676.7	56.4	

probably fulfils the “bottleneck of European importance” criterion (Heath and Evans 2000) that states that 5000 or more storks, or 3000 or more raptors (Accipitriformes and Falconiformes) or cranes (Gruidae) pass regularly on spring or autumn migration.

Species composition

Spring migration in Dadia NP was particularly strong for common buzzard, black stork and short-toed eagle. These three species show the highest numbers and also showed higher proportions when compared with those from the Bosphorus and Antikythira (Üner et al. 2010; Lucia et al. 2011). The Kapıdağ Peninsula (Tuncali

Table 2. Number of migrating individuals per third of the month for the most abundant migrating species throughout the three years 2003, 2004 and 2005.

Species	\bar{x}_a/\bar{x}_d	March	March	March	April	April	April	May	May	May	June
		1–10	11–20	21–31	1–10	11–20	21–30	1–10	11–20	21–31	1–10
Number of survey days	Range	0–6	4–12	10–22	7–9	9–12	7–16	8–17	12–18	5–11	11–13
Common buzzard	\bar{x}_a	43.5	106.3	68.3	27.0	18.0	1.7	1.0	0.7	0	0
	\bar{x}_d	10.9	13.3	4.6	3.2	1.7	0.1	0.1	0.0	0	0
Black stork	\bar{x}_a	5.5	46.7	59.7	30.3	24.0	13.3	17.3	4.7	0	0
	\bar{x}_d	1.4	5.8	4.0	3.6	2.3	1.1	1.4	0.3	0	0
Short-toed eagle	\bar{x}_a	0	9.0	21.0	8.7	10.0	1.7	1.0	0	0	0
	\bar{x}_d	0	1.1	1.4	1.0	0.9	0.1	0.1	0	0	0
Eurasian sparrowhawk	\bar{x}_a	0.5	6.0	19.3	12.7	6.7	0.7	0.7	0	0	0
	\bar{x}_d	0.1	0.8	1.3	1.5	0.6	0.1	0.1	0	0	0
Honey buzzard	\bar{x}_a	0	0	0.3	0.3	0.7	5.7	18.0	7.7	3.5	5
	\bar{x}_d	0	0	0.0	0.0	0.1	0.5	1.5	0.5	0.5	0.3
Levant sparrowhawk	\bar{x}_a	0	0	0	0.3	0.7	5.3	18.0	7.0	0	0
	\bar{x}_d	0	0	0	0.0	0.1	0.4	1.5	0.5	0	0
Marsh harrier	\bar{x}_a	0.5	0	2.7	9.7	8.3	2.3	3.7	1.0	0.5	0
	\bar{x}_d	0.1	0	0.2	1.2	0.8	0.2	0.3	0.1	0.1	0.0
Red-footed falcon	\bar{x}_a	0	0	0	0.3	0.7	0.3	16.3	1.7	0	0
	\bar{x}_d	0	0	0	0.0	0.1	0.0	1.3	0.1	0	0
Eurasian hobby	\bar{x}_a	0	0	0.7	0.3	1.3	2.3	3.7	1.7	1.5	0
	\bar{x}_d	0	0	0.0	0.0	0.1	0.2	0.3	0.1	0.2	0.0
Lesser spotted eagle	\bar{x}_a	0.5	1.0	3.0	5.3	3.0	0	0	0	0	0
	\bar{x}_d	0.1	0.1	0.2	0.6	0.3	0	0	0	0	0
Others	\bar{x}_a	1.0	1.3	4.0	11.7	10.7	2.3	2.7	4.0	0.5	0
	\bar{x}_d	0.3	0.2	0.2	1.1	0.9	0.2	0.1	0.2	0.1	0.0
Total	\bar{x}_a	51.5	170.3	179.0	106.7	84.0	35.7	82.3	28.3	6.0	5.0
	\bar{x}_d	12.9	21.3	11.9	12.8	7.9	2.9	6.7	1.9	0.8	0.3

Notes: **Bold** values indicate migration peaks (in the case of “Total” also the secondary migration peak). Results are shown as arithmetic mean per year (\bar{x}_a) and per survey day (\bar{x}_d). The number of survey days per third of the month differed among years due to weather constraints.

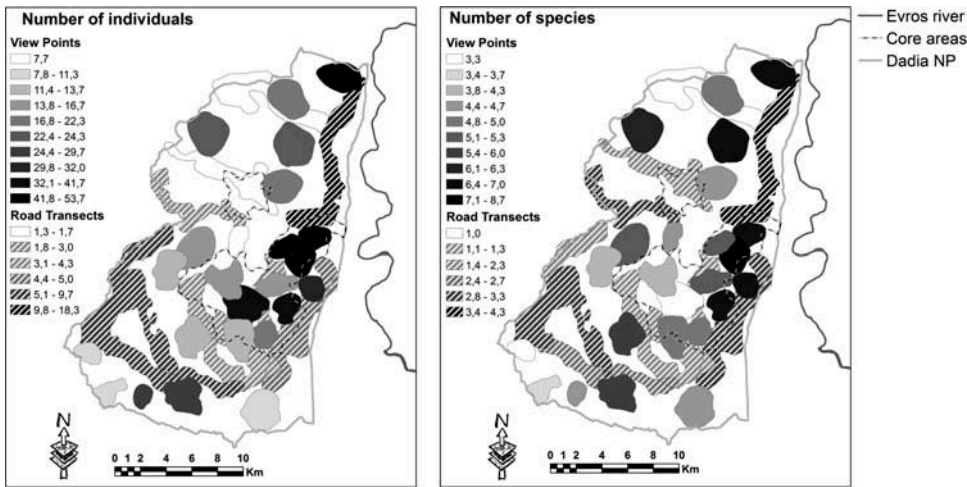


Figure 3. Performance of the 34 sampling units for raptor migration surveys. Numbers represent the average of migrating individuals and species among the three years 2003, 2004 and 2005. Each sampling unit was surveyed for 5 h in each of the five months March, April, May, June and July.

2010) was the only location where the proportion of short-toed eagle was equally high and the proportion of black stork was even higher than in Dadia NP. On the other hand, Dadia NP showed a lack of honey buzzards when compared with the proportions at the other sites, again with the exception of Kapidağ Peninsula (Tuncali 2010), where the proportion of honey buzzards was slightly lower than in our study area. Denac (2010) reported > 90% for honey buzzards for northwest Slovenia, but her study focused on this species with surveys during May only. The pronounced honey buzzard migration in Antikythira (Lucia et al. 2011) suggests that this long-winged species is better capable of crossing the sea and less constrained to the Eastern Flyway than broad-winged species (Panuccio 2011). Dadia NP showed a lack of lesser spotted eagle when comparing proportions with the Bosphorus (Üner et al. 2010) and the Kapidağ Peninsula (Tuncali 2010), and a lack of marsh harrier and black kite (*Milvus migrans*) when comparing proportions with Antikythira (Lucia et al. 2011).

Common buzzards, black storks and short-toed eagles are very abundant breeding species in Dadia NP (Poirazidis et al. 2011a) and some of the individuals observed during spring migration might proceed to the northern parts of Dadia NP or adjacent areas in northeast Greece or southern Bulgaria. However, the comparatively high numbers of short-toed eagles fit to the migration pattern recently discovered by Panuccio et al. (2011, 2012), who observed that this species migrates southwards through central Greece during spring and explained this pattern by suggesting that breeders from central and southern Greece perform a circular migration and enter via Bosphorus and Dardanelles to avoid the sea crossing along the Cretan–Peloponnese Flyway (cf. Lucia et al. 2011). This suggestion can be supported not only by the high proportion of migrating short-toed eagles in Dadia NP, but also by the westward migration in Porto Lagos (De Nobel et al. 1990). A similar pattern might be the case

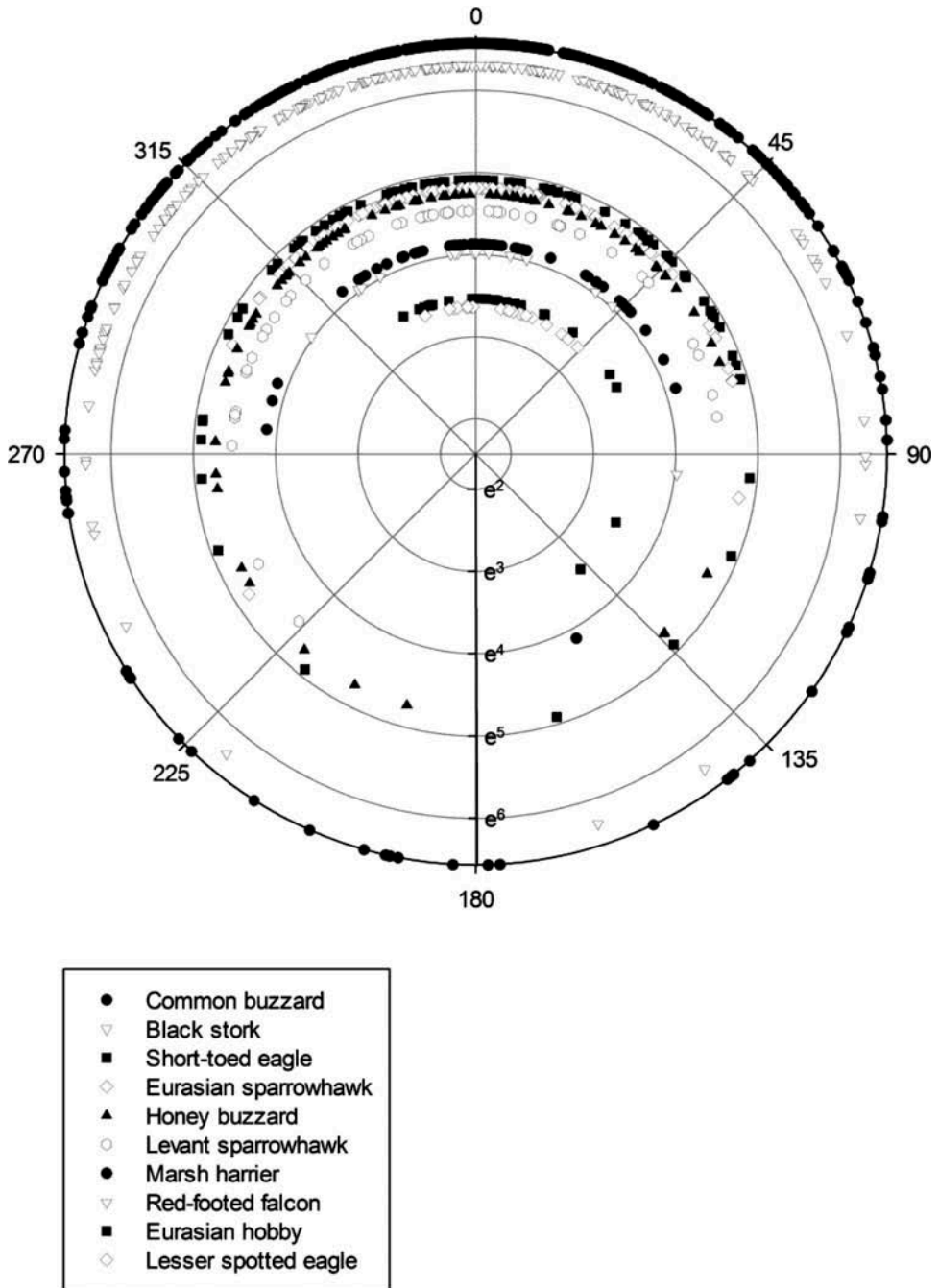


Figure 4. Polar plot of the directions of migrating raptors and black storks in Dardia NP during spring 2003, 2004 and 2005. The average direction considering all species was 359° . Species are located along the radial axes (scale: log natural) according to the number of individuals observed, ranging from the lesser spotted eagle ($n = 29$) to the common buzzard ($n = 715$).

for other broad-winged raptors such as the Eurasian and Levant sparrowhawk as well as the lesser spotted and the booted eagle (*Aquila pennata*), which all show higher proportions in Dadia NP than in Antikythira (Lucia et al. 2011). A possible reason for the lack of lesser spotted eagles when comparing proportions of Dadia NP with the Bosphorus and the Kapıdağ Peninsula might be a strong migration of this species along the Black Sea coast. This is supported by recent studies applying satellite telemetry (Meyburg et al. 2007; Meyburg and Meyburg 2009) and by autumn migration surveys at Bourgas Bay (Bulgarian Black Sea coast), where an average of 10,000 lesser spotted eagles per year were counted between 1979 and 2003 (Michev et al. 2011).

Migration phenology

We found two migration peaks for the Dadia NP: a main peak at the end of March, when the most common migratory species pass our study area, and a secondary peak at the beginning of May that mainly consisted of long-distant migrants. The detected migration phenology in Dadia NP is consistent with that recorded in other parts of the Central and Eastern Mediterranean and the Balkans. The highest numbers of common buzzards were counted in Dadia NP during the last 20 days of March, as was the case in Porto Lagos in 1987 (De Nobel et al. 1990), at the Bosphorus in 2006 (Üner et al. 2010) and at Kapıdağ Peninsula in 2008 (Tuncalı 2010). In Antikythira the peak occurred 1 month later (Lucia et al. 2011). Common buzzards detected in Dadia NP and at the Bosphorus winter probably in Turkey, whereas those detected in Antikythira might winter in Crete, where high winter densities occur (Tzortzakaki et al. 2012), and eventually in Africa. The late migration peak and the high proportion of immature common buzzards in Antikythira might indicate that the Cretan Flyway is mainly used by inexperienced, delayed or non-breeding individuals, whereas most reproducing individuals seemingly migrate towards their Greek breeding grounds from the east as suggested by westward spring migration in Porto Lagos (De Nobel et al. 1990).

The migration peaks of black storks, short-toed eagles and Eurasian sparrowhawks were recorded in Dadia NP during the last 10 days of March. Satellite-tracked black storks leave their African wintering grounds between mid-February and late March, intensively use the route via both the Kapıdağ Peninsula and the Bosphorus, and strictly avoid sea crossing along the Eastern Flyway (Bobek et al. 2003, 2008). At Bosphorus, the 25 March was the peak migration of black storks in 2006 (Üner et al. 2010), whereas in the study by Arslangündoğdu et al. (2011), the highest numbers of black storks were registered at the Bosphorus in the second 10-day period of April. At the Kapıdağ Peninsula most black storks crossed during the last week of March and the first week of April, but there were secondary peaks at 21 April and 2 May and migration remained high until the middle of May (Tuncalı 2010). Üner et al. (2010) detected a second peak, probably of non-breeders, in mid-May and for Dadia NP we observed a small secondary peak at the beginning of May. These secondary peaks might indicate that late birds, probably non-breeders, still choose to take the longer but less risky Eastern Flyway over Turkey. The short-toed eagle migration peak in the Dadia NP matches perfectly with the peaks at Porto Lagos (De Nobel et al. 1990), Bosphorus (Üner et al. 2010), Kapıdağ Peninsula (Tuncalı 2010) and Mount Olympus (Panuccio 2011). However, this species seems to migrate slightly

earlier through Italy (Baghino and Premuda 2007, but see also Premuda et al. 2010). Regarding the Eurasian sparrowhawk, the phenology observed at Dadia NP matches the peaks at Porto Lagos (De Nobel et al. 1990), the Kapidağ Peninsula (in 2008, 67% of the totally 323 individuals passed at 24 March; Tuncalı 2010), and the Bosphorus (in 2006, the migration peak occurred during the last week of March and the first week of April; Üner et al. 2010).

The lesser spotted eagles in Dadia NP showed a migration peak from the last 10 days of March until the second 10-day period of April. At the Bosphorus a more pronounced peak occurred in 2006 during the last days of March until the second week of April (Üner et al. 2010), whereas at the Kapidağ Peninsula the migration peak was very broad, lasting from the end of March until the middle of May (Tuncalı 2010). For Marsh harriers, the main migration period in the Dadia NP was the first 20 days of April, which matches perfectly with the migration phenology detected at the Kapidağ Peninsula (Tuncalı 2010), but less so with that observed at the Bosphorus, where a secondary peak in the last half of May was detected (Üner et al. 2010).

The migration peak in the Dadia NP during the first 10 days of May mainly consisted of honey buzzards, Levant sparrowhawks, red-footed falcons and Eurasian hobbies. At the Kapidağ Peninsula, 53% of honey buzzards observed crossed between the 5 May and 8 May, in Antikythira the maximum numbers were detected on the 5 May (Lucia et al. 2011), for the Bosphorus on the 12 May (Üner et al. 2010), for Porto Lagos between the 11 and 20 May, and for northwest Slovenia on the 14 May (Denac 2010). For Levant sparrowhawk, Üner et al. (2010) detected a migration peak at the Bosphorus on the 19 May. They observed very few birds in spring, contrasting with thousands of birds passing annually in autumn. At the Kapidağ Peninsula Tuncalı (2010) observed a total of 1726 Levant sparrowhawks between 27 April and 3 May, Porto Lagos was crossed by most individuals of this species on the 5 May (De Nobel et al. 1990). Panuccio et al. (2011) recorded Levant sparrowhawks migrating southward at Mount Olympus during spring and suggest also for this species that breeding populations of central and southern Greece tend to avoid the crossing of the Mediterranean Sea and concentrate at Bosphorus and/or Kapidağ Peninsula. Shirihihi et al. (2000) proposed that Levant sparrowhawks may prefer the eastern Black Sea migration route in spring, but the observations at the Kapidağ Peninsula (Tuncalı 2011) suggest that spring migration towards breeding grounds in the Balkans might bypass the Bosphorus also in the southwest. For red-footed falcon and Eurasian hobby the detected migration phenology matches the pattern from the Bosphorus, which shows a very pronounced and a less pronounced peak, respectively, during the first week of May (Üner et al. 2010).

Flight directions

It is generally assumed that the observed direction of migrating birds can provide some insights about their origin (Denac 2010). As migration routes are strongly affected by ecological barriers and geographical landforms (Kerlinger 1989; Panuccio 2011; Bohrer et al. 2012; Duerr et al. 2012; Panuccio et al. 2012), northern directions are not always the case during spring migration. For instance, in Antikythira (Lucia et al. 2011) raptors mainly headed in a northwest direction, and in northwest Slovenia raptors mainly headed in an eastern direction, whereas

migration towards the north and northeast accounted for only 10% (Denac 2010) of the observations. De Nobel et al. (1990) report considerable raptor migration mainly in a western direction along the edge of the Rhodopi Mountains.

Interspecific differences of the impact of intrinsic and extrinsic factors on migration strategies can be small (Mellone et al. 2012) or considerable (Bohrer et al. 2012). Although some variation could be found in Dadia NP among individuals, the average direction of migrating raptor species was always towards the north. The relatively small interspecific variation in flight direction may be caused by Dadia NP and the Evros valley being seemingly an important part of the migration corridor that connects northwest Turkey with Eastern Europe where large breeding populations of most species occur. For this reason, birds that cross Dadia NP from the east to west on their way to breeding grounds in the rest of Greece and adjacent areas are possibly outnumbered by those migrating north. The birds migrating westwards, however, may travel along the northern coastline of the Aegean Sea and south of the Rhodopi Mountains (De Nobel et al. 1990). As the Dadia NP is mainly approached from the south by migratory raptors, it can be assumed that most of the detected birds originate from the Evros Delta, approximately 20 km to the south. The Evros Delta is more than 250 km west-southwest from the Bosphorus, but only 100 km northwest from the Strait of Dardanelles and the recently described Marmara Flyway via Kapıdağ Peninsula, Marmara Island, Avşa Island, Paşalimanı Island and the Marmara Sea (Dochy 2006; Tuncali 2010; Boyla 2011). When comparing the species composition and migration phenology, Dadia NP shows slightly more similarities with the observations from Kapıdağ Peninsula at the Marmara flyway than with the Bosphorus. For this reason, we assume that Dadia NP receives, at least for some species, a good proportion of migrating raptors that enter Europe via the Marmara Flyway (see Figure 1).

Conclusions and recommendations

It is considered that the lower Evros valley and the foothills of the Rhodopi Mountains function as a corridor for migratory birds. The species observed in this study showed different migration patterns, caused by different morphological and biological constraints. Phenological patterns, but also migration routes at the large scale (e.g. Cretan Flyway versus East Mediterranean Flyway) and the smaller scale (Bosphorus versus Marmara Flyway) were affected by these differing constraints. Raptors and black storks that cross over the Dadia NP might breed in the immediate vicinity of Dadia NP, neighbouring areas or in the rest of Greece. However, most species have population strongholds in Eastern Europe and it is likely that these migratory birds proceed further north to their breeding grounds. To avoid sea crossings, most individuals seemingly used the Eastern flyway and entered Europe via the Bosphorus or at alternative locations at Dardanelles and the Kapıdağ Peninsula. Given the importance of the Bosphorus and the large knowledge gaps regarding the other two routes, raptor migration monitoring should be established at these three sites. Migration watch sites should also be established at several suitable points along the Evros valley, particularly because of booming development of wind farms in the area, which are a potential risk to migratory birds (Cárcamo et al. 2011; Vasilakis et al. 2011). Effective risk mitigation for wind farms requires well-designed

assessments that deliver high-quantity and high-quality data at fine spatial and temporal resolution (Kuvlesky et al. 2007; Carrete et al. 2012). For large and sensitive species, precise information on the distribution and abundance is required in this respect (Carrete et al. 2012). Alongside continuous monitoring of raptor breeding populations, as recommended by Poirazidis et al. (2011a, 2011b), raptor migration monitoring should be established in the Evros valley that should cover spring and autumn because migration patterns might differ between the seasons.

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