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# Movements of Immature Eurasian Spoonbills *Platalea leucorodia* from the Breeding Grounds of the Eastern Metapopulation in the Pannonian Basin

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**Abstract.**—Data on the movement of immature Eurasian Spoonbills from the southern Pannonian Basin are presented for the first time and differences in migration patterns between the Atlantic and southern Pannonian breeding populations are identified. Movements of spoonbills from Western Europe are well known, but there is uncertainty about the movements of the eastern metapopulation, of which the southern Pannonian population forms part. Analyses were based on 707 resightings in Europe and North Africa of 272 color-ringed birds. The studied birds wintered in North Africa (predominantly Tunisia) or southern Italy (Sicily and Sardinia). Most birds used the central Mediterranean flyway, but crossed the Adriatic Sea at more northern latitudes than had previously been reported. With increase in age, the ratio of birds spending the breeding period at the wintering sites decreased (54.2% for second-year and 13.6% for third-year birds), while the ratio of those returning to the Pannonian breeding grounds increased (37.5% and 66.6% respectively). Older spoonbills arrived back at their natal areas earlier. Immature spoonbills from the southern Pannonian Basin population visited breeding colonies in Germany, confirming at least sporadic contacts between two metapopulations. Identification of migration routes and wintering areas is a major precondition for the conservation of the eastern metapopulation. Illegal hunting, tourism development on staging areas and lack of suitable feeding habitats along flyway have been identified as the most important threats. *Received 6 July 2011, accepted 10 April 2012.*

**Key words.**—colour rings, Eurasian Spoonbill, *Platalea leucorodia*, migration routes, wintering areas.

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The Eurasian Spoonbill *Platalea leucorodia* has a patchy distribution ranging from the East Atlantic to India and China (del Hoyo *et al.* 1992; Triplet *et al.* 2008). The nominate subspecies breeds from Western to Central and Southeastern Europe. Two metapopulations: Atlantic (western) and Central/Southeastern (eastern) are recognized, differing in their distribution, migration routes and wintering areas (Triplet *et al.* 2008). While movements of the western population have been intensively studied (De le Court and Aguilera 1997; Bauchau *et al.* 1998; Overdijk and De le Court 2001; Overdijk *et al.* 2002; Navedo *et al.* 2010a; Lok *et al.* 2011), those of the eastern population are less well-known. Previous data, based on ringing recoveries, suggest that spoonbills from the eastern population winter in Tunisia or Libya, with a small number of birds also found south of the Sahara, in Egypt, Sudan, Niger and Mali (Hagemeyer and Blair 1997; Smart *et al.* 2007; Pigniczki 2010). The number of

spoonbills observed in their known wintering areas is low, indicating many gaps in knowledge relating to wintering sites of this population (Triplet *et al.* 2008). Some immature spoonbills may summer in Israel, Tunisia and probably also Algeria (Smart *et al.* 2007). Eastern metapopulation uses two distinct migration routes: one leads over the Adriatic Sea, through Italy to North Africa, and the other leads south-east, through the Balkans, Anatolia, the Middle East to Upper Nile river (Triplet *et al.* 2008).

The Eurasian Spoonbill and its breeding habitats are legally protected in most of Europe, but illegal hunting on staging areas and lack of suitable feeding habitats along flyways have been identified as the most important threats for the eastern metapopulation (Triplet *et al.* 2008). Identification of their staging and wintering areas is therefore crucial for conservation planning. The Pannonian Basin population, estimated at 1,450-1,750 breeding pairs, is part of

the Central/Southeastern metapopulation (Triplet *et al.* 2008). Approximately 270-480 pairs of spoonbills breed in its southern part including lowland Croatia and Vojvodina (northern Serbia). Movements of the Pannonian population are not well understood. An analysis of their movements has only been published for the Hungarian breeding population, based on metal-ring recoveries (Pigniczki 2010), while only preliminary results of color-ringing projects have so far been published (Mikuska *et al.* 2006; Pigniczki and Karcza 2006). Additional assumptions relating to the migration patterns of Pannonian spoonbills have been made, based on isolated recoveries and from data obtained for the Atlantic population (Smart *et al.* 2007). Recent observations of spoonbill flocks of up to 220 birds along the eastern Adriatic coast (Štumberger and Schneider-Jacoby 2010) indicated the importance of so-called "Adriatic Flyway" (Denac *et al.* 2010). In this paper we describe the movement of young and immature Eurasian Spoonbills from the breeding areas of the southern part of Pannonian Basin, based on resightings of color-ringed birds. The color ringing carried out in Croatia and Vojvodina (northern Serbia) was part of a general marking project coordinated by the Working Group for Spoonbills (based in the Netherlands). Color-ringing programs have an advantage over traditional ringing in that they result in a higher number of observations, and multiple sightings of individual birds. Their advantage over the use of satellite and radio transmitters is their typically much larger sample size. On the other hand, all ringing data (including color-ringing data) are highly influenced by spatial and temporal patterns in observer effort, especially if sightings are collected over a wide area and for longer periods (Korner-Nievergelt *et al.* 2010).

We focused on geographic distribution patterns throughout the year and distances between wintering and summering areas. In particular, we wanted to identify any differences in the patterns of movements of young spoonbills between the Atlantic and south Pannonian breeding populations.

## METHODS

In the Pannonian Basin, the Eurasian Spoonbill breeds on carp fishponds and in natural marshes, with nests situated in either reedbeds or low trees (Radović *et al.* 2003; Tucakov and Žuljević 2006). Ringing of spoonbills that breed in this area started in 1908, but the number of recoveries had been low: between 1908 and 2008 only 20 recoveries had been reported. In 2003 a color-ringing project, as a part of a general marking project coordinated by the Working Group for Spoonbills (based in the Netherlands), started in Croatia and Vojvodina (northern Serbia) which increased the number of resightings. Until 2009, a total of 910 nestlings had been color-ringed. We analysed the recovery data of these color-ringed spoonbills, adding a limited amount of data originating from metal-ring recoveries. Observations of color-ringed spoonbills were obtained from a network of both professional ornithologists and amateur birdwatchers in Europe and North Africa. Ring-readings originated from 113 locations, and were made by more than 130 observers. The monitoring technique and coverage were not uniform among the different wintering and staging areas. In Italy, between 2002 and 2007 a total of 3,699 Eurasian Spoonbills (an average of 617 per year) were counted during International Waterbird Census counts (IWC), most of them concentrated in Sicily, Sardinia, Puglia and Tuscany. In southern Italy, including Sicily and Sardinia, the counts were carried out at 23 sites (N. Baccetti, pers. com). In Tunisia, monitoring of spoonbills was also carried out through IWC, at 35 wetland Important Bird Areas (IBAs) and twelve potential IBAs, and also by specific spoonbill monitoring campaigns. Between 2007 and 2010 these activities resulted in a total of 9,151 spoonbills observed (an average of 2,288 per year) at 36 localities in Tunisia. Ninety-two per cent of all observations were obtained during the winter period (November to February) (H. Azafzaf/AAO, pers. com.). Data from other areas came from more casual observations of color-ringed birds. The observation effort on staging area was even less uniform, with low effort along the Adriatic flyway (Denac *et al.* 2010). However, organised waterbird counts carried out in January, March/April, June and October between 2007 and 2009 on the four most important wetland areas along the Adriatic flyway (Štumberger and Schneider-Jacoby 2010) resulted in only two observations of one ringed spoonbill.

## Analysis

As Eurasian Spoonbills do not breed until they are at least three years old (De le Court and Aguilera 1997; Bauchau *et al.* 1998), we analysed only resightings of immature birds until April of their fourth calendar year. Sixteen birds (2.26% of all reports) were found dead, so we combined resightings and recoveries in the analysis. For each report of the ringed bird, the loxodromic distance (rhumb line distance that maintains a constant direction and makes the same angle with all meridians) and direction of movements were calculated according to Imboden and Imboden (1972). For the analysis of the

direction of movements, we excluded repeated observations of the same bird in one month and only analysed the longest distance resighting from each month. Percentages of birds observed in any region during any particular period were calculated based on the total number of birds observed in that period. Mean values and standard error were used for distance and direction. A Chi square test was used, with Yates correction applied when  $df = 1$ . The circular statistic was used for analysis of the spatial distribution of spoonbills (Zar 1999). The mean angle was calculated only when Rayleigh's Uniformity test confirmed non-uniform distribution. We used the Watson-Williams F-test (the circular counterpart of Fisher's analysis of variance) to test the variation of the mean direction at which spoonbills were observed during the same stage of the annual cycle between different age groups.

Stages of the Eurasian Spoonbill's annual cycle were assessed according to Cramp and Simmons (1977), specifically: the breeding period lasting from May to July, dispersal and post-breeding migration from August to October, wintering from November to February and spring migration from March to April. However, Cramp and Simmons (1977) allow that migration might also take place in February and November. In our study, all observations of south Pannonian spoonbills recorded in February were at their recognised wintering sites, as were more than 75% of observations submitted for November. Records from these two months were therefore included by us as being in the wintering period. Oriana 3 software (Kovach Computing Services 2010) was used for analysing circular data, and Statistica ver. 7.0 (StatSoft 2004) for linear data.

## RESULTS

In the period 2003 to 2009, a total of 272 immature birds (29.9% of all color-ringed birds) were observed, with 707 resightings altogether, or 2.6 observations per reported bird (Table 1). After excluding monthly repeated observations, 423 resightings were included in the analysis of the direction of movements.

Ringed immature spoonbills were observed in 16 countries, from Spain to Romania and from Scotland to sub-Saharan Africa (Fig. 1). Resightings were grouped by region according to: breeding area, i.e. the Pannonian Basin ( $N = 417$ ), wintering area ( $N = 169$ ), and localities that include stopover sites on migration and dispersal ( $N = 121$ ). The Pannonian Basin group encompasses resightings from lowland Croatia, Vojvodina (northern Serbia), Hungary, eastern Austria and western Romania. During winter time

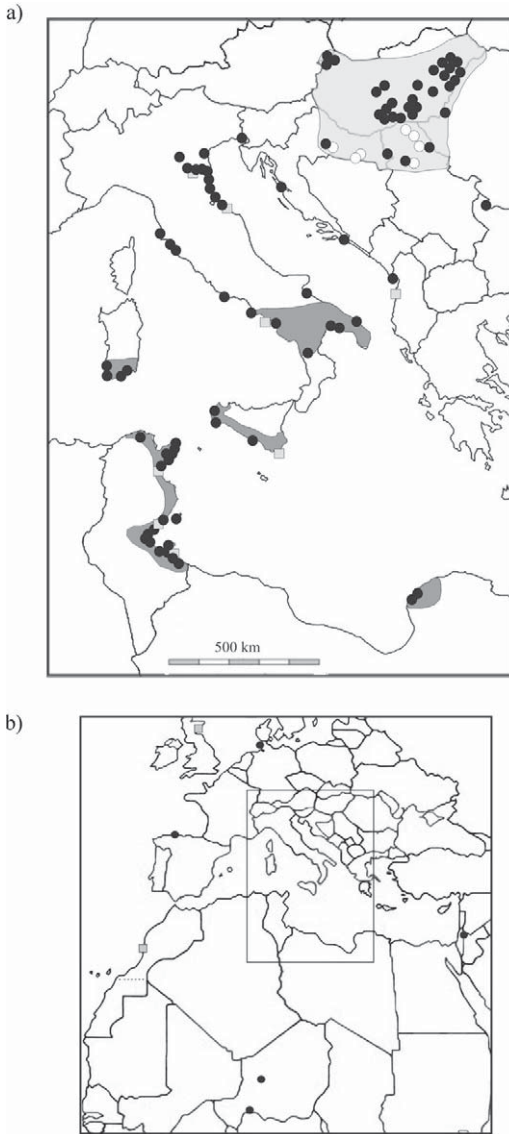
**Table 1. Number of resighted and recovered color-ringed and metal-ringed Eurasian Spoonbills and number of observations in the first three years of their life. Fourth year includes only the period until April.**

Year	Color-rings		Metal rings
	Number of observed birds	Number of resightings	Number of recoveries
1st	189	416	7
2nd	74	125	5
3rd	52	137	7
4th	18	29	1

(November to February) spoonbills were observed in two distinct geographic areas: northern Africa and southern Italy with one observation in Israel. Wintering grounds were mostly situated between  $32^\circ$  and  $41^\circ$  N. The majority of African resightings were from Tunisia (94%,  $N = 74$ ), with two observations in Libya (3%) and two recoveries from sub-Saharan Africa, namely Niger (3%). The most important wintering localities in Tunisia were Thyna saltpans, Lake Ichkeul, the Gulf of Gabes and the Gulf of Boughrara, while in Italy the saltpans near Trapani (Sicily) and the surroundings of Cagliari (Sardinia) were the main areas used. The third group of resightings appeared to be stopover sites along migration routes and areas of dispersal, with majority of recoveries reported along eastern and north-western Adriatic coast and western Italian coast. The average distances of all resightings were shorter for 3rd year than for 2nd year birds (Table 2). These differences were statistically significant for May, August and October (t-test, May:  $t = 3.75$ ,  $P < 0.005$ ; Aug:  $t = 2.61$ ,  $P < 0.05$ ; Oct:  $t = 2.25$ ,  $P < 0.05$ ).

### Wintering and Breeding Areas

From the 272 birds observed during the first three years of their life, 83 (30.5%) were recorded on the wintering grounds. Altogether, 57 birds with 98 resightings were observed in Africa (68.7% of birds recorded in the wintering area), and 26 birds with 71 resightings (31.3%) were observed in southern Italy during the first three years of their life. Young and immature birds were observed in these areas in all months, but no



**Figure 1.** Resighting sites of Eurasian Spoonbills ringed in the southern Pannonian Basin. a) The main range of south Pannonian spoonbills; b) Outlying recoveries. Symbols: light grey - area with observations considered to belong to the breeding area in the Pannonian Basin, dark grey - wintering area, open circles - breeding colonies, black circles - resightings of color-ringed birds, grey squares - recoveries of metal-ringed birds.

single bird was observed both in southern Italy and Africa. The mean direction between natal colonies and wintering sites was  $210.5^\circ \pm 1.5^\circ$  for Africa, and  $221.7^\circ \pm 1.7^\circ$  for Italy with a statistically significant difference ( $F = 24.907$ ,  $P < 0.001$ ). The majority of the birds

recorded in Africa were observed in only one year (87.7%), whereas repeated observations of the same bird in successive years were significantly more common in southern Italy ( $\chi^2_1 = 7.79$ ,  $P = 0.005$ , Fig. 2). The difference might be the result of the different observation effort in the two wintering areas: ring-readings from Italy were reported by 42 observers, while from Tunisia only 18 observers were involved. The mean distance between wintering locations of the same bird in successive years was  $7 \pm 4$  km for Italian sites, and  $368 \pm 167$  km for African sites (due to the movement of the birds between Tunisia and Libya). There were no observations of young spoonbills in the Pannonian Basin between November and February.

The directions of spoonbill movements during the winter period were not significantly different among age classes ( $F = 1.369$ ,  $P = 0.26$ ), while the directions obtained during the species' breeding period were significantly different ( $F = 14.596$ ,  $P < 0.001$ ), which was the result of the difference between movements of 1st year and 2nd year birds ( $F = 34.07$ ,  $P < 0.001$ ). The percentage of birds observed in Africa and southern Italy during the species' breeding period (May to July) decreased with the age of the birds: 54.2% of all 2nd year birds observed in that period ( $N = 24$ ) and 13.6% of 3rd years ( $N = 22$ ), but the difference was not significant ( $\chi^2_1 = 3.05$ ,  $P = 0.08$ ). The ratio of birds observed in the Pannonian Basin during March and April (during return migration) increased with the age of the birds: 7.1% ( $N = 14$ ) in 2nd year birds, 18.2% ( $N = 11$ ) in 3rd year birds and 53.3% ( $N = 15$ ) in 4th year birds. The difference between the ratio of 1st and 3rd year birds observed in the Pannonian Basin in March and April was significant ( $\chi^2_1 = 5.22$ ,  $P < 0.05$ ). Between May and July 37.5% of all 2nd year birds observed in that period, and 66.6% of all 3rd year birds, were recorded in the Pannonian Basin.

#### Migration Routes

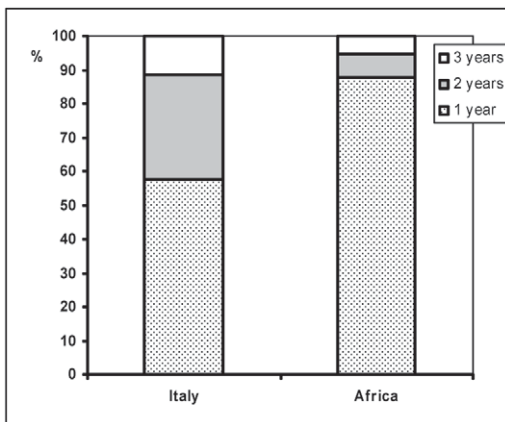
Spoonbills from the southern Pannonian Basin mostly used the Central Mediterranean migratory route, flying south-west over



**Table 2. Number of resightings and average, minimum and maximum distances (km) of observed Eurasian Spoonbills from the southern Pannonian Basin per month in the first three years of their life (N = 423).**

	1st year		2nd year		3rd year		4th year	
	N	distances	N	distances	N	distances	N	distances
Jan			7	1,056 521 - 1,497	6	1,286 980 - 1,517	5	1320 612 - 1,596
Feb			5	1,952 1,428 - 3,683	4	1,231 980 - 1,529	1	1,145
Mar			6	984 88 - 1,589	2	747 514 - 980	4	904 507 - 1,447
Apr			8	1,211 1,044 - 1,487	9	949 51 - 1,447	11	282 0 - 1,329
May			7	910 90 - 1,315	9	303 62 - 628		
Jun			12	759 51 - 1,560	7	360.5 77 - 1,447		
Jul	41	113 0 - 372	6	573 22 - 1,245	13	336 4 - 1,447		
Aug	76	243 37 - 1,245	15	882 51 - 1,329	15	427 77 - 1,539		
Sep	62	193 37 - 1,568	10	595 51 - 1,393	4	266 113 - 240		
Oct	32	644 94 - 3,429	6	1,142 908 - 1,447	7	628 94 - 1,149		
Nov	5	1,028 560 - 1,527	6	1,165 612 - 2,033	4	1,005 612 - 1,169		
Dec	12	1,068 560 - 1,519	3	1,051 973 - 1,149	3	753 612 - 1,034		

the Adriatic Sea, to Italy and North Africa, from where only small numbers continued to fly on across the Sahara. The use of the eastern route, through the Balkans and Middle East to Egypt and Sudan was confirmed for only one bird. Resightings of 1st year spoonbills during the autumn migration showed that movement was in two direc-



**Figure 2. Proportion of all Eurasian Spoonbill observations in Italian and African wintering grounds observed in 1st, 2nd and 3rd years (N = 83).**

tions: the majority (80.7%) travelled SW or SSW to the Tyrrhenian coast of Italy, Sardinia and Sicily (mean direction:  $225.8^\circ \pm 2.8^\circ$ ), while others took a more western route and were reported from the much more northern Italian region of Emilia-Romagna (between Modena, Ravenna and Rimini, mean direction:  $262.2^\circ \pm 4.7^\circ$ ). The difference between directions was significant ( $F = 34.113, P < 0.001$ ). During spring migration, 21% of observed 3rd year birds were found on Italian north-Adriatic coasts, and four birds were found during the summer, and even during the next winter, on the northern Adriatic Sea coasts (around Gorizia).

### Dispersal

Upon fledging, in May and June, young spoonbills mostly remained around their natal colonies. The post-natal dispersal started in July, but birds stayed within the Pannonian Basin (maximum distance = 372 km, average =  $113 \pm 14$  km, mean direction =  $4.98^\circ \pm 5.53^\circ$ ). Post-breeding migration started in August. In August and September the major-

ity of resightings were from the Pannonian Basin (81% and 88% respectively), but six birds (5.2%) had already reached southern Italy and Tunisia (the earliest observation in Tunisia was on 17th August). The percentage of resightings in the wintering area increased in October to around 40%.

The directions in which the spoonbills were seen travelling during dispersal and migration were significantly different among age classes (spring:  $F = 20.098$ ,  $P < 0.001$ ; autumn:  $F = 6.343$ ,  $P < 0.005$ ). During autumn migration, the difference was the greatest between 2nd and 3rd year birds (mean values: 2nd:  $214.8^\circ \pm 11.7^\circ$ , 3rd:  $259.1^\circ \pm 22.2^\circ$ ,  $F = 11.675$ ,  $P = 0.001$ ) while in spring between 2nd and 4th year birds (mean values: 2nd:  $213.1^\circ \pm 10.3^\circ$ , 4th:  $297.7^\circ \pm 29.0^\circ$ ,  $F = 11.534$ ,  $P < 0.005$ ). Six immature birds (6% of all 2nd to 4th year birds observed outside the wintering period) were found on foreign spoonbill breeding colonies far from their natal sites: at Lake Neusiedl in Austria (303 km NNW), in Valle Doga (513 km SW) and Valli de Ravenna (450 km WSW) in Italy, and in Speicherkoog in Schleswig-Holstein in Germany (1,243 km NW). These colonies were mostly visited during the spring and autumn migration period. One 2nd year bird was observed in November in Villaviciosa in Spain (2,032 km W of its natal colony), at a stopover site of West European spoonbills.

### Metal Ring Recoveries

Apart from color-ringed birds, 20 Eurasian Spoonbills ringed with a metal ring only were recovered during the first three years of their life (Fig. 1). Two recoveries refer to birds observed alive; others were either shot or found dead. The majority of recoveries were from Italy and Tunisia but two of them extend our knowledge about winter distribution: during December and February young spoonbills were found in coastal Albania and on the Atlantic coast of Morocco.

### DISCUSSION

The analysis of recoveries of color-ringed spoonbills from the southern Pannonian

Basin identified a new wintering area and revealed differences in migration strategies between two metapopulations. Previous papers suggest that Eurasian Spoonbills from the eastern metapopulation winter in Tunisia and Libya and probably also in Egypt, with small numbers south of the Sahara (Hagemeijer and Blair 1997; Smart *et al.* 2007; Cepak *et al.* 2008; Pigniczki 2010). Our study showed that spoonbills from the southern Pannonian Basin wintered both in North Africa and southern Italy, with 31.3% of observed birds found wintering in Europe. The spoonbill wintering population in the coastal zone of southern Tunisia was estimated to be 3,000 birds, which represents between 20-50% of the eastern metapopulation (Azafzaf *et al.* 2006). Recoveries of ringed birds showed that Tunisia is the wintering area for spoonbills breeding from the Netherlands to Greece (Smart *et al.* 2007). The Italian wintering spoonbill population seems to have increased recently and is now estimated to be 500-650 birds (Volponi *et al.* 2008), but up to 863 spoonbills were counted in January 2007 (N. Baccetti, pers. comm.). Important wintering sites have been identified in Sicily and on the west Italian coast (Baccetti *et al.* 2002). The estimated Italian wintering population size equates to less than 10% of the eastern metapopulation, but the percentage of wintering birds originating from the southern Pannonian Basin may well be much higher. The number of birds observed in the wintering area during more than one season, and the lack of observations of any one bird in both south Italy and Africa, indicate fidelity to wintering areas. High winter fidelity of the western metapopulation is already known, but we did not record movements toward more southern wintering areas between 1st and 2nd winter, as reported by Lok *et al.* (2011).

The main wintering area of spoonbills breeding in Spain is the delta of the Senegal River, ca 2500 km from the natal colonies (De le Court and Aguilera 1997). Birds from the Dutch colonies winter in Senegal and Mauritania at distances of ca 4200 - 4500 km (Bauchau *et al.* 1998). Compared with those from the Atlantic metapopulation,

birds from the southern Pannonian Basin fly much shorter distances to wintering sites: 700-1200 km to southern Italy and 1200-1600 km to Tunisia. More than one third of observed 2nd year birds and two thirds of 3rd year spoonbills from the southern Pannonian Basin spend their summer in their natal area. In contrast, for the Spanish population, only a few young birds returned to their natal area during the breeding season (De le Court and Aguilera 1997). The higher percentage of young spoonbills that return to their breeding areas in the southern Pannonian Basin might be a consequence of the shorter distances between breeding and wintering areas. Shorter distances are also shown to be positively correlated with higher spoonbill survival (Lok *et al.* 2011).

The proportion of young birds spending summer in the wintering areas decreased with their age, while the percentage of birds returning to their natal area and the period of their stay in the Pannonian Basin increased. With increasing age, spoonbills arrived back in their natal area earlier, this being the case already established for the western population (De le Court and Aguilera 1997).

Smart *et al.* (2007) described the migration route of spoonbills through the Central Mediterranean as leading from the Pannonian Basin to Albania, southern Italy and Sicily to North Africa. These authors assumed that spoonbills cross the Adriatic Sea at its narrowest place - the Strait of Otranto. Certainly, observations of birds in Montenegro and Albania confirm migration along the Adriatic flyway. However, a great number of spoonbills from the southern part of the Pannonian Basin seem to cross the Adriatic Sea at more northern latitudes. Such is confirmed by the 37 resightings from central and northern Italy in the period from August to October, and from observations of spoonbill flocks overflying the Adriatic Sea. The passage of spoonbills was even observed on the isolated offshore island of Palagruža, situated in the middle of the Adriatic Sea (project "Fauna of Croatian islands", Natural History Museum Zagreb, unpublished data). Spoonbills from the southern Pannonian Basin have therefore proved to be

more ready to undertake a long sea crossing than was previously thought. Although 57 spoonbills have been observed in Tunisia and Libya, not a single bird found in Africa has also been observed at any stopover site during the previous migration period. We postulate that spoonbills either travelled the distances between breeding and wintering sites in a single journey (Navedo *et al.* 2010b), that they made stopovers of very short duration, or that they used some different route, still to be confirmed. Certainly, studies of the western population demonstrated longer stopover durations for spoonbills wintering in Africa compared to those wintering in Europe (Navedo *et al.* 2010b). However, the underlying reason for the low number of resightings might also be due to the low observation effort along the Adriatic flyway where flocks of spoonbills have been observed (Štumberger and Schneider-Jacoby 2010) but there were no ring-readings to confirm their origin. Illegal hunting and disturbance were identified as the primary threats to waterbirds migrating along the Adriatic flyway (Denac *et al.* 2010).

Only one spoonbill from the studied area was seen in Israel, suggesting the use of the eastern flyway, but the same bird was also observed in Tunisia 29 days later. In contrast, Hungarian breeders were shown to use both flyways, but comparison between old metal-ring recoveries and more recent observations of color-ringed birds showed a decrease in numbers of recoveries along the eastern flyway (Pigniczki 2010). The lack of records along the eastern flyway might to a certain extent be a consequence of the lower observation effort compared to more western areas (Busse 2000).

During July, most 1st year birds moved towards the north and east-northeast because their colonies are situated in the southern part of the species' breeding range and good foraging sites exist north of their colonies. Some immature birds dispersed far north to Austria, Germany and Italy. This may represent exploratory movements (Berthold 2001), such as to investigate potential future breeding sites. It is known that spoonbills may breed quite far



from their natal area. One Croatian bird was found breeding in southern Bohemia (510 km NNW), at a colony that was presumed to originate from birds from the Pannonian Basin (Cepak *et al.* 2008). Birds from the Balkans are also considered to be the most likely source of colonisation for the recently established and increasing Italian breeding population (Volponi *et al.* 2008). One bird ringed in the southern Pannonian Basin during its second summer reached a spoonbill colony in Germany (Günther 2008), 1,243 km NW from its natal colony. Long-distance dispersion has also been recorded within the western metapopulation (De le Court and Aguilera 1997). Spoonbills from this metapopulation have been found breeding between 1837 km and 4170 km from their natal colonies. In spite of such long-distance movements, there has been a view, already expressed some decades ago by Brouwer (1964), that eastern and western spoonbill populations are isolated. More recently, it has been known that western and eastern metapopulations sporadically come into contact in the wintering areas (Smart *et al.* 2007). However, movements of several individuals from the southern Pannonian Basin population showed that some of these birds not only visit wintering areas (Morocco) or stopover sites (Spain) of the western metapopulation, but also visit their breeding colonies (Germany). As far as we are aware, the resighting from Germany was the first record of a spoonbill from the eastern metapopulation in the vicinity of a western colony.

The lack of uniformity in the sighting efforts between areas is the source of a bias that cannot be quantified in the present case, but the main wintering areas were relatively well covered by IWC, monitoring of IBAs, organised field trips and the efforts of individual ring-readers. Other possible wintering areas, especially in North and sub-Saharan Africa, as well as possible stopover sites along the Adriatic flyway were poorly covered.

The study shows some differences in migration strategies of eastern and western spoonbill metapopulations. Birds from the southern Pannonian Basin cover shorter

migratory distances and high percentage of immature birds spend summer in their breeding areas. Wintering grounds of 30-40 % of eastern metapopulation are still unknown (Triplet *et al.* 2008), therefore more detailed studies are needed to understand the wintering area selection. The continuation of this study and more intensive observation effort, especially within the Adriatic flyway and in sub-Saharan areas is needed for identification of the exact migration routes used by spoonbills from the southern Pannonian Basin. Identification of previously unrecognised migration routes and wintering sites may help to ensure better conservation of south Pannonian spoonbills outside the breeding area, especially through improvement of wetland connectivity along their migration routes (Haig *et al.* 1998; Denac *et al.* 2010). Further studies may contribute to a better understanding of possible gene-flow between metapopulations.

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