

Spatiotemporal distribution of Eurasian Spoonbills (*Platalea leucorodia*) outside the Carpathian Basin – the results of the Hungarian colour-ringing project based on twenty years (2003–2023)

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Abstract The Eurasian Spoonbill (*Platalea leucorodia*) is a migratory waterbird. We used the confirmed observations of colour-ringed individuals (2,735 specimens) of the Hungarian population collected outside the Carpathian Basin between May 2003 and February 2023. 546 Spoonbills occurred in 28 countries. They used mainly the Central Mediterranean Flyway, however, some individuals were seen along the East Atlantic Flyway or the East Mediterranean Flyway. Three individuals were observed north of the Alps, too. A small proportion of Spoonbills crossed the Sahara and they occurred in the Sahel zone, between Sudan in the east and Senegal and Mauritania in the west. A few individuals were observed on Saharan wetlands in Algeria during winter. The most important destination for the Hungarian (Pannonian) population during the migration is Tunisia, where many of them spend the winter, primarily in the tidal area of the Gulf of Gabes. The first adults reached North Africa (Tunisia) on 28 July during their southward migration, while the last ones stayed there until 23 April. The first observation of juveniles in North Africa (Tunisia) happened on 31 August. Immature, 2- and 3-year-old birds spend the summer in unknown numbers in Tunisia. The majority of Pannonian Spoonbills migrate through the Balkans and Italy and some stay there to winter, mainly in Italy. Some of the immatures spent the summer in Italy. In southern Europe, the peak of the spring migration was in March, and the peak of the autumn migration was in September. There was also a difference in the migration of different age groups: in Southern Europe, the migration peak of adult birds falls between March and April, while most of the immatures were observed in May and June during northward migration. The peak of the southward migration in all age groups was observed in September. In the southern part of Europe, there may still be adults migrating north on 13 May, while other adults may already migrate southward on 15 May. The earliest juvenile migrating south was documented on 30 June in Italy.

Keywords: bird migration, summering, wintering, Mediterranean areas, Sahara, Sahel, Gulf of Gabes, Tunisia, Italy

Összefoglalás A kanalasgém (*Platalea leucorodia*) vonuló vízimadár. Ebben a tanulmányban a magyar populáció színes gyűrűs egyedeiről (2735 pd.) húsz év alatt (2003 május – 2023 február között), a Kárpát-medencén kívül összegyűjtött megfigyeléseket használtuk fel, amelyek 547 egyedről 28 országból érkeztek. A kanalasgémek vonulásuk során elsősorban a Közép-Mediterrán Madárvonulási Útvonalat használták, de néhány példányt a Kelet-Atlanti, vagy a Kelet-Mediterrán Madárvonulási Útvonal mentén is észleltek. Három egyedet megfigyeltek az Alpoktól északra is. A kanalasgémek egy kis hányada átkelt a Szaharán és a Száhel Szudán illetve Szenegál és Mauritánia közé eső területein fordultak elő. Néhány példány télen Algériában, szaharai vizes élőhelyeken került elő. A magyar (pannon) populáció számára a vonulás során a legfontosabb célterület Tunézia, ahol sokan át is telnek, elsősorban a Gabesi-öböl árapály zónájában. Észak-Afrikát (Tunézia) az első öregek július 28-án ér-

ték el az őszi vonulásuk során, míg az utolsók április 23-ig kitarthatnak. A fiatalok első észak-afrikai (tunéziai) megfigyelése augusztus 31-én történt. Az ivaréretlen, 2. és 3. naptári éves madarak ismeretlen mennyiségben átnyaralnak Tunéziában. A hazai kanalasgémek többsége a Balkán-félszigeten és Olaszországon átvonul. A hazai populációból a legtöbb madár Olaszországban tel a dél-európai területek közül, a Balkánon csak néhány tölti a telet. Az ivaréretlen madarak egy része Olaszországban átnyaralt. Dél-Európában a tavaszi vonulás csúcsa márciusban van, az őszi vonulás csúcsa pedig szeptemberre esik. Eltérés van a különböző korcsoportok vonulásában is: Dél-Európában az öreg madarak tavaszi vonulási csúcsa márciusra és áprilisa esik, míg a legtöbb ivaréretlen május és június során észlelték. Az őszi vonulás csúcsa minden korcsoportnál szeptemberre esett. Európa déli részén május 13-án még észak felé vonuló öreg egyedek is lehetnek, míg más öregek május 15-én már déli irányba vonulhatnak. A legkorábbi, déli irányba vonuló fiatal június 30-án észlelték Olaszországban.

Kulcsszavak: madárvonulás, átnyaralás, telelés, mediterráneum, Szahara, Száhel, Gabesi-öböl, Tunézia, Olaszország

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Introduction

The nominate race of the Eurasian Spoonbill (*Platalea leucorodia*) (hereafter Spoonbill) breeds in a wide zone in Eurasia from the Atlantic coast of Europe east to the Pacific coast of Asia with breeding populations in India and Sri Lanka (Triplet *et al.* 2008). While the population is increasing in coastal West Europe, other European populations are declining (Champagnon *et al.* 2019). The European breeding population comprises at least four flyway populations (Pigniczki 2022). The Hungarian breeding population belongs to the Pannonian breeding population and primarily uses the Central Mediterranean Flyway to reach its most important wintering areas. The majority of Spoonbills marked in Hungary returned to the Carpathian Basin to breed (Pigniczki 2009, Pigniczki & Végvári 2015). The breeders arrive in their Hungarian nesting areas between the second half of February and May (Pigniczki 2021). The Hungarian breeding population reached its lowest size by the middle of the 20th century and was estimated at 280 pairs. Later, this population started to increase and it was estimated at 450–700 pairs in the 1990s, 850–1,300 pairs between 2002 and 2013, and finally 550–900 pairs between 2014 and 2020 (Pigniczki 2021). The bulk of the Pannonian individuals are short-distance migrants and winter in the Central Mediterranean areas, however, there are a few long-distance migrants amongst them, which winter in the Sahel zone, while a few individuals are residents and stay in the Carpathian Basin even in winter (Pigniczki 2010, 2022, Kralj *et al.* 2012).

Spoonbills predominantly depend on shallow wetlands during their life, including breeding, migration, and wintering (Pigniczki & Végvári 2015, Pigniczki 2022). For conservation purposes, it is important to analyse the spatiotemporal distribution of the Hungarian breeding population. In this paper, the observations and recoveries of the colour-ringed Spoonbills are collected from outside the Carpathian Basin.

Material and Methods

2,735 Spoonbill chicks were marked in Hungary with colour rings between 2003 and 2022. For this study, only those records were used that were collected outside the Carpathian Basin between May 2003 and February 2023. Three types of colour-ringing schemes were used in the Hungarian colonies (see details in Pigniczki 2022). The colour-ringed Spoonbills can be identified with telescopes even from large distances (up to 300–400 m). Professional and amateur ornithologists collected the observations of colour-ringed individuals in Europe, the Middle East, and Africa. In several cases, special ring-reading expeditions were organised to Tunisia to find as many colour-ringed Spoonbills as possible.

The dataset was analysed to identify Spoonbills' spatial and temporal distribution outside the Carpathian Basin. For the analysis, three age groups were created: 1) juveniles, 2) immatures, and 3) adults. A bird was treated as a juvenile in the calendar year (hereafter cy) of its hatching. A Spoonbill was an immature if it was 2-cy-old or 3-cy-old. A Spoonbill in 4-cy-old age or older was treated as an adult. Similarly, three time periods were defined to describe the annual cycle of the birds: the winter period lasts between November and February when Spoonbills generally occur in their wintering area. Spring was defined as the period between March and June. During this period, most Spoonbills do their northward migration and on the breeding ground (in the Carpathian Basin), this is the main period of their nesting. Autumn was identified as the period between July and October. During this period, Spoonbills finish their breeding and start their post-natal/post-breeding dispersal, and then, the majority of the birds complete their southward migration.

We created four maps that represent the distribution of Spoonbills. One of the maps is a general map that contains all records (including data with no exact date) that were reported outside the Carpathian Basin. We created maps that show the winter (between November and February), spring (between March and June), and autumn (between July and October) distributions. In these maps, two records were excluded where the inaccuracy in the date of the record exceeded the monthly rate.

The majority of Spoonbills occurred south of the Carpathian Basin. The analysis of the migration of Spoonbills was divided into two large geographic areas: we separately analysed the data of individuals detected in South Europe and North Africa. South Europe was defined as the areas south of the Alps and the Carpathian Basin, generally south of 45 °N, including the observations from Turkey. North Africa was defined as African territories north of 22 °N and the observations from Israel were also added to this area. The data were analysed in a monthly distribution for the three age groups in the case of both geographic areas. If a single immature or adult individual was detected in the same month in multiple years within the same geographical area, each observation was added to the number of monthly observations of the proper age groups in the appropriate geographic area. If a single individual was reported multiple times in the same month in the same year in a geographic region, those records were pooled and treated as a single occasion. Records from sub-Saharan Africa and the northern part of Europe are not available in the proper quantity, thus they were excluded from this analysis.

Finally, we tested the hypothesis that during winter, spring, and autumn, the number of Spoonbills is the same in Europe (outside the Carpathian Basin) and Africa. The chi-square

test was applied for given probabilities in the R statistical program (R Core Team 2023). However, the dataset contains a few Asian records from the Middle East, those records were not involved in this test.

Results

Geographical distribution

547 different individuals (20.00%) of 2,735 specimens were observed outside the Carpathian Basin and 1,737 records were collected on them from 28 different countries between May 2003 and February 2023 (*Table 1, Figure 1*). 525 (19.20%) individuals were reported along the Central Mediterranean Flyway (in the case of Spoonbills, it is alternatively referred to as the Adriatic Flyway), from the central part of south Europe (Italy and the western part of Balkans), the central part of north Africa (east Algeria, Tunisia, and coastal Libya), and the central part of the Sahel (Mali, Niger, and Nigeria). The majority of Spoonbills were found in Tunisia (368 individuals, 13.46%) and Italy (174 individuals, 6.36%).

The most important African sites for Spoonbills based on ring readings of Hungarian specimens lay in the tidal wetlands and salinas of the Gulf of Gabes (Tunisia), with a notable

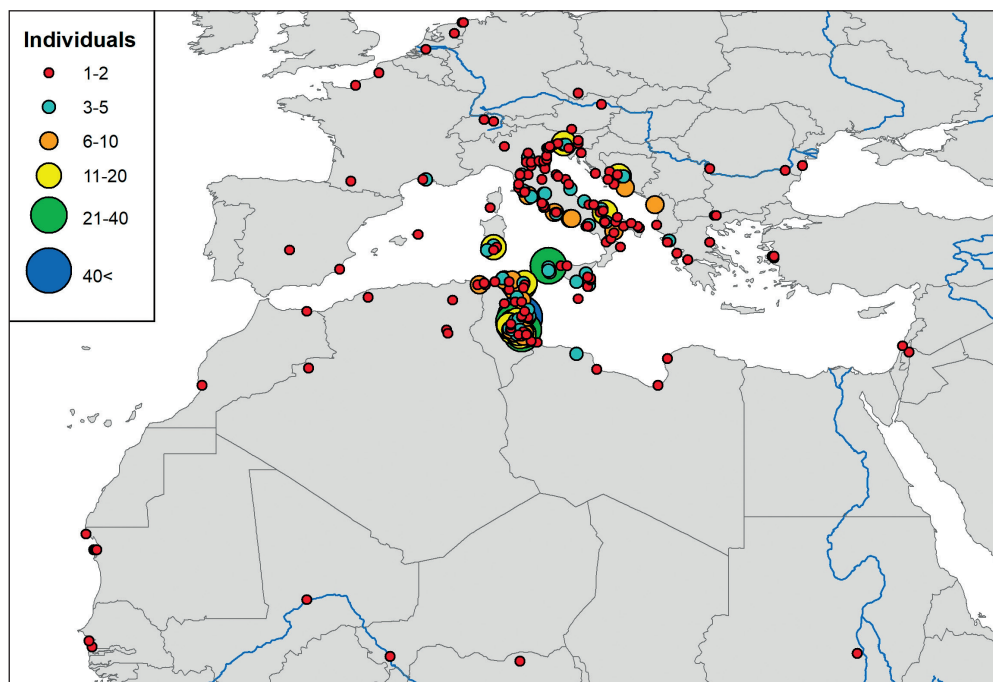


Figure 1. General distribution of Spoonbills marked in Hungary with colour-rings between 2003 and 2023 in Europe (outside the Carpathian Basin), Asia, and Africa.

1. ábra A Magyarországon színes gyűrűvel jelölt kanalasgémek általános elterjedése 2003 és 2023 között Európában (Kárpát-medencén kívül), Ázsiában és Afrikában

Table 1. Number of Spoonbills (individuals) marked in Hungary, occasions of their occurrences, and monthly occurrences in countries, outside the Carpathian Basin. Abbreviations: CB means the Carpathian Basin

1. táblázat A magyar gyűrűs kanalasgémek egyedszáma, előfordulási eseteinek száma és havi előfordulásai országonkénti bontásban, a Kárpát-medencén kívül. Rövidítések: CB jelentése Kárpát-medence

Country	Individuals (%)	Occasions	Months
Germany	1 (0.04%)	4	9
The Netherlands	1 (0.04%)	3	6–7
France	5 (0.18%)	28	5–10
Spain	3 (0.11%)	4	3–4
Switzerland	1 (0.04%)	3	5
Czechia	1 (0.04%)	1	4
Austria (outside the CB)	2 (0.07%)	4	5–6
Italy	174 (6.36%)	618	1–12
Malta	1 (0.04%)	2	6
Slovenia (outside the CB)	3 (0.11%)	3	3–5
Croatia (outside the CB)	17 (0.62%)	20	2–6; 10
Bosnia & Hercegovina (outside the CB)	19 (0.69%)	28	3–4; 8–10
Montenegro	6 (0.22%)	14	3–6; 9
Albania	1 (0.04%)	1	7
Romania (outside the CB)	3 (0.11%)	3	3–5
Greece	10 (0.37%)	18	11–6; 9
Turkey	3 (0.11%)	5	1–2; 5; 9–10
Israel	2 (0.07%)	2	10
Morocco	2 (0.07%)	3	4; 11–12
Algeria	15 (0.55%)	28	9–3
Tunisia	368 (13.46%)	921	1–12
Libya	11 (0.40%)	12	1; 3; 8; 10–11
Mauritania	3 (0.11%)	6	11–1; 6; 9
Senegal	1 (0.04%)	2	3; 10
Mali	1 (0.04%)	1	2 or 3
Niger	1 (0.04%)	1	11
Nigeria	1 (0.04%)	1	2
Sudan	1 (0.04%)	1	2
Total	547 (20.00%)	1737	

concentration of colour-ringed specimens 1) at Thyna Saltpans near Sfax, 2) the archipelago of Kneiss Island and the coastal areas near to it, and 3) around Djerba together with the Gulf of Boughrara (*Figure 1–4*). Besides coastal wetlands, the freshwater reservoirs and lagoons of Cape Bon play an important role as well, mainly during the migratory periods, however, some wintering Spoonbills also stayed there. Most African sites are important

during winter (between November and February) for Spoonbills (*Figure 2*). During spring (between March and June), the number of reported individuals is much lower in Africa and most of them are late birds (*Figure 3*). In the autumn (between July and October), the number of reported Spoonbills is higher (*Figure 4*), however, it is not as high in winter.

The European sites are generally important during migration as stop-over sites, however, some of them are also essential as wintering sites (*Figure 2–4*). The most important European sites based on the readings of Hungarian rings are 1) Busko Lake (Bosnia & Hercegovina), 2) the river mouth of Isonzo (Italy), 3) the wetlands of Apulia around the Gulf of Manfredonia (Italy), 4) the wetlands at Trapani (Sicily, Italy), and 5) the wetlands around Cagliari (Sardinia, Italy).

Three (0.11%) Spoonbills were observed or found north of the Alps between April and August. These individuals occurred in Switzerland, Czechia, and Austria (*Figure 1*). Ten (0.37%) specimens were identified east of the main migratory paths of the Pannonian Spoonbills. They occurred in east Romania, east Greece, west Turkey, Israel and Sudan (*Figure 1*). These observations come from the East Mediterranean Flyway. 13 (0.48%) individuals were seen west of the main migratory paths of Central European birds in Germany, the Netherlands, France (along the Atlantic coast and in the Camargue), Spain, Morocco, west Algeria, Mauritania, and Senegal (*Figure 1*). These resightings have been recorded along the East Atlantic Flyway.

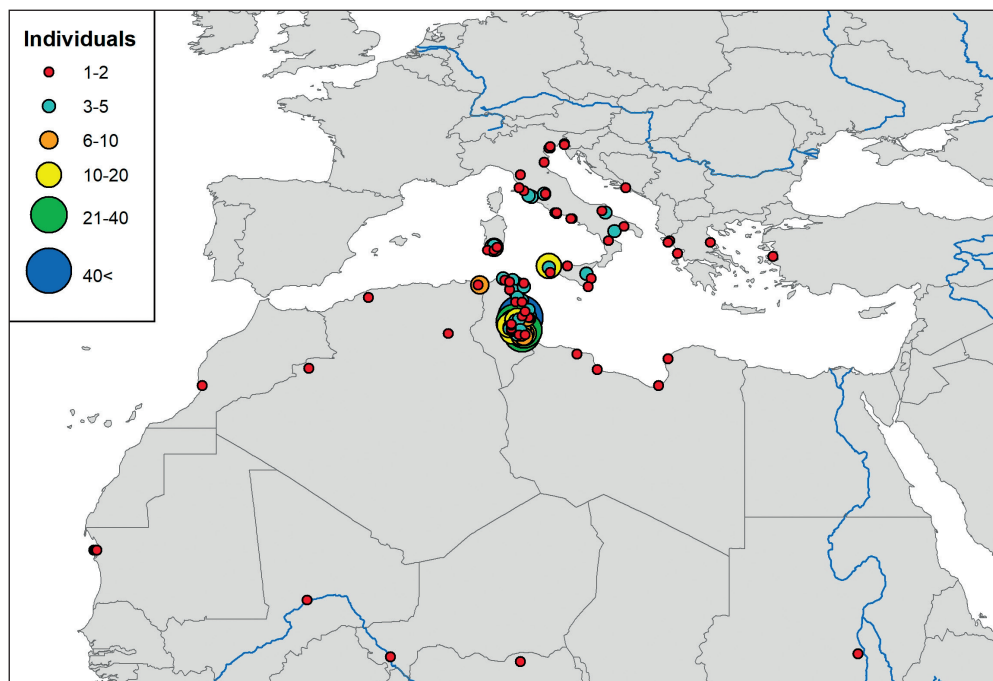


Figure 2. Winter (between November and February) distribution of Spoonbills marked in Hungary with colour-rings between 2003 and 2023 in Europe (outside the Carpathian Basin), Asia, and Africa.
 2. ábra A Magyarországon színes gyűrűvel jelölt kanalasgémek téli (november és február közötti) elterjedése 2003 és 2023 között Európában (Kárpát-medencén kívül), Ázsiában és Afrikában

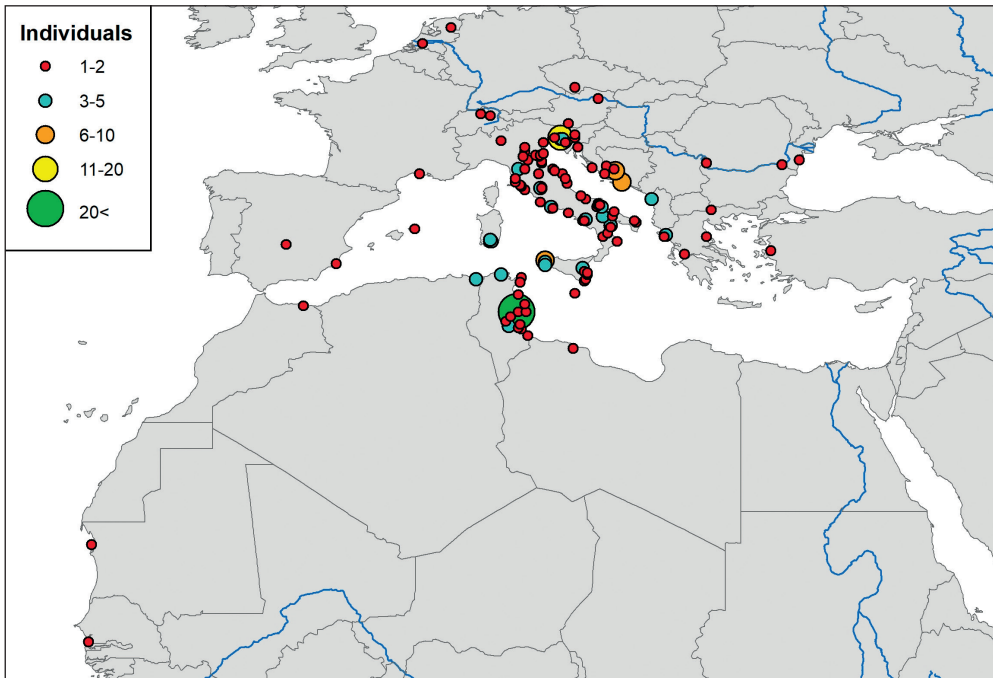


Figure 3. Spring (between March and June) distribution of Spoonbills marked in Hungary with colour-rings between 2003 and 2022 in Europe (outside the Carpathian Basin), Asia, and Africa

3. ábra A Magyarországon színes gyűrűvel jelölt kanalasgémek tavaszi (március és június közötti) elterjedése 2003 és 2022 között Európában (Kárpát-medencén kívül), Ázsiában és Afrikában

Migration dynamics

General movement dynamics

The South European records of Spoonbills had a peak (62 cases) in March then declined slowly until June (from 54 monthly occasions to 38) and finally, steeply reached the minimum value (15 occasions) by July. From August onwards, the number of observations in Europe started to increase and reached its maximum (70 cases) by September. During winter (between November and February), the number of reported events declined (24–42 occasions monthly) (Figure 5). Spoonbills from the winter period were mainly detected in Italy, however, a few were reported from Turkey, Greece, and Croatia (Neretva Delta), too (Figure 2).

Contrastingly, the number of observations was the highest during the winter in North Africa: between November and January, there was a significant peak (154–200 occasions monthly), while their number dropped by February (39 occasions). Wintering individuals were detected in Morocco, Algeria, Libya, and principally in Tunisia. Interestingly, there are two wintering records from Saharan wetlands in Algeria (Figure 2). Between March and September, the number of records was even lower (5–32 occasions monthly) in North Africa and reached its minimum in July. From August onwards, the number of reported Spoonbills

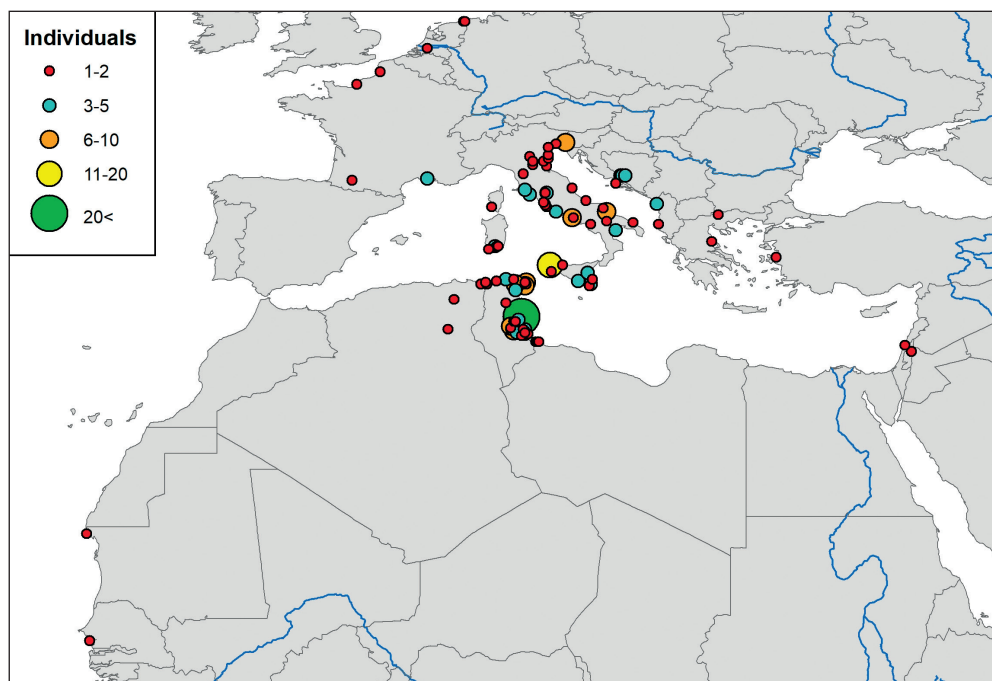


Figure 4. Autumn (between July and October) distribution of Spoonbills marked in Hungary with colour-rings between 2003 and 2022 in Europe (outside the Carpathian Basin), Asia, and Africa
 4. ábra A Magyarországon színes gyűrűvel jelölt kanalasgémek őszi (július és október közötti) elterjedése 2003 és 2022 között Európában (Kárpát-medencén kívül), Ázsiában és Afrikában

started to increase and in October, 94 occasions were reported indicating strong autumn migration and arrival in North Africa (Figure 5).

During winter, 320 individuals were reported from Africa, 59 from Europe (outside the Carpathian Basin), and 2 from Asia (the Middle East) (Figure 2). Significantly more Spoonbills were observed in Africa than in Europe (outside the Carpathian Basin) during winter (chi-square test: $\chi^2 = 179.74$, $df = 1$, $p < 0.0001$). In spring, 50 specimens were observed in Africa, 144 in Europe (outside the Carpathian Basin), and one in Asia (the Middle East) (Figure 3). Significantly more Spoonbills were detected in Europe (outside the Carpathian Basin) than in Africa in spring (chi-square test: $\chi^2 = 45.546$, $df = 1$, $p < 0.0001$). In autumn, 126 individuals were reported from Africa, 121 from Europe (outside the Carpathian Basin), and 3 from Asia (the Middle East) (Figure 4). The number of reported Spoonbills in Europe (outside the Carpathian Basin) and Africa did not differ significantly during autumn (chi-square test: $\chi^2 = 0.10121$, $df = 1$, $p = 0.7504$).

Juveniles

Juvenile Spoonbills start to leave the Carpathian Basin after the second half of June:

JA59 was found on 19 June in Austria, north of the Alps and YRa/R(Bf)Y was photographed on 30 June in northern Italy (at Staranzano, Isola della Cona) (Table 2). The first yearling

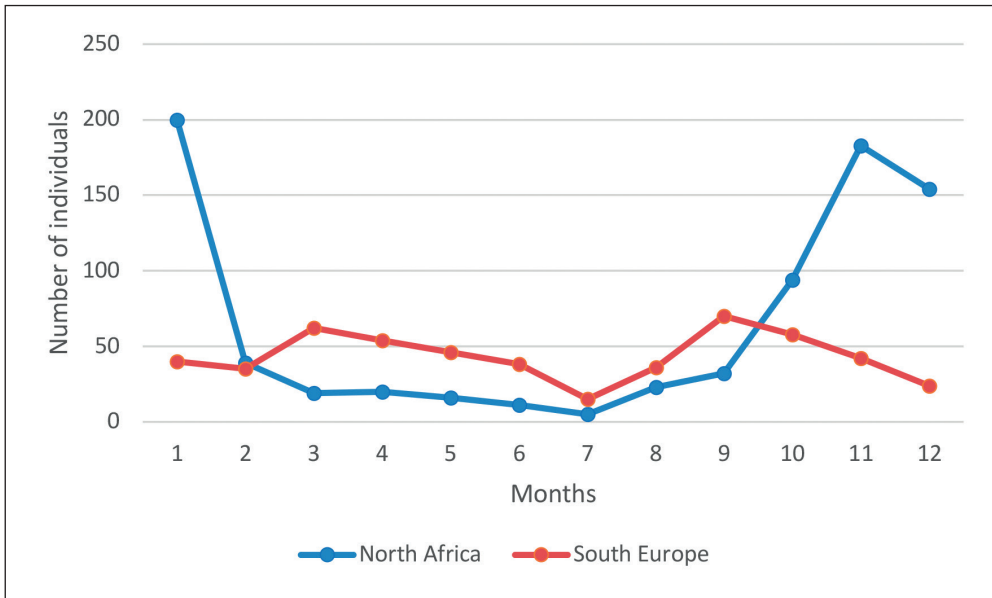


Figure 5. Migration dynamics of Spoonbills in South Europe and North Africa. All age-groups were pooled into the proper geographic groups. Turkey was pooled to South Europe and Israel to North Africa

5. ábra A kanalasgémek vonulási dinamikája Dél-Európában és Észak-Afrikában. Minden korcsoport összevonásra került a megfelelő földrajzi csoporton belül. A török megfigyeléseket Dél-Európával, az izraeli megfigyeléseket Észak-Afrikával vontuk össze

(JP05) was reported on 31 August in North Africa (Thyna Saltpans, Tunisia) (Table 2). Based on observations of the colour-ringed juveniles, their migration mainly fell between August and October with a peak in September in South Europe (Figure 6) and they started to reach North Africa in larger numbers from the middle of September (Figure 7). There was a peak in their number in November in North Africa (Figure 7). In the Sahel, a juvenile (JK70) was found dead on 25 November in Niger (Table 2). This is the earliest known observation of a colour-ringed juvenile from sub-Saharan Africa in this project.

Immatures

Immature Spoonbills occurred in North Africa and South Europe in the whole year (Figure 6, 7). Some immatures stay in North Africa even in the summer: ten 2-cy-old and three 3-cy-old specimens were observed in June and July in Tunisia (Figure 7). One of them, a 2-cy-old immature [L/L (GB)] was observed at Lake Ichkeul (Tunisia) on 5 June and 8 August suggesting that likely spent the summer there. L/L (ZN) was observed in Tunisia in June when it was 2-cy-old and 3-cy-old, too (Table 4). The number of reported immatures is low (4–15 occasions monthly) between March and September contrasting with the period between November and January when their number was higher (42–95 occasions monthly) in North Africa (Figure 7). During southward migration, J225 (3-cy-old) reached Tunisia

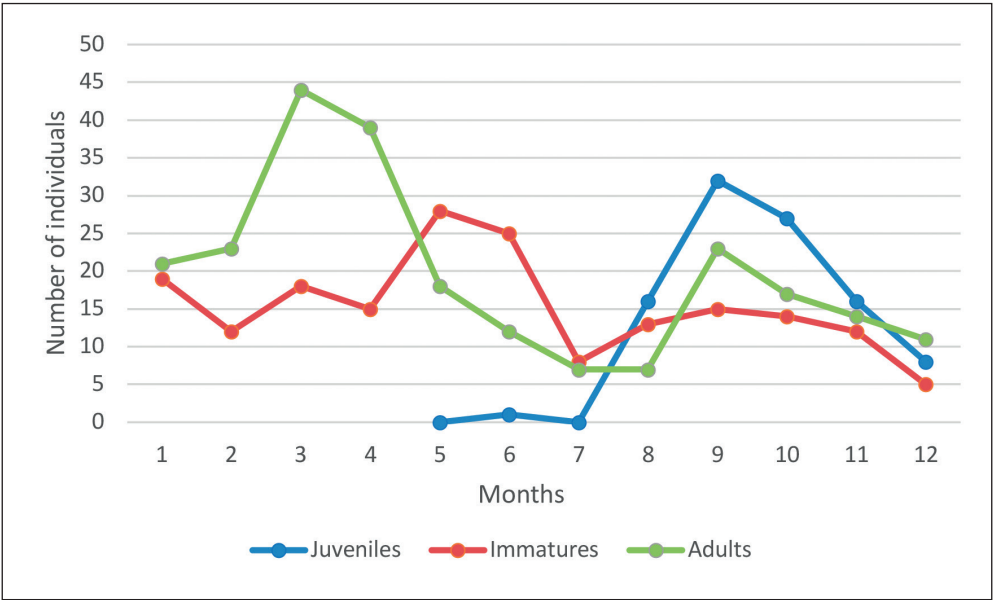


Figure 6. Migration dynamics of juveniles, immatures and adults in South Europe based on monthly observations (occasions in age groups). Note that most adults were mainly observed in March and April during the northward migration while immatures had a peak later, in May and June. All three age groups had a peak in September during their southward migration

6. ábra A fiatal, immatur és öreg kanalasgémek vonulási dinamikája Dél-Európában, havi bontás alapján (az adott korcsoportban megfigyelt alkalmak alapján). Az öregek többnyire márciusban és áprilisban voltak a tavaszi vonulásuk csúcsán, míg az ivaréretlen madarak vonulási csúcsa később, május és június során történik. Az őszi vonulás csúcsa mind a három korcsoport esetén szeptemberre esett

Table 2. Early arrival dates of Spoonbills to Europe (outside the Carpathian Basin), North Africa and sub-Saharan Africa during southward migration

2. táblázat Kanalasgémek korai érkezési dátumai Európában (Kárpát-medencén kívüli területek), Észak-Afrikában és Afrika száheli területein az őszi (déli irányú) vonulás során

Ring code	Age	Country	Date of arrival	Note
J836	5 cy	Italy	15 May 2020	seen on 16 April in Hungary
L/L (HE)	16 cy	Italy	2 June 2019	seen on 10 May in Hungary
YRa/(Bf)YG	6 cy	Italy	7–8 June 2014	seen on 8 April in Hungary
J42H	1 cy	Austria	19 June 2020	ringed on 17 May in Hungary
YRa/R(Bf)Y	1 cy	Italy	30 June 2009	ringed on 22 May in Hungary
aG(Bf)/RGR	7 cy	Tunisia	28 July 2014	seen on 5 May in Hungary
J225	3 cy	Tunisia	28 July 2014	seen on 26 June in Hungary
JP05	1 cy	Tunisia	31 August 2018	seen on 2 July in Hungary
JK70	1 cy	Niger	25 November 2016	found dead; seen on 4 July in Hungary

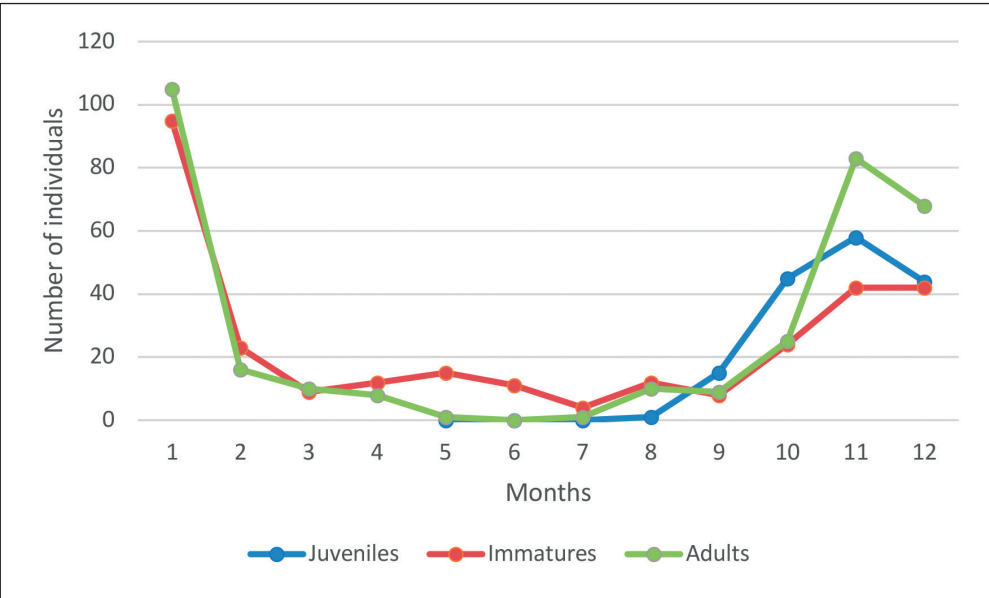


Figure 7. Migration of juveniles, immatures and adults in North Africa based on monthly observations (occasions in age groups)

7. ábra A fiatal, immatur és öreg kanalasgémek vonulási dinamikája Észak-Afrikában, havi bontás alapján (az adott korcsoportban megfigyelt alkalmak alapján)

(Cape Bon) on 28 July (Table 2). That is the earliest African record of an immature moving to the south.

In South Europe, immature Spoonbills had a migration peak in May and their number was still close to the peak in June (28 and 25 occasions monthly, respectively) (Figure 6). They occurred regularly in Italy in June and July, too. Some of the birds observed in June continued their movement and appeared in the Carpathian Basin later (Table 3). Based on regular observations, four individuals likely spent the whole summer in northern Italy (Table 4). Another peak in the number of immatures was detected in January (19 occasions) (Figure 6).

Table 3. Dates of late observations of Spoonbills in North Africa and Europe (outside the Carpathian Basin) during northward migration

3. táblázat Kései kanalasgém megfigyelések Észak-Afrikában és Európában (a Kárpát-medencén kívül) a tavaszi (északi irányú) vonulás során

Ring code	Age	Country	Date	Note
aR(Bf)/GYG	8 cy	Tunisia	23 April 2016	seen on 4 September in Hungary
J718	5 cy	Romania (Danube Delta)	13 May 2017	seen between 23 May and 26 August in Hungary
(Bf)Ga/RYR	3 cy	Italy	12 June 2011	found dead in winter 2011/12 in Hungary
YaR/(Bf)YG	3 cy	Italy	12 June 2011	seen on 9 July in Hungary

Table 4. Irregular summer occurrences and oversummering of Spoonbills in Europe (outside the Carpathian Basin), North Africa, and sub-Saharan Africa. If a single individual stayed long and observed multiple times the summering is very likely

4. táblázat Kanalasgémek nyári előfordulásai Európában (a Kárpát-medencén kívül), Észak-Afrikában és a Száhelban. Ha egy-egy egyed hosszabb ideig tartózkodott egy területen, az ottani átnyarálása nagyon valószínű

Ring code	Age	Country	First observation	Last observation	Days	Note
L/L (HE)	2 cy	Italy (N)	12 June 2005	4 August 2005	54	21 occasions
B/O (ND)	2 cy	Italy (N)	14 May 2007	18 July 2007	66	23 occasions
J027	3 cy	Italy (N)	15 June 2012	18 July 2012	34	5 occasions
J179	3 cy	Italy (N)	19 June 2013	28 July 2013	40	5 occasions in 3 locations; wintered in 2012/13 in Tunisia
L/L (ZN)	2 cy	Tunisia	8 June 2008			1 occasion
L/L (ZN)	3 cy	Tunisia	14 June 2009			1 occasion
L/L (GB)	2 cy	Tunisia	5 June 2006	8 August 2006	65	2 occasions
B/R (VY)	2 cy	Tunisia	25 June 2004			1 occasion
LaY/R(Bf)L	2 cy	Tunisia	25 June 2010			1 occasion
aR(Bf)/GYG	2 cy	Tunisia	23 June 2010	3 July 2010	11	2 occasions
aRY/L(Bf)L	2 cy	Tunisia	26 June 2010	4 July 2010	9	3 occasions
J363	4 cy	Tunisia	29 May 2019			1 occasion
B/W (TN)	4 cy	Mauritania	30 June 2010			1 occasion

Adults

There are no observations of adults in June in North Africa (*Figure 7*). During the southward migration, the earliest record of an adult [aG(Bf)/RGR] was noted at Oued Lebna reservoir (Cape Bon, Tunisia) on 28 July (*Table 2*). The number of observations of adults is the highest in North Africa during the wintering time, between November and January, with a peak in November and a higher peak in January (83, 68, and 105 occasions monthly, respectively). The number of observations declined by February and the majority of the adults left North Africa by May (*Figure 7*). The latest North African observations of adults were recorded on 23 April [aR(Bf)/GYG] and 29 May (J363) (both cases in the Thyna Saltpans, Tunisia) (*Table 3*). It is unclear whether J363 (4-cy-old) had been in Africa since winter and spent all summer in its wintering site or was an early arrival (*Table 4*). aR(Bf)/GYG was observed on 23 April and occurred later, in the same year in Hungary (*Table 3*).

During the northward migration of the adults in South Europe, the observation events had a peak in March (44 occasions) and it was still high in April (39 occasions), then declined sharply by May. The observation events of adults were low between May and August (7–18 occasions monthly) (*Figure 6*). Interestingly, J718 was on her northward migration in May: she was photographed in the Danube Delta (Romania) on 13 May and appeared in Hungary on 23 May (*Table 3*). Contrastingly, the southward migration started in several cases as early

as May: J836 was in Venezia on 15 May (*Table 2*). There were further early observations in Italy such as the detection of L/L (HE) at Staranzano (Italy) on 2 June, and the observation of YRa/(Bf)YG in south Italy on 7 and 8 June (*Table 2*). All three individuals mentioned above started their southward migration in May or early June. They were observed in Hungary previously, in the same year. During the southward migration, there was a peak in September in South Europe (23 occasions). The number of winter observations was smaller than in the peaks of the spring or autumn migration (*Figure 6*). Furthermore, the observation of (Bf)aG/RLG in the Neretva Delta on 17 and 18 February likely indicated an individual that stopped there during its northward migration (*Figure 2*).

In sub-Saharan Africa, B/W (TN) (4-cy-old) was observed on 30 June in Mauritania (Banc d'Arguin) (*Table 4*). That individual was observed there several times in winter, too.

Discussion

We analysed the observations of Spoonbills of Hungarian origin outside the Carpathian Basin, in 28 countries. In those regions, 20% of the Hungarian population was observed and reported. In winter, a significant part of the population occurred in Africa compared to Europe. Africa is the main wintering site of the Central European Spoonbill population: 80% of wintering data came from Africa contrasting the 20% of the European wintering data (Pigniczki 2022). In spring, a significant part of the Hungarian population was reported from Europe (outside the Carpathian Basin) compared to Africa. This result indicates that Spoonbills leave Africa in spring and reach Europe during their northward migration. However, the observation activity is lower in Africa between March and June because there were no ring-reading trips and large-scale waterbird counts. Reports indicate that the majority of Spoonbills leave Tunisia in February/March which is the main African wintering area (Isenmann *et al.* 2005). It means that at the beginning of the spring period, most of the wintering birds should be in Africa but there are only sporadic observations. The increased European observations outside the Carpathian Basin must be the result of the northward migrating Spoonbills. During autumn, no significant differences were found between the African and European (outside the Carpathian Basin) records. It indicates that Spoonbills stopped at several parts of Europe during their southward migration before reaching Africa. Autumn is the main part of postnuptial migration between July/August and October (Isenmann *et al.* 2005). Similarly to the spring period, the observation effort is lower in Africa during the autumn period.

The majority of Spoonbills occurred along the Central Mediterranean Flyway (which is also referred as the Adriatic Flyway) because, in the case of Spoonbills, they cross the Adriatic Sea. Several studies underlined the importance of the Adriatic Flyway for Spoonbills (Schneider-Jacoby 2008, Pigniczki *et al.* 2016). The East Atlantic and the East Mediterranean Flyways are only marginally important for the Pannonian population (Pigniczki *et al.* 2016, Pigniczki 2022).

Three Spoonbills of Hungarian origin were reported from north of the Alps in Austria, Czechia, and Switzerland. Especially, the observations of the single individual in Switzerland may indicate an undescribed migratory flyway that leads north of the Alps. It is

known, for example, that a part of the Hungarian populations of Great Egrets (*Ardea alba*) and Mediterranean Gulls (*Ichthyaeetus melanocephalus*) follow migration flyways north of the Alps (mme.hu 2024a, mme.hu 2024b, pers. comm. Hungarian Bird Ringing Centre). This flyway seems only marginally important for the Pannonian Spoonbill population. One individual of Hungarian origin occurred in Czechia in April. A bird of Croatian origin was observed in a Czech Spoonbill colony (Kralj *et al.* 2012). It is supposed that the Czech population originated from the Pannonian population and it is likely that a connection between the two populations still exists (Kralj *et al.* 2012, Pigniczki 2017).

Some Spoonbills from the Hungarian population joined the West European population and appeared in Germany, the Netherlands, Atlantic France, and Spain. Furthermore, Spoonbills from the Pannonian population reached Scotland (Kralj *et al.* 2012). At least, a part of the adult Spoonbills of Hungarian origin probably shifted their breeding area and they likely bred in Western Europe, however, the breeding is not confirmed by field observations. Adults from the East Atlantic population (Denmark and the Netherlands) also appeared during the breeding period in Hungary and potentially nested, however, the breeding was not confirmed either in these cases (Pigniczki 2017). These records highlight potential gene flow between the East Atlantic and the Pannonian Spoonbill populations. Interestingly, a Spoonbill marked in the Danube Delta was also observed in Switzerland, Germany, and France in multiple years, however, it is not confirmed whether that bird nested anywhere in West Europe (Kiss *et al.* 2022).

South Europe

The South European areas – especially in Italy – bear valuable importance for the Pannonian Spoonbill population. Individuals of Pannonian origin use the South European sites as wintering areas, stop-over sites to have food and rest during migration, and finally, immatures may stay there to summer (Kralj *et al.* 2012, Pigniczki 2015, 2022, Pigniczki *et al.* 2016).

Our data indicates a peak in March during the northward migration in southern Europe. In spring migration, the peaks of adults and immatures were detected in different months: the bulk of adults were reported in March and April, while the majority of immatures were detected later, mainly in May and June. In the eastern Adriatic region, there is a migration peak in March at the coastal sites, while the spring peak was detected between mid-March and April in Bosnia-Herzegovina (Stumberger *et al.* 2013). In Sicily (Italy), a peak was detected in February and March (Ientile *et al.* 2020). This spring peak may likely be related to the start of migration of Spoonbills wintering in North Africa. In Italy, the spring migration is concentrated between late February and early April (Spina & Volponi 2008).

In this study, we identified four immatures that spent the summer in northern Italy, those birds did not appear in their natal area, in the Carpathian Basin. Summering Spoonbills were regularly seen in Sicily between 2014 and 2018 in June and July, their maximal numbers varied between 5–33 individuals (Ientile *et al.* 2020). Ring readings did not confirm the summering of individuals of Hungarian origin in Sicily.

During the autumn migration, all age groups had peaks in September in southern Europe. Based on surveys, Spoonbills have a peak in September in the eastern Adriatic region, too

(Stumberger *et al.* 2013). In Sicily (Italy), a marked peak was observed in September and October (Ientile *et al.* 2020). This peak is related to the southward migration, when Spoonbills migrate through Sicily to their wintering grounds in North Africa, however, a part of them stay to winter in Sicily as well. Interestingly, our data indicates that the southward migration starts as early as mid-May and early June when individuals that occurred previously in the Carpathian Basin started to move to the south and appeared in Italy. Contrastingly, some adults can be on their northward migration even in May.

The Pannonian Spoonbill population that winters in South Europe has a peak in January, probably because of the wintering waterbird census and the higher observation effort. In the Balkans, the number of Spoonbills is moderate in winter compared to the pre- and post-breeding migrations (Stumberger *et al.* 2013).

Among European countries, the most wintering individuals of Hungarian origin were reported from Italy, however, Spoonbill was a rare species in Italy during winter in the largest part of the country some decades ago. Spoonbills in Italy are still scarcely abundant and quite localised: there are 20–25 coastal sites where the winterers are distributed. The Lagoon of Orbetello and the wetlands of Sicily, Sardinia, and Apulia host the most numerous and stable wintering populations in Italy (Spina & Volponi 2008, Zenatello *et al.* 2014). The colour-ringed individuals of Hungarian origin are mainly reported from the abovementioned localities. In Italy, the number of wintering Spoonbills has increased from max. 99 individuals in the period 1991–1995 to over a thousand individuals recently, and was estimated at 1,027 specimens in 2017, 1,365 in 2018, 1,440 in 2019, and 1,210 in 2020 (Pigniczki 2022, Wetlands International 2024). In Sicily, the first wintering group of Spoonbills was observed in December 1992. Spoonbills have become regular wintering birds there since 1992, and their maximal numbers varied between 40–105 individuals in December or January between 2014 and 2018 (Ientile *et al.* 2020). The system of wetlands in western Sicily (e.g. the salinas of Trapani and Marsala) plays a key role for Spoonbills during winter and other periods of the year as well. In turn, the wintering in south-eastern Sicily is less regular and abundant, probably the abandonment of the practice of salt cultivation may have adversely affected this species. Despite, there are former salinas and natural, temporary ponds in south-eastern Sicily, their fish fauna is absent or has little abundance, therefore, Spoonbills mainly forage on invertebrates such as Branchiopods in those areas (Surdo 2020). Invertebrates have irregular life cycles because they are connected to the water level and their density can be low or they may be totally absent from the area. Therefore, the lack of available food does not make possible a stable or abundant wintering Spoonbill population in most of the wetlands in the southeastern part of Sicily.

Italy is the most significant wintering site of Spoonbills of Hungarian origin in the northern Mediterranean and there are further, known wintering sites in Greece and Turkey with a few wintering individuals from the Hungarian population (Pigniczki 2022). Besides Hungarian individuals, Italy is an important wintering area for specimens from Croatia and Serbia, too (Kralj *et al.* 2012). Probably, the wetlands of the Balkans and Turkey are more important for the wintering Spoonbills of Hungarian origin, however, clarifying this is the task of the future.

North Africa

In North Africa, the quality of data is very likely biased, because the ring-reading effort is definitely higher during the wintering period due to the special Tunisian ring-reading expeditions in November and December, and the survey of wintering waterbirds in January (Pigniczki 2022). Despite that, our data clearly indicate that North Africa holds essential wintering areas for the Hungarian population, especially in Tunisia. The relevancy of Tunisia was confirmed by several studies: the tidal wetlands and Thyna Saltpans in the Gulf of Gabes are very important for the Pannonian population according to ring readings and recoveries (Smart *et al.* 2007, Kralj *et al.* 2012, Pigniczki *et al.* 2017, Pigniczki 2022). Besides the Pannonian population, a massive number of Spoonbills from the Camargue and Italy also winter in Tunisia (Volponi *et al.* 2008, Pigniczki 2022, Ferreira *et al.* 2024, CP, HA, HD & MAD pers. obs.). The number of wintering Spoonbills was estimated at 4,033 in 2008, 3,447 in 2014, and 5,002 in 2023 during the waterbird census in January in Tunisia (Azafzaf *et al.* 2015, 2023, Pigniczki 2022). The tidal wetlands in the Gulf of Gabes provide appropriate foraging areas during all year. We found that the freshwater reservoirs of Cape Bon are also important for Spoonbills, but mainly during migration periods. The freshwater reservoirs are temporary habitats because, in the recent dry years, they dried out (M. A. Dakhli pers. obs.). All these results indicate the outstanding importance of Tunisia along the Central Mediterranean Flyway. In smaller numbers, Spoonbills from the Hungarian population also spend the winter in Libya, Algeria, and Morocco (EGA – RAC/SPA waterbird census team 2012, Pigniczki 2022). Probably the importance of Algeria for the Pannonian Spoonbill population is underestimated, because 830 individuals were observed there in January 2019 (Wetlands International 2024). Despite the valuable number of wintering individuals, the number of reported colour-ringed specimens is relatively small, probably because of a lower ring-reading activity. Interestingly, records on wintering Spoonbills from the Algerian Sahara are known in some cases (Pigniczki 2022), and new observations have been reported recently, too. Two individuals of Hungarian origin were observed on their Israeli stop-over sites indicating the Middle East is marginally important for the Pannonian population (Pigniczki *et al.* 2016, Pigniczki 2022). Despite several old records of Hungarian Spoonbills in Egypt until the 1950s, recent and confirmed data are missing from there (Pigniczki 2010, 2022). Only a single record is known with Pannonian origin in Egypt: a specimen marked in Serbia was photographed at Aswan in 2007 (Pigniczki 2022).

In North Africa, the earliest arrival records of adults and immatures were known from late July, while the first juvenile reached that area in late August. In Tunisia, Isenmann *et al.* (2005) supposed that postnuptial migration takes place between July/August and October. Our results based on ring reading show similar consequences, however, a GPS-tracked adult arrived in Tunisia on 15 June indicating Spoonbills may complete their southward migration quite early (Cs. Pigniczki unpublished data).

Prenuptial migration happens in February/March in Tunisia (Isenmann *et al.* 2005). Our ring-reading data indicate that the majority of Spoonbills leave North Africa by the end of March, however, a few may stay there even in April and these late African individuals do appear in the Carpathian Basin. Furthermore, we know an adult individual that was

observed in Tunisia in late May, however, we do not know any other previous and subsequent movement of that bird. These late records indicate that the northward migration of adults on a population level could be a longer process and probably takes place between February and April/May. According to the data of GPS-tracked adults, it is confirmed that the northward migration starts in February and other individuals may start it in the last third of April (Cs. Pigniczki unpublished data).

Ring readings confirmed that immatures may stay in North Africa during the summer period, however, their exact number and detailed movement are unknown because of the lower observation effort. Likely, immatures stay longer in North Africa than adults. Records on colour-ringed adults are missing from June in North Africa. Smart *et al.* (2007) hypothesized that Africa is the 'kindergarten' of the Spoonbills because they occur there during the whole year, however, they mentioned that more evidence is needed to support this hypothesis. Isenmann *et al.* (2005) suppose that the Tunisian observations in May and June are the results of observations of immatures and considered the records from early July as early arrivals. The first Tunisian ring-reading of an adult happened in late July, however, a Spoonbill tracked with a GPS device reached Tunisia on 15 June (Cs. Pigniczki unpublished data). Thus, we rather think that both late/early adults and summering immatures can be observed during summer in the flocks of Spoonbills. Despite having more records on summering immatures in North Africa than fifteen years ago, the situation is still unclear. It seems that immatures follow very different strategies: in unknown numbers, they may spend the whole summer in Tunisia, while some of them migrate northward to summer in Italy (and probably other parts of Europe), and others may reach their natal areas in the Carpathian Basin (Pigniczki 2009).

Sub-Saharan Africa

Only a limited number of data came from sub-Saharan Africa. Records are known from a wide range of the Sahel between Mauritania/Senegal and Sudan (Pigniczki 2022). Spoonbills visit that area to winter there, however, even the adults likely stay there during the summer in certain conditions. In small numbers, Spoonbills of Pannonian origin regularly cross the Sahara (Smart *et al.* 2007, Pigniczki 2010, 2022, Kralj *et al.* 2012).

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