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ANALYSIS OF RING RECOVERIES OF SONG THRUSHES *TURDUS PHILOMELOS* IN NORTH AFRICA

Sergio Scebba[1*], Maria Oliveri del Castillo[1] and Michele Sorrenti[2]

ABSTRACT

This study investigates the wintering range and migratory patterns of the Song Thrush in North Africa, focusing on the Maghreb region. Despite the fact that this is the southernmost limit of its wintering range, comprehensive analyses of its geographic origin and spatial distribution are lacking. The research utilizes 840 records, representing the first comprehensive analysis of ringed bird recoveries in North Africa. Findings reveal that the Song Thrush is a common visitor to the Mediterranean belt of North Africa, with distinct migratory routes for different populations. Notably, Italy contributes significantly to the total number of recoveries. The study highlights North Africa as a wintering area for both long-distance migrants and partially migratory populations from Western and Central Europe.

An intriguing observation is the disproportionate concentration of recoveries in Algeria (89.6%), particularly in the Kabylie region, suggesting potential biases due to hunting and trapping activity. Temporal analyses indicate a decline in captured birds from the 1960s to the 2000s, possibly reflecting changes in hunting pressures across North Africa.

The seasonal distribution of recaptures shows a peak in January, emphasizing the thrushes' southward movements within their wintering range. The study challenges previous assumptions of early spring migration, suggesting onset in the second 10-day period of February. Contrary to previous claims, our data do not support prenuptial movements from Kabylie to Tunisia. Instead, sedentary behaviour in wintering areas until March is suggested by both geographical coordinates and recovery data. Satellite transmitter data confirm departure dates in March for thrushes marked in December in Italy.

In summary, this study provides a concise overview of Song Thrush wintering dynamics in North Africa, offering insights into diverse migratory patterns and regional biases and challenging previously held assumptions about prenuptial movements and migration onset.

[1] Gruppo Inanellamento Limicoli (G.I.L., Napoli), Via Traversa Napoli 58, 80078 Pozzuoli, Naples, Italy. Email: serscebba@katamail.com

[2] Ufficio Studi e Ricerche Faunistiche ed Agro-ambientali FIdC, Via Garigliano 57, 00198 Roma, Italy. Email: fidc@fidc.it, Correponding author

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INTRODUCTION

An understanding of avian migratory patterns is pivotal to acquiring valuable insights into the biology and ecology of species, as well as to effective management of the natural environment. From a scientific standpoint, it facilitates the assessment of migratory strategies adopted by populations and species based on their respective habitats. Furthermore, from an operational and managerial perspective, this knowledge enables the adjustment of hunting plans in accordance with spatio-temporal distributions and the effective management of resting sites based on the 'basins of origin' specific to each species.

According to Wernham *et al.* (2002), the Song Thrush *Turdus philomelos* is a partial migrant. It boasts an extensive breeding range extending from Ireland to Lake Baikal in southern Siberia and from southern Spain and Iran to Lapland and Arctic Russia (Hagemeijer and Blair 1997). Several publications have contributed to a general understanding of the wintering areas for populations across most European countries, as outlined by Skovgaard (1931), Eichler (1934), Brunner (1943), Verheyen and Le Grelle (1951), Holgersen (1953), Rendhal (1960), Gromadzki (1964) and Speek (1971). Notably, Ashmole (1962), employing recovery analysis, delineated the principal migratory flyways and wintering areas within Europe. In the Mediterranean region, migration and wintering patterns have been investigated using recovery data in Spain (Santos Martinez 1982), France (Claessens 1988; Olioso 1989, 1995), and Italy (Scebba 1987, 1988; Andreotti *et al.* 1999).

In more recent investigations, Milwright (2006), applying recovery analysis, has provided evidence that breeding populations in various European countries utilize distinct migratory routes. Thrushes originating in Scandinavia and north-western Russia show a predilection for descending along the north-western coast of continental Europe, concentrating in significant numbers in south-western France in October, where adults are notably prevalent. Subsequently, they tend to migrate further to western Spain for the winter. On the other hand, song thrushes ringed in central Europe, spanning from Switzerland to Belarus, demonstrate a tendency to follow a Rhine-–Rhône route towards Mediterranean France before dispersing for wintering in eastern Spain, the Balearic Islands, and eventually Algeria. Birds breeding in the Netherlands and north-western Germany exhibit two distinct migration strategies: one group of short-distance migrants disperses across Belgium and north-western France and then migrates in late winter towards England and Wales, while a group of long-distance migrants moves towards the south-east of the Bay of Biscay and then proceeds towards western Spain and Morocco.

Thrushes arriving in Italy in autumn and early winter originate in breeding grounds situated in the Baltic region (Estonia, Lithuania, Latvia, the Baltic area of Russia, Sweden, Finland, northern Poland, northern Germany, and Denmark), central Europe (southern Germany, Switzerland, Austria, and eastern France) and central-eastern Europe (southern Poland, the Czech Republic, Slovakia, and Hungary). Additionally, it is likely that Italy will be reached by birds breeding in areas

with limited ringing efforts (Milwright 2006) and where nest ringing is sparsely conducted, such as central-northern Russia, Belarus, Ukraine, and the Balkans.

The main wintering areas for birds ringed in Italy are identified in the French Mediterranean, the Balearics, and Algeria (Andreotti *et al.* 1999). The influx of birds wintering in the Mediterranean typically begins in October, persisting throughout the autumn. Winter movements are commonly observed in southern Europe and the Middle East, influenced by adverse weather conditions and/or food availability, as evidenced by substantial arrivals in North Africa (Andreotti *et al.* 2010). Nevertheless, there is a notable absence of estimates regarding the magnitude of the migratory flow of arriving and wintering birds in this region. The species is only broadly characterized as a highly abundant and regular winter visitor across the Mediterranean area, particularly in Tunisia (Isenmann and Moali 2000; Isenmann *et al.* 2005). Moreover, notwithstanding the relevance of the species, which is consistently exposed to substantial hunting pressure and intense poaching throughout the region, no comprehensive investigations have been undertaken to evaluate the specific proportions of distinct arriving populations and the phenology of migration.

The aim of this study is to delineate the origin, phenology, destination, and migration routes of populations migrating and wintering in Northern Africa through the comprehensive analysis of recaptures. In pursuit of these goals, an extensive recapture database has been meticulously examined.

MATERIALS AND METHODS

The dataset compiled for the analysis of Song Thrush recoveries in North Africa comprises a total of 839 records, spanning the period from 1916 to 2021. It included 799 recoveries of foreign-ringed birds reported from North Africa, along with 27 North African ringed thrushes recovered in Europe. A thorough search was conducted to compile records of birds that were either ringed or recovered in North Africa, drawing from information published in ornithological literature or reports from European ringing centres or stations.

We specifically sought recovery data published between 1910 and 2021 in the following journals: *Le Gerfaut* (Belgium), *Lotos*, *Sylvia*, *Krouzkovatel* and *Tichodroma* (Czech Republic and Slovakia), *Videns. Medd. Dansk Nat. Forening* and *Dansk Orn. Tidd.* (Denmark), *Mem. Soc. Fauna Flora Fennica* (Finland), *Journal für Ornithologie*, *Vogelzug*, *Vogelwarte*, *Auspicium*, *Luscinia* and *Berichte Vogelwarte Hiddensee* (Germany), *Bird Study* and *Ringing & Migration* (Great Britain), *Regulus* (Luxembourg), *Sterna* (Norway), *Acta Ornithologica* (Poland), *Var Fagelvärld* and *Report on Swedish Bird Ringing* (Sweden), *Ornithologische Beobachter* (Switzerland), *Acrocephalus* (Slovenia), *Aquila* (Hungary), *Bulletin Centre Reserche Migration* and *Bulletin de la Fondation Tour du Valat* (France), *Loodusvaatlusi* (Estonia), *Ecologia* (Spain), *Memoires Société Sciences Naturelles Tunisie* and *Institut Recherches Scientifiques et Techniques* (Tunisia), *Bulletin Société Sciences naturelles physiques*, and *Documents Institut Scientifique* (Morocco). Additional data were directly sourced from various European ringing centres, including Radolfzell, Hiddensee, Sempach, Budapest,

Praha, and Kaunas. Information was also obtained from Operation Baltic in Poland, Dehorter and CRBPO (2023), and a web application displaying the geographic distribution of recoveries of birds ringed in Norway, Sweden, Denmark, Belgium, and the Netherlands. Specific to Italy, Corsica and Malta, bird recovery data were extracted from the database of Gruppo Inanellamento Limicoli (G.I.L., Napoli) and integrated with information provided by ISPRA at FACE Italia until 2001.

All recoveries were computerized, and data management and analyses were conducted using the Microsoft Office package. Access software facilitated the generation of standardized data queries and the organization of sub-samples of data. For each recovered bird, the following information was entered into the database: (1) ring number, (2) age, condition and circumstances of finding, (3) date, place, and geographical coordinates of ringing, (4) date, place, and geographical coordinates of finding, (5) precision of the finding date, (6) bibliography, (7) distance in kilometres, and (8) number of days between the ringing date and finding date. In cases where the distance between the ringing and finding places was not reported, it was calculated using a formula based on a loxodrome (Imboden and Imboden 1972).

The analyses were preceded by a meticulous examination of recovery data, given that much of the information was sourced from literature rather than from original datasheets. Corrections were applied to rectify errors, including missing ring numbers, duplicated data, inconsistencies in recapture/recovery condition or circumstance codes, date mismatches, missing coordinates, or incorrect country codes. For geographical coordinates, we predominantly relied on those reported in the literature, with missing or inaccurate coordinates retrieved using Google Earth. Detailed checks were performed to ensure the accuracy of coordinates for specific locations. The country of origin was indicated in accordance with current political boundaries.

Among the data, we identified instances that could depict direct movement between the places of capture and recovery, without intervening migratory activity in the period between these events; these data are referred to as ‘direct recovery’.

The total number of recoveries at any given location and time varies depending on the number of birds ringed and the likelihood of reporting. To assess the propensity of different populations to arrive and winter in North Africa, considering variation in ringing effort among countries of origin, a recovery rate (*Rr*) was calculated for some countries (Classens 1990). The *Rr* was determined by dividing the number of recaptures by the total number of birds ringed within a specific period. This information was extrapolated from reports published on the EURING website (https://euring.org/data-and-codes/ringing-totals). A higher *Rr* value indicates a greater propensity to frequent North Africa. Given differences in ringing effort and missing ringing totals for some countries and/or years, the *Rr* was calculated only for birds recovered in North Africa and ringed in countries with known ringing efforts during the period of 1975–2001. For northern Italy, the recovery rate was calculated based on standardized ringing activity conducted in the same years by the Arosio Bird Observatory near Como in Lombardy (Capasso 2018).

To assess potential movements towards coastal areas in January and February, potentially indicative of early pre-nuptial movements, the geographical coordinates of recoveries during six 10-day periods were scrutinized. Recoveries with highly impre-

cise recovery dates, referring to a period greater than one week (Euring code of the finding date from 3 to 9), were excluded from the analysis. For each 10-day period, the Geographic Midpoint Calculator (http://www.geomidpoint.com) was employed to calculate the geographic midpoint, also known as the centroid. This point represents the average coordinate of a set of points on a spherical Earth and actually appears to be in the centre. The analysis aimed to elucidate patterns or trends in the spatial distribution of recoveries during these specific time intervals, particularly focusing on potential movements towards coastal regions during those months.

RESULTS

Data set composition

The 799 recoveries in North Africa encompass a broad geographic range, extending from Spain in the west, Norway, Sweden, and Finland in the north, and Russia in the east to Italy in the south. Among these recoveries, 24 distinct ringing countries were identified, underscoring the significance of the Maghreb region as a transit or wintering area for the Song Thrush (Table 1).

Table 1. Number of ringed song thrushes *Turdus philomelos* subsequently recovered in North Africa

Country of ringing	*N*	%
Italy	329	41.2
Switzerland	89	11.1
Germany	78	9.8
France	50	6.3
Sweden	40	5.0
Denmark	36	4.5
Poland	32	4.0
Czech Republic	31	3.9
Finland	26	3.2
Spain	22	2.7
Belgium	18	2.2
Great Britain	7	0.9
Netherlands	7	0.9
Norway	6	0.7
Hungary	6	0.7
Luxembourg	6	0.7
Russia	4	0.5
Slovakia	3	0.4
Austria	2	0.2
Latvia	2	0.2
Lithuania	2	0.2

Estonia	1	0.1
Belarus	1	0.1
Slovenia	1	0.1
TOTAL	799	100

Among the thrushes recovered in North Africa, 41.2% (329 birds) were ringed in Italy, with a notable concentration in the north, particularly in Lombardy (242 birds, 73.6%). Lombardy has historically been a region with intense ringing activity during the autumn migration of this species. Additionally, a small number of recovered birds were ringed in two other regions of northern Italy with lower ringing efforts – Piedmont (19 birds) and Veneto (12 birds). Impressively, 83% of Italian recoveries were associated with migratory flows involving northern Italy. Another noteworthy contributor to recoveries in North Africa is Switzerland, which accounted for 11.1% (89 birds), likely influenced by the same migratory flow. Germany also played a significant role, contributing 9.8% (78 birds). Furthermore, 9.5% of recaptures originated in Sweden and Denmark, while 6.3% came from France (50 birds). A smaller number of recoveries were reported on individuals ringed in 18 other countries.

The lack of information regarding the circumstances of recapture for a substantial number of individuals (37%) poses a challenge for any statistical analysis. However, for approximately 80% of the birds with known circumstances, they were reported as being hunted, trapped, or shot.

There were 716 thrushes (89.6%) reported from Algeria, and notably, 45.3% (320 birds) of the recaptures with a precisely identified geographic location were concentrated in the province of Tizi Ouzou; when combined with three other provinces belonging to the same Kabylie region, i.e. Bejaia, Bouira, and Boumerdes, this percentage was as high as 78.2% (553 birds). In contrast, the recoveries in the other two Maghreb countries constituted a significantly lower percentage, together amounting to just 10.4% (Table 2).

Table 2. Number of recoveries of song thrushes *Turdus philomelos* in North African countries

Country of finding	Recoveries (*N*)	%
Algeria	716	89.6
Morocco	50	6.3
Tunisia	33	4.1
TOTAL	799	100

The limited number of song thrushes ringed in Tunisia (Arnould and Lachaux 1974) and Morocco (with 143 thrushes ringed from 1967 to 1985 and 1,306 thrushes ringed from 1932 to 1984, as reported on https://euring.org/data-and-codes/ringing-totals) has resulted in a modest number of recoveries. Moreover, there was almost no ringing activity of song thrushes in Algeria (Haddad *pers. comm.*), despite the establishment of a national ornithological centre at the National Agronomic Institute

(I.N.A.) of El-Harrach in 1980. This limited ringing activity in North Africa has resulted in a small number of thrushes recovered in Europe, as outlined in Table 3.

Table 3. Number of song thrushes *Turdus philomelos* ringed in North Africa and recovered in Europe

Ringing data/Country	Recovery data/Country (*N*)						*N*
	Italy	France	Spain	Portugal	Poland	Belarus	
Tunisia	11	1	—	—	-	1	13
Morocco	3	6	2	1	1	-	13
Algeria	—	1	—	—	—	-	1
TOTAL	14 (51.8%)	8 (29.6%)	2 (7.4%)	1 (3.7%)	1 (3.7%)	1 (3.7%)	27

Notably, 27 birds ringed in Morocco (13), Tunisia (13), and Algeria (1) between October and March were subsequently recovered between June and April one or more years after ringing. These thrushes were recovered in Italy (14 birds, 51.8%) and other European countries, such as France, Spain, Portugal, Poland, and Belarus (13 birds, 48.2%). Notably, only two recoveries were identified as direct, enabling the description of a direct movement between the capture site and recovery site. Both of these direct recoveries were from March, one from south-western France and the other from central Italy.

Recapture rates (*Rr*) for countries

Table 4 presents the recovery rates (*Rr*) for specific ringing areas, calculated by examining the ratio between the total number of song thrushes ringed in a given period (1975–2001) by a particular ringing scheme and the corresponding number of recaptured individuals found in North Africa. This approach allows the recovery data to be associated with the corresponding ringing effort, providing insights into the propensity of different populations to migrate towards North Africa. The period defined for the purpose of this analysis is dependent on the availability of data, as these are published annually on https://euring.org/data-and-codes/ringing-totals. For the Arosio Bird Observatory, ringing totals were based on data given by Capasso (2018). The recovery rates offer valuable information for understanding the migratory patterns and behaviours of different populations of song thrushes in relation to North Africa.

Table 4. Ringing totals by ringing scheme (EURING code is given) and the recapture rate (*Rr*) = (*N* of birds recovered / *N* of total birds ringed)×1000 over the period of 1975–2001.

Ringing centre	Total ringed 1975-2001	Recoveries	%
Arosio Bird Observ. IAB	17,344	53	3.06
Switzerland HES	18,384	41	2.23
Germany DER	9,158	20	2.18
Italy IAB	**152,333**	284	1.86
Denmark DKC	48,380	26	0.54
Sweden SVS	59,489	26	0.44
Finland SFH	42,792	16	0.37
Czech Republic CZP	9,774	3	0.31
Hungary HGB	13,970	6	0.43

Table 4 presents the ringing totals of song thrushes from 1975 to 2001 for selected ringing schemes. During this period, 62% (499) of all recoveries were concentrated in North Africa . Based on the number of ringed individuals, the highest recovery rate (*Rr*) was calculated for the Arosio Ornithological Observatory in northern Italy, with a value of 3.06. This observatory conducted autumn migration ringing, with a total of 17,344 thrushes ringed (Capasso 2018). High *Rr* values were also observed for birds ringed in Switzerland (2.23) and at the Radolfzell ringing centre (2.18) in southern Germany, especially during autumn migration and to some extent during the breeding period. In comparison, the *Rr* value for all birds ringed in Italy is lower, as its calculation is based on a total that encompasses thrushes ringed in the rest of the country and during the wintering period. The *Rr* calculated values for birds ringed in Sweden, Finland, and Denmark vary from 0.54 to 0.37. Although indicative of a discrete presence in Africa of populations originating in Fennoscandia and Northern Europe, they are decidedly lower. These percentages do not vary significantly even when we add recoveries linked to the migratory flow that crosses the Baltic Sea area, including birds ringed in the Baltic States, in northern Russia, on the Polish Baltic coast, and on the island of Heligoland in northern Germany.

Distribution of recoveries by 10-year periods

The recoveries of song thrushes in North Africa during autumn and winter in 1911–1960 (78, 9.8%) were limited. The first recovery was in 1916, followed by just four in the 1920s and 38 in the 1930s. The increased number of recoveries in the 1930s was primarily attributed to ringing activity carried out in Italy by the Ornithological Station of Castel Fusano near Rome and the Garda Ornithological Observatory (Chigi *et al.* 1938, Toschi 1934, Caterini *et al.* 1937, Duse 1941). Recovery numbers become more substantial from the 1960s to 2000 (652, 81.6%), with a notable peak in the 1980s and 1990s, reaching 51.9% (415 individuals) (Fig. 1). However, a marked decline has been observed since the early 2000s.

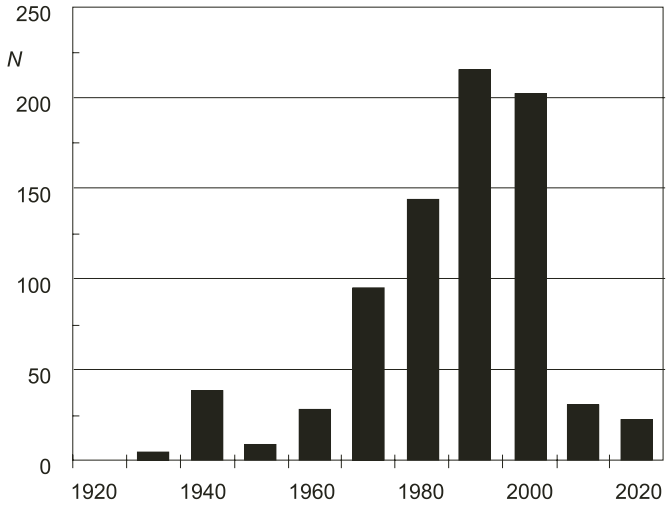

Fig. 1. Number of recoveries of song thrushes in North Africa by 10-year periods

Distribution of recoveries based on 10-day periods

Analysis of recovery phenology based on 10-day periods offers a visual representation of the arrival times of the first migrants, the wintering period, and the initiation of spring migration (Fig. 2). The histograms derived from this analysis provide a representative depiction of the migration phenology.

The seasonal trend of recoveries in North Africa of song thrushes ringed elsewhere for which there is a precise finding date indicates that the first reports begin as early as the second 10-day period of September, but they remain modest until the second 10-day period of October. The frequency of recoveries steadily increased after this date, reaching its peak in the middle 10-day period of February (N = 94), followed by a clear and rapid decrease starting from the third 10-day period of February. In subsequent phases of the spring, numbers of recoveries were very low. Two birds ringed in Denmark and Sweden and recaptured in Algeria on 10 May 1987 and 6 July 1989, along with atypical observations near Tunis in May and June 1972 documented by Isenmann *et al*. (2005), may be indicative of birds potentially incapable of migration, possibly impaired by hunting.

The majority of recoveries were distributed between the second 10-day period of October and the first 10-day period of April (N = 714), with only sporadic occurrences in the second 10-day period of September and in the third 10-day period of April and first 10-day period of May. The highest numbers were recorded between the first 10-day period of January and the third 10-day period of February (N = 460, 62.9%). The substantial increase in migrant arrivals to the southernmost region of the wintering area during this period was confirmed when only direct recaptures were considered (Fig. 2A), i.e. those indicating direct movement between the capture and

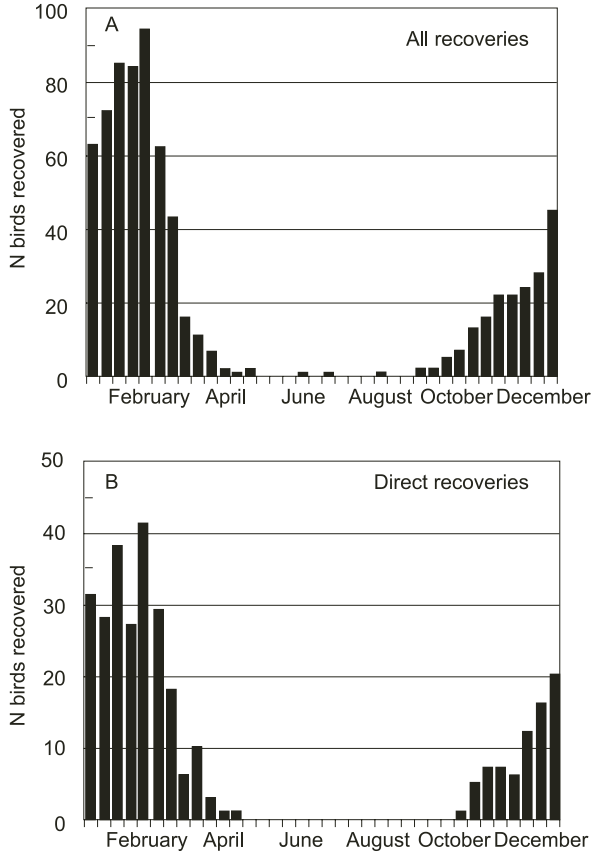

Fig. 2. Phenology of foreign recoveries of song thrushes in North Africa based on 10-day periods from 1916 to 2021
A= all recoveries; B= direct recoveries.

recovery locations, after eliminating any recaptures with imprecise dates referring to a period longer than one week (Euring code of the finding from 3 to 9).

Among 308 thrushes ringed in Europe during the breeding season or autumn migration and found between the second 10-day period of October and the third 10-day period of April, 194 individuals (63%) were recaptured between the first 10-day period of January and the third 10-day period of February. Recapture rates decreased rapidly from the first 10-day period of March onward.

Geographic distribution of recaptures between January and February

Table 5 presents the coordinates of the geographic midpoints or centroids representative of the recaptures that occurred in January and February. These locations allowed for the extrapolation of whether individuals found in Algeria between the first 10-day period of January and the second 10-day period of February exhibited a tendency to move towards the Tunisian coasts. Such movement could suggest a possible

initiation of pre-nuptial migration. Analysis of these geographic midpoints provided insights into the spatial dynamics of migration and potential migratory patterns during this specific time frame.

Table 5. Number of recoveries and geographic midpoints calculated for the 10-day periods in January and February

10-day period	Recoveries (*N*)	Latitude	Longitude
January 1	61	36°34'N	04°10'E
January 2	54	36°31'N	04°15'E
January 3	65	36°30'N	04°19'E
February 1	67	36°36'N	04°14'E
February 2	74	36°35'N	04°10'E
February 3	52	36°33'N	04°14'E

Analysis of the coordinates of the six geographic midpoints obtained for January and February revealed no significant movements towards the Tunisian coasts during these two months. All six midpoints were closely clustered in the southern part of the province of Tizi Ouzou in the Kabylie region, where 45.3% of recaptures were concentrated (320). The easternmost geographic midpoint was calculated for the third 10-day period of January, but it was only 15.3 km away from that obtained for the first 10-day period of January. The distance between the midpoints of the first 10-day period of January and the third 10-day period of February was only 6.2 km. Similarly, the distance between the geographic midpoints of the second 10-day period of January and the second 10-day period of February was very small (10.5 km), as was the distance between the midpoints of the first 10-day period of January and the first 10-day period of February (7 km). These minimal distances suggest that the individuals recaptured in January and February remained within close geographic proximity in the southern part of the province of Tizi Ouzou, rather than showing a tendency to move towards the Tunisian coasts.

Life expectancy

Mortality is a significant factor influencing population density, and its assessment is crucial. The data collected from the recovery of ringed birds can be valuable for investigating the relationship between mortality in different age classes, yielding a fairly faithful depiction of reality. However, only 41% of the recoveries corresponded to individuals of known age (Euring codes 1, 3, and 5). As a result, the information primarily reflects the survival time of the birds. Table 6 presents numbers related to the recoveries categorized according to the time between the ringing and recapture dates, along with their respective percentages. Individuals with imprecise recovery dates (Euring code from 5 to 9) were not considered in this analysis.

Table 6. Life expectancy of song thrushes recovered in North Africa

Time between ringing and recovery	Number of recoveries	%
Less than a year	356	50.6
1 year	166	23.6
2 years	78	11.1
3 years	54	7.7
4 years	23	3.3
5 years	13	1.8
6 years	5	0.7
7 years	2	0.3
8 years	1	0.1
9 years	2	0.3
10 years	1	0.1
11 years	1	0.1
12 years	1	0.1
Total	703	

Table 6 shows that the time between the ringing and recovery dates varied from less than a year to approximately 13 years. The range spanned from 16 days for an individual of unknown age, ringed in Italy on 16 October 1993 and recovered in Kantidja (Tizi Ouzou, Algeria) on 11 January 1993, to 12 years and 303 days for an adult thrush ringed in Belgium on 31 March 1974 and shot in Boghni (Tizi Ouzou, Algeria) on 2 February 1987.

The distribution of recaptures based on time intervals revealed that half of the birds (356, 50.6%) were recovered less than a year after ringing, 23.6% (166 recaptures) within 1–2 years, 11.1% (78 recoveries) within 2–3 years, 7.7% (54 recoveries) within 3–4 years, and 3.3% (23 recoveries) within 4–5 years. For the other eight intervals, the percentages varied from 0.1% to 1.8%, and the number of recoveries ranged from 1 to 13.

Life expectancy was represented by the average number of days elapsed between the ringing date of recovery date. It was calculated using the following formula:

$$\text{Life expectancy} = \frac{\sum \textit{time between ringing recapture date}}{\textit{number of recoveries}}$$

The average survival time, or more precisely the interval between the ringing date and recovery date, was 1 year, 5 months, and 14 days (529.7 days). For more detailed and interesting examples, please refer to the *APPENDIX*.

DISCUSSION

The Mediterranean region of North Africa, especially the Maghreb, represents the southernmost part of the Song Thrush wintering range; however, there are no studies analysing the geographic origin and spatial distribution of birds that migrate and/or winter in this area. There is only a brief examination of data relating to thrushes

ringed in Europe and found in Algeria, based on 62 recoveries, carried out by Djennane (1989) and subsequently taken up by Middah (2001), with a broader study of the phenology and origin of 96 individuals. This work therefore presents the first analysis of recoveries of ringed thrushes in North Africa, based on 840 records of birds recovered during both migration and wintering.

The species is defined as a very abundant visitor throughout the Mediterranean belt of northern Africa (Isenmann et Moali 2000; Isenmann *et al.* 2005), even if there are no data on the number of wintering individuals. Migration occurs on a broad front in a south-westerly or south-easterly direction, but the various populations follow well-defined flyways (Ashmole 1962, Busse and Maksalon 1986, Milwright 2006). Most birds nesting in Fennoscandia, north-western Russia and the eastern Baltic States move along the north-western coasts of Europe, following the Atlantic route and reaching southwestern France mainly in October. From there, many birds, especially adults, continue on to winter in western Spain, and to a lesser extent in Morocco. Birds originating in central-eastern Europe, from Switzerland to Belarus, tend to follow a more southern course, the Rhine–Rhône route towards the French Mediterranean, before moving to wintering sites in the eastern Iberian Peninsula, the Balearics, and Algeria. Populations from south-eastern Europe mainly migrate towards Italy, with some individuals continuing to Corsica or Sardinia and even reaching Tunisia. Breeding populations from countries further east, such as Ukraine and south-eastern Russia, presumably winter in the eastern Mediterranean area, although data are limited due to the small number of individuals ringed. Birds which breed in the Netherlands and north-western Germany, probably of the *clarkei* subspecies, also follow a short loop migration route, passing through Belgium and arriving in northwestern France, then heading towards England and Wales around the end of winter, and finally returning to their nesting territories (Milwright 2006). Following these migratory routes, birds from different populations reach North Africa.

Ringing effort, represented by the number of individuals ringed, varies greatly from country to country and thus directly affects the probability of recovery; consequently, findings of ringed birds may not accurately reflect the composition of migratory flows arriving in North Africa. Furthermore, the variation found in recovery rates (*Rr*) in relation to the countries of origin (Table 4) also reflect the different migratory strategies adopted by this species. North Africa in fact represents a wintering area both for long-distance migrants, coming from geographically more distant regions (north-eastern Russia and Fennoscandia), and for partially migratory and short-distance populations that come from Western and Central Europe, as described by Milwright (2006).

A total of 24 different countries of origin were identified, with a significant predominance of thrushes ringed in Italy (41.2% of the total) during migration and, to a lesser extent, in Central Europe. Lower percentages come from Fennoscandia (Finland, Sweden, and Denmark) and from north-eastern Europe, crossing the Baltic Sea area. Only five recoveries of birds from Estonia, Lithuania, and Latvia were recorded. Despite the intense capture activity conducted by the Rybachy Biological Station in the Courish Spit, which ringed 22,907 thrushes in 1956–1999, the lists of long-distance recoveries (Payevskij 1973, Bolshakov *et al.* 1999, 2000, 2001) reported only

two for Algeria, in 1933 and 1980, of a total of 358 recoveries by the end of 2000 (Payevskij and Vysotsky 2003). More substantial numbers are linked to the activity carried out by Operation Baltic on the Baltic coast of Poland, with 20 recoveries in Algeria, two in Tunisia, and one in Morocco (Busse *in litt*.).

The modest presence in North Africa of thrushes coming from north-eastern Europe is confirmed by the *Rr* calculated for the total number of birds ringed in the Baltic Sea area in 1975–2001. Based on data obtained from reports published by EURING (https://euring.org/data-and-codes/ringing-totals) and some ringing centres, it is estimated that no fewer than 315,595 individuals were ringed in this area (Norway, Sweden, Finland, Denmark, Estonia, Latvia, Lithuania, Kaliningrad, Heligoland and Poland) during the period analysed. This number is considered inaccurate and likely underestimated, as complete ringing data for all the years (1975–2001) were not accessible for all the countries considered. When compared to the number (89) of subjects recovered in North Africa, it produces the lowest *Rr* value (0.28) among those reported in Table 4.

The high number of recaptures of birds ringed at the Arosio Bird Observatory produces the highest *Rr* value among those calculated, reflecting the intense migratory flow that passes through northern Italy after crossing the Alps, primarily originating in Central Europe. In October, northern Italy serves almost exclusively as a transit area for birds, which then continue towards the coast of the French Mediterranean – also a crucial transit area for some of the long-distance migrants heading to eastern Spain and Algeria. The recaptures of birds ringed in Switzerland and southern Germany, both during migration and the breeding season, are also attributable to this migratory flow.

Only a small portion of these birds cross the Apennines to reach central-southern Italy (Vigorita and Reguzzoni 1998), an area reached instead by a high number of birds coming from eastern Europe, and in particular from Hungary. The distribution map of the recoveries of thrushes ringed in Hungary (Csörgö *et al*. 2017) shows a high concentration in central-southern Italy; some of these birds can then move further towards the Corsica/Tunisia area during the winter. Among 48,068 thrushes ringed in Hungary from 1951 to 2022, only six were found in North Africa (Karcza *pers. comm*.), all between 1983 and 2021, representing just 1.8% of the total 284 recoveries between 1951 and 2016 (Csörgö *et al*. 2017). Consequently, when *Rr* is calculated for the same period used for the countries in Table 4, the resulting value (0.43) does not differ much from those calculated for Sweden and Denmark. It is possible, however, that southern Italy is also reached by other birds of more eastern origin, which then tend to move towards Tunisia. The small number of recoveries in Tunisia, compared to Algeria, despite high hunting pressure, could be due to wintering in this country of populations that are not intensely ringed in their countries of origin.

Of great interest is the high number of recoveries reported for Algeria, around 90% of the total, occurring mainly in Kabylie. This is a mountainous coastal region that extends east of Algiers, in the north of the country, rich in olive groves and biotopes used by thrushes, and divided into the administrative territories of seven provinces. Among the recaptures, 45.3% (320 birds) are concentrated in the province of Tizi Ouzou, but if we also consider the provinces of Béjaia, Bouira, and Boumerdés,

we arrive at 78.2% (553 recaptures) in an area that constitutes less than 2% (32,486 km^2) of the whole of Algeria (2,381,741 km^2). This is most likely due to the traditional hunting and trapping activities practiced in this region, which exert strong pressure on numerous passerine species, probably leading to overestimates of the importance of this part of Algeria as a wintering area. The significant difference in the frequency of recaptures in Algeria compared to the other two Maghreb countries suggests how the disproportion in the intensity of some human activities can be related to a corresponding disproportion in the number of recoveries: Algeria 89.6%, Morocco 6.3% and Tunisia 4.1%. However, it should be noted that McCulloch *et al.* (1990) report very high hunting rates for all three countries; it is therefore possible that, since the birds arriving in the Maghreb area are all subjected to strong hunting pressure, this does not influence the relative recovery rates.

The temporal analysis of recaptures highlights the fact that the number of captured birds becomes more substantial from the 1960s to the 2000s, followed by a marked decline. This decrease may be attributed to a reduction in the number of reported shot/hunted birds, but it is perhaps more likely to reflect an actual decline in hunting pressure across North Africa.

Few captures are reported for the month of October; the peak is observed in January, while a rapid decrease is noted from February. The higher number of captures during the winter period may be attributed to the birds' tendency to undertake significant movements southwards within their wintering range to escape unfavourable climatic conditions (Ashmole 1962, Thonnerieux 1981, Cramp 1988, Claessens 1990, 1991; Milwright 1994, 2003), in terms of both survival (Robinson *et al.* 2007) and food availability (Berthold 1996). In fact, large-scale arrivals in North Africa can occur in mid-winter (Smith 1965), when the species can exploit the typical vegetation of the Mediterranean scrubland and olive and vine cultivations.

Among recaptured birds, 62.9% are concentrated between the first 10-day period of January and the third 10-day period of February, with the peak reached in the middle 10-day period of February, followed by a decline. This trend is even clearer when only direct recaptures are examined, demonstrating a marked increase in January and February, attributed to the arrival of thrushes from alternative wintering areas. This indicates that these birds are still present in North Africa, in the southernmost part of their wintering range, at a time when, according to Andreotti *et al.* (1999), prenuptial migration towards Italy would commence, and it confirms the lack of south-north movements in the specified timeframe. In this regard, it is noteworthy that in Algeria, the highest number of direct recaptures of thrushes ringed in Italy occurred in February. Furthermore, among the few recaptures of ringed individuals in North Africa, there were only two direct recaptures in Europe: one individual ringed in Tunisia in the third 10-day period of January and shot in the first 10-day period of March in Lazio in central Italy, and another individual ringed in the first 10-day period of March in Morocco and shot after 21 days in Dordogne in south-western France. Therefore, there is no data supporting the hypothesis that birds originating in the southernmost parts of the wintering range are recaptured in Europe in January, indicating an unusually early start of spring migration. Ashmole (1962) also considers it likely that returning thrushes leave North Africa between late March and mid-April.

Based on the temporal pattern of recaptures (Fig. 2), it may be hypothesized that the onset of migration does not occur before the second 10-day period of February.

Examination of the geographical coordinates calculated for the centroids related to captures that occurred in the 10-day periods of January and February in Algeria (Table 5) does not reveal movements from the Kabylie area to Tunisia, as described by Andreotti *et al.* (1999). According to these authors, such movements are indicative of initial prenuptial movements that would later lead the birds to migrate to Sardinia. Indeed, there are only two recaptures in Sardinia of individuals ringed in Tunisia, occurring in September and November, several years after ringing. In January, there are only three recaptures, after several years, in Sicily and central-southern Italy, and these could be birds overwintering in this area. Furthermore, several individuals ringed in January in southern Italy (Calabria 4, Campania 9, Lazio 26), as well as in Marche (1), Emilia Romagna (1) and Lombardy (2), have been recaptured at the same ringing location (auto-recaptures) within a timeframe from the second 10-day period of January to the second 10-day period of March (Archivio GI.L; Scebba *et al.* 2014, Scebba and Oliveri del Castillo 2017, Muscianese *et al.* 2018). These recaptures do not indicate direct movements from south to north in January but rather suggest sedentary behaviour until March in the wintering areas. Similarly, there are no direct recaptures further north in January of individuals ringed in Corsica or Malta. Further confirmation comes from the departure dates in March of thrushes marked in December with satellite transmitters from wintering areas in the Sardinia, Marche and Apulia regions. The researchers acquired the last recorded wintering location and the first location during pre-breeding migration for a sample of 10 individuals spanning the years from 2021 to 2023. The mean date of the last wintering location was determined to be March 15 (min: February 20, max: March 26), with a corresponding mean date of March 24 (min: March 17, max: April 4) observed for the first location during pre-breeding migration (McKinlay *et al.* 2023).

Based on the recapture data, it can be concluded that the wintering area in North Africa is reached by various populations originating at different latitudes and exhibiting distinct migratory dynamics. The migratory flow from Central Europe is the most prominent, following both the Rhine–Rhône route towards the French Mediterranean and the Balearics and the route crossing the Alps and northern Italy before rejoining the former. Additionally, the Italian recapture data mentioned earlier do not confirm populations initiating prenuptial migration from January. This aligns with the ringing data, together with the corresponding analyses of body fat and weight, as reported in some publications related to central-southern Italy (Scebba and Sorrenti 2018).

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APPENDIX

Some data extracted from the recoveries of song thrushes in North Africa

Some interesting longevity records:

- A Song Thrush of unknown age, ringed in Ploegsteert, Hainaut (Belgium) on 31 March 1974, with ring Brussels 2X93419, shot in Boghni, Tizi Ouzou (Algeria) on 2 February 1987, after 4,691 days (12 years, 10 months, 2 days)
- A Song Thrush ringed as a nestling in Nagykovacsi, Pest (Hungary) on 19 May 1971, with ring Budapest 672282, captured near Bizerte (Tunisia) on 5 January 1983, after 4,249 days (11 years, 7 months, 17 days)
- A Song Thrush ringed as a juvenile in Sa Dragonera, Mallorca (Spain) on 11 October 1992, with ring Icona 3075407, killed in Tizi Ouzou (Algeria) on 3 January 2004, after 4,101 days (11 years, 2 months, 23 days)

Some interesting distance and time-distance records:

- A Song Thrush ringed as a nestling in Kunnasniemi, Pohjois-Karjala (Finland) on 12 June 1962, with ring Helsinki A136876, shot near Marrakech (Morocco) on 15 January 1963, at a distance of 4,373 km
- A Song Thrush ringed as a nestling in Ammarnas, Lapland (Sweden) on 18 June 1974, with ring Stockholm 4102017, captured in Eyr (Morocco) on 12 March 1978, at a distance of 4,116 km
- A Song Thrush ringed as a juvenile in Tulskyezaseki, Krapyva, Tulskaja (Russia) on 23 June 1951, with ring Moscow F79726, recaptured near Oran (Algeria) on 31 October 1951, at a distance of 3,524 km
- A Song Thrush ringed in Signilskär, Eckerö (Finland) on 18 September 1956, with ring Helsinki A56276, shot in Imouzzer du Kandar (Morocco) on 20 October 1956, covering a distance of 3,432 km in 32 days, averaging 107 km per day
- A Song Thrush ringed in Scalot, Sueglio, Como (Italy) on 16 October 1993, with ring Bologna Z130390, recaptured in Kantidja, Tizi Ouzou (Algeria) on 1 November 1993, covering a distance of 1,147 km in 16 days, averaging 72 km per day
- A Song Thrush ringed in Forcellino, Bergamo (Italy) on 7 October 1982, with ring Bologna S31305, found dead in Bouchagroune, Tolga (Algeria) on 26 October 1982, covering a distance of 1,293 km in 19 days, averaging 68 km per day