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Exploratory analyses of migration timing and morphometrics of the Song Thrush *(Turdus philomelos)*

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Abstract Ornithological studies often rely on long-term bird ringing data sets as sources of information. However, basic descriptive statistics of raw data are rarely provided. In order to fill this gap, here we present the third item of a series of exploratory analyses of migration timing and body size measurements of the most frequent Passerine species at a ringing station located in Central Hungary (1984–2016). First, we give a concise description of foreign ring recoveries of the Song Thrush in relation to Hungary. We then shift focus to data of 4137 ringed individuals and 1051 recaptures derived from the ringing station, where birds have been trapped, handled and ringed with standardized methodology since 1984. Timing is described through annual and daily capture and recapture frequencies and their descriptive statistics. We show annual mean arrival dates within the study period and present the cumulative distributions of first captures with stopover durations. We present the distributions of wing, third primary, tail length and body mass, and the annual means of these variables. Furthermore, we show the distributions of individual fat and muscle scores, and the distributions of body mass within each fat score category. We distinguish the spring and autumn migratory periods, breeding and wintering seasons, and age groups (i.e. juveniles and adults). Our aim is to provide a comprehensive overview of the analysed variables. However, we do not aim to interpret the obtained results, merely to draw attention to interesting patterns that may be worth exploring in detail. Data used here are available upon request for further analyses.

Keywords: Ócsa Bird Ringing Station, wing, third primary, tail length, body mass, fat, muscle, bird banding, capture-recapture, long term data, meta-analyses

Összefoglalás Madártani tanulmányokban gyakran elemeznek hosszútávú madárgyűrűzési adatsorokat, de az alapvető leíró statisztikák és exploratív elemzések általában nem hozzáférhetőek. E hiányt pótolandó, cikksorozatot indítottunk, melyben egy közép-magyarországi gyűrűző állomáson leggyakrabban előforduló énekesmadár fajok vonulás időzítésének és testméreteinek exploratív elemzéseit közöljük (1984–2016). A sorozat harmadik tagjaként szolgáló jelen cikkben először áttekintjük az énekes rigó magyar gyűrűs külföldi és külföldi gyűrűs magyarországi megkerüléseit, majd rátérünk a faj egy magyarországi, 1984 óta standard módszerekkel dolgozó gyűrűzőállomásról származó 4137 gyűrűzött és 1051 visszafogott egyedétől származó adatainak elemzésére. Az időzítés jellemzéséhez az éves és a napi átlagos első megfogások és visszafogások leíró statisztikái mellett megmutatjuk az évenkénti átlagos érkezési időket és azok változását. Az éven belüli időzítést az első megfogások kumulatív eloszlásával ábrázoljuk feltüntetve a tartózkodási időket is. Közöljük a szárnyhossz, a harmadik evező hossz, a farokhossz és testtömeg leíró statisztikáit. Ábrázoljuk ezen változók éves átlagait, a zsír- és izomkategóriák gyakorisági eloszlását, valamint a testtömegek eloszlását zsírkategóriák szerinti bontásban. Az elemzésben elkülönítjük a vonulási (tavasz, ősz), költési és telelési időszakokat és a korcsoportokat (fiatal, öreg). Célunk a vizsgált változók átfogó bemutatása és a bennük található mintázatok feltárása volt az eredmények interpretálása nélkül. Kérésre a cikkhez felhasznált adatsort rendelkezésre bocsátjuk.

Kulcsszavak: Ócsai Madárvárta, szárnyhossz, harmadik evező hossza, farokhossz, testtömeg, zsír, izom, madárgyűrűzés, hosszútávú adatsor, meta-analízis

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Introduction

Bird ringing or banding is one of the principal and oldest methods in use to study various aspects of avian populations (Robinson *et al.* 2009). Overwhelming amount of data has been collected in over a century of bird ringing, and has been used excessively in a diverse array of disciplines. However, compared to the amount of data available throughout the world, concise descriptive information suitable for meta- or comparative analyses is sporadically available (Gienapp *et al.* 2007, Harnos *et al.* 2015). Though purely descriptive studies are often hard to publish within the framework of current hypothesis-focused science, we feel that such studies may well play an outstanding role in generating new hypotheses for future studies. For this purpose, it is essential that descriptive studies apply the most appropriate statistical methodologies (Harnos *et al.* 2015, 2016). The bulk of currently available ringing data is often derived from long-term projects carried out at permanent ringing stations where large amount of individuals of various species are trapped simultaneously (Csörgő *et al.* 2016). These projects generally apply standardized methodologies in trapping, handling and data collection, thus information derived from these sites is suitable for location-wise comparisons (Schaub & Jenni 2000, Marra *et al.* 2004, Schaub *et al.* 2008, Tøttrup *et al.* 2010).

Here we present exploratory and descriptive statistics on the migration timing and morphometrics of the Song Thrush *(Turdus philomelos)* between 1984–2016 from a Central European ringing station (Ócsa Bird Ringing Station, Hungary, see Csörgő *et al.* 2016 for details).

The Song Thrush is a sexually monomorphic, omnivorous, medium-sized species of the Turdidae family. The upperparts are brown-toned, with a slightly more olive-tinged rump. Wing-covers have a weak buff spotting while the underparts are buff-white with dark boldly spots. The axillaries and the under wing-covers are orange-buffed. The adults and juveniles are similar in appearance, but usually there is a clear contrast between moulted inner great covers (generally 1–5) and rusty-brown juvenile outer great covers, with clearer and triangular yellowish mark at tip (Cramp 1988, Svensson 1992, Demongin 2016). Sexing is only possible in hand using the incubation patch of breeding adults.

The Song Thrush is polytypical, with 3 European subspecies, namely *T. ph. philomelos*, *T. ph. clarkei*, *T. ph. hebridensis*. The subspecies are quite similar in their appearance, making the identification of a single individual almost impossible (Cramp 1988, Svensson 1992, Collar 2005, Demongin 2016). However, wing length of males and females increases northwards (Cramp 1988, McCollin *et al.* 2015).

The breeding area ranges from the western Palearctic and extends eastwards into the central-eastern Palearctic (from northern Spain and Ireland to the Caspian Sea and Lake Baikal) (Cramp 1988, Tucker & Heath 1994, Tomiałojc 1997). The nominate subspecies breeds throughout most of Europe (except the northwest Mediterranean). *T. ph. clarkei* breeds on the British Isles, the Low (Benelux) Countries and northern France. Finally, *T. ph. hebridensis* on the Western Isles (Hebrides) and the Isle of Skye. The species was also introduced to Australia and New Zealand (Cramp 1988, Collar 2005), where it now has a stable breeding population.

Since the early 20th century, the Song Thrush has expanded to Fennoscandia (Melde & Melde 1991). From 1900 to the mid-1950's, it colonized urban parks and suburban habitats, however, this trend has tended to reverse since then (Tomiałojc 1997).

The Song Thrush is classified as Least Concern in the IUCN Red List; the European populations are moderately decreasing (Tomiałojc 1997, BirdLife International 2016). The British Song Thrush population suffered a marked decline since the 1975, falling by 65% at an average rate of 5–7% per annum in farmlands (Thomson *et al.* 1997).

Turdus thrushes are important quarry species in the western and central Mediterranean countries, with annual bags comprising many tens of millions of birds (McCulloch *et al.* 1992, Aebischer *et al.* 1999, Andreotti *et al.* 1999, Ricci 2001). Hunting is a significant cause of mortality: 70% of the recovered Swedish Song Thrushes (Fransson & Hall-Karlsson 2008), 41% (86% of birds found dead) of the Finnish birds (Valkama *et al.* 2014), 58% (90% of birds found dead) of Danish birds (Bønløkke *et al.* 2006), 83% (98% of birds found dead) of Czech and Slovakian birds (Klvaňa 2008), 82% of Hungarian birds (BirdLife Hungary 2017) were killed by hunters. This proportion of killed birds has not changed in the last half century (Valkama *et al.* 2014). Appart from hunting, meteorological conditions such as dense fog during sea crossing may have an impact on mortality in the migratory period (Alerstam 1990).

Out of 358 recoveries of Song Thrushes ringed in the Eastern Baltic between 1957–1999, 92.9% in Italy, 92.3% in France, 81.1% in Spain, and 72.7% in Portugal were killed by hunters. This is markedly different from other European countries, where the estimated proportion of hunting recoveries is only 28%. In the British Isles, where the Song Thrush is mainly resident and is not considered as a game species, adult survival rates did not differ from the values obtained for the Baltic populations, whereas first-year survival was somewhat higher than in Baltic birds. The hunting mortality of first-year thrushes may be balanced by a higher productivity (double-broods) of populations under hunting pressure (Payevsky & Vysotsky 2003).

In Western Europe the Song Thrush inhabits coniferous, broad-leaved or mixed forests, parks and gardens. These birds prefer moist, mossy forests with dense undergrowth, and avoid dry regions or habitats (Cramp 1988, Tomiałojc 1997). Their mating system is social monogamy, the parental care is generally biparental (Cramp 1988).

Different subspecies exhibit various migratory strategies (resident, partial or obligate migrant). *T. ph. hebridensis* is largery sedentary, however, some individuals moved to Ireland. British thrushes of the *T. ph. clarkei* subspecies are also largely sedentary, although a quarter of birds ringed during the breeding season and recovered in winter moved more than 20 km. The majority of these are migrants, wintering in Ireland, northwest France, northern Spain and Portugal. These populations demonstrate a leap-frog migration pattern. The British Isles also serve as wintering grounds for thrushes from the continent, individuals from the Netherlands, Belgium and Fennoscandia may winter here, or may also winter northern Iberia and the Mediterranean (Ashmole 1962, Cramp 1988, Thomson 2002).

The nominate subspecies *(T. ph. philomelos)* is an obligatory migrant in the northern parts of its breeding range, and partial migrant in the south. The general direction of autumn migration is in a large angle from southwest to southeast. The migration/winter recovery regions were defined mainly by boundaries of major water catchment areas. Migrants mainly winter in southwest Europe: in the Iberian, Apennine, Balkan Peninsulas, and in North Africa, Asia Minor and the Near East (Cramp 1988, Tomiałojc 1997, Milwright 2006).

The average migration speed is relatively slow (approx. 60–68 km/h) compared to other migrants (Ellegren 1993, Kaiser 1993, Chernetsov 2002, Fransson & Hall-Karlsson 2008). Song Thrushes are nocturnal migrants, migration activity typically peaks about 2 hours after sunset (Alerstam 1976, Berthold 1991). Migration intensity shows significant positive correlation to southwest and west winds, warm front passages and decreasing barometric pressure in spring, and eastwest-northeast wind and cold front in autumn in southern Sweden (Alerstam 1976).

In general, Song Thrushes move on a broad front in autumn. Fennoscandian and northwestern Russian birds move along the northwest coast of Europe, and winter mainly in West Iberia with presumably a smaller proportion of birds in Britain and in North Africa. The Fennoscandian birds have a leap-frog migration. The majority of individuals of this breeding population winter in the western part of the Iberian Peninsula, and also in Denmark, Germany, and the Czech Republic. Birds originating from Denmark winter mainly in Portugal, Spain, southwest France, and a smaller proportion of individuals may winter in Britain, the Apennine and Balkan Peninsulas and in North Africa. The birds breeding in the Netherlands and northwest Germany are partial migrants. Birds that do migrate can be categorized to two distinct groups; a) short-distance migrants that disperse to Belgium and northwest France in autumn/early winter, moving later to England and Wales in winter, and b) long-distance migrants, that move to southeast Biscay in October, many then move on in midwinter to West Iberia. The Song Thrushes originating from north and northeast Europe migrate through the Polish Baltic coast and have three main wintering areas: (1) Portugal and northwest Spain, (2) south Spain and France, (3) the

Apennine Peninsula, Corsica, Sardinia, North Africa and a hypothetical one on the Balkan Peninsula. (The birds wintering here are presumably from Russia.) The birds from Switzerland to Belarus follow the Rhine-Rhone route to the French Mediterranean and move to the Iberian and North African wintering sites. Most birds ringed in the Czech Republic use the migration route via Austria and Switzerland and winter from Portugal to Italy, from Belgium to North Africa. Intriguingly, the Slovakian birds probably use a different migratory route and wintering area, like the birds ringed in Hungary. The birds originating from Central and southeast Europe (including the Carpathian Basin) migrate to North and West Italy in autumn and winter on the Apennine Peninsula, Corsica and Sardinia. The Croatian breeders move to winter to Italy and southern France. Recoveries of foreign birds ringed during the breeding period and on autumn migration indicated three different routes toward Italy: a southwest route from Central and East Europe (southern Poland, Germany, Czech Republic, Slovakia, Austria, Hungary), one from the Baltic region (northern Poland, Baltic Republics, Finland and Russia), and a south-southeast route from Switzerland and eastern France. High frequencies of high fat score birds are recorded during the most intense phases of the autumn movements (Busse & Maksalon 1986, Schubert *et al.* 1986, Andreotti *et al.* 1999, Thomson 2002, Huttunen 2004, Bønløkke *et al.* 2006, Milwright 2006, Fransson & Hall-Karlsson 2008, Klvaňa 2008, Spina & Volponi 2008, Budinski 2013, Bairlein *et al.* 2014, Busse *et al.* 2014, Valkama *et al.* 2014).

Autumn migration commences in late August, early September and is finished by November in the northern parts of Europe. While adults leave Sweden earlier than juveniles and reach winter quarters ahead of the juveniles (Fransson & Hall-Karlsson 2008), but according to Valkama *et al.* (2014) the timing of adults and juveniles are similar in Finland. The birds ringed in Finland are concentrated in the Baltic region in October (Valkama *et al.* 2014), meanwhile the Fennoscandian and northwest Russian birds arrive in large numbers in southwest France in October (Milwright 2006). Migrants from Norway, Sweden, Finland, Russia pass Denmark in September-October. Recoveries south of the Pyrenees are mainly in November (Bønløkke *et al.* 2006). The birds from the Czech Republic depart in early September, the most intensive migration is in the period between late September and early October. The birds arrive in northern Italy and southern France in October and most of them fly to the Iberian Peninsula and North Africa (Klvaňa 2008). The median arrival date is in mid-September for Reit (Northern Germany) and early October for Mettnau and a few days later for Illmitz (north of the Alpine ridge (Bairlein 1981 in Schubert *et al.* 1986). Arrival median date is the third week of October in Lombardy (Schubert *et al.* 1986). The first thrushes ringed abroad are recorded in Italy in August, but trapping frequency increases considerably only from the second half of September, peaking between the end of October and early November. Winter recoveries in Italy are mainly in the northern and central Tyrrenian region, south of the Apennines and Sardinia between the second half of November and early January (Schubert *et al.* 1986, Andreotti *et al.* 1999, Spina & Volponi 2008).

Although the species migrates on a broad front, individual populations use narrow, well defined routes. For example the birds ringed at Ottenby Bird Observatory spend the winter east of birds ringed at Fasterbo Bird Observatory (Fransson & Hall-Karlsson 2008). After the Chernobyl accident, the mean levels of cesium radioisotope activity of Song Thrushes from Catalonia and Mallorca differed significantly. It is possible therefore, that the birds migrating to Catalonia and the Balearic Islands have different breeding areas (Ruiz *et al.* 1988). The birds ringed is Bohemia, Moravia (Czech Republic) and western Slovakia winter in southern France, eastern Spain and the Balearic Island. Birds ringed in eastern Slovakia were recovered in the Apennine Peninsula and Sardinia (Klvaňa 2008).

In contrast with most thrushes, the Song Thrush has high winter site fidelity (Ashmole 1962), but individuals can adaptively relocate. For instance, if the weather is unfavourable in southern Europe, the number of recaptures increases in Africa (Andreotti *et al.* 1999).

The spring migration starts in January in the most southern wintering area (North Africa) (Andreotti *et al.* 1999), in the second decade of February in Campania (Italy). In Latium (Italy), 91% of birds with fat scores 3 and 4 were recorded between the third decade of February and the third decade of March (Scebba & Oliveri Del Castillo 2017), with the majority in between the second and third decades of February. These results forecast the commencement of migration in these periods (Scebba *et al.* 2014). Furthermore, the number of recoveries declines in Spain and increases in France in February. The birds arrive to the Czech Republic in March (Klvaňa 2008). The first Song Thrushes arrive in Sweden and Finland in March, but most of the Swedish birds are in the Pyrenean region at this time. The Finnish birds are in typically in Germany in April, and arrive at the breeding area in May (Fransson & Hall-Karlsson 2008, Valkama *et al.* 2014).

While the migration phenology of age classes are similar in spring in Sweden (Fransson & Hall-Karlsson 2008), the median spring arrival day of adults is five days earlier, compared to the second calendar year birds in Finland (Valkama *et al.* 2014). At both western and central Mediterranean wintering sites the adult birds migrate further than the juveniles (Bønløkke *et al.* 2006, Milwright 2006).

In spring, northern populations presumably use the same routes as in autumn with no indication of loop migration (Cramp 1988, Fransson & Hall-Karlsson 2008, Bairlein *et al.* 2014). However, birds wintering in the Mediterranean may demonstrate a typical loop: the birds ringed in Italy move towards the Mediterranean coast of France, before reaching the Iberian Peninsula and North Africa (mainly in Algeria), later moving eastwards through Tunisia and flying back north via Sardinia and Corsica (Spina & Volponi 2008). On the east coast of Britain, considerable number of Song Thrushes are observed in autumn, that is in contrast with the handful of birds observed in spring, thus further suggesting also loop migration (Thomson 2002). Breeding site fidelity is high (Milwright 2006).

Spring migration shifted towards earlier dates in the last decades in Germany, Finland, the Baltic region and Russia (Forchhammer *et al.* 2002, Tryjanowski *et al.* 2005, Tøttrup *et al.* 2006, Lehikoinen & Sparks 2010). Furthermore, this species reacted to North Atlantic Oscillations (NAO); in high NAO winters, migrants arrived earlier, than after low NAO winters (Forchhammer *et al.* 2002). Moreover, the onset of migration was related to the March NAO index value in the Eastern Baltic (Sinelschikova & Sokolov 2004). It is plausible that the advancement of the timing of spring migration may be related to two factors. One of them is the more abundant food and its availability, and/or the higher migratory speed because of the tailwinds in flight (Alerstam 1976, 1990, Sinelschikova *et al.* 2007). Timing of autumn passage of this species in the Eastern Baltic did not show any trends (Sinelschikova & Sokolov 2004), while the timing was delayed in West Europe (Fiedler 2003).

The Song Thrush is common breeder in Hungary, mainly in the Alpine Foothills, Transdanubian Hills and the Northern Upland, in coniferous, mixed and deciduous woodlands. It is less widespread in the Great Plain, in remnant forests, floodplain gallery forests, and older plantation forests. Recently, the Hungarian population showed a moderate increase and is estimated to 2700–41000 pairs (trend of breeding period: 4.99 ± 0.55%, $p < 0.01$). The species is protected in Hungary (Hadarics & Zalai 2008, Szép *et al.* 2012, BirdLife Hungary 2017).

The Song Thrush is also a common passage migrant from March to April and from late September until early November. The number of overwintering individuals increased in recent years (Hadarics & Zalai 2008, Csörgő & Gyurácz 2009).

Our aim is to provide a comprehensive overview of migration timing, body size measurements and inter-annual changes in these variables. Hopefully, these patterns will help formulate research questions and provide information for further higher level analyses. However, we do not aim to interpret the obtained results, merely draw attention to interesting patterns, that may be worth exploring in detail.

Materials and methods

Bird ringing data

The Ócsa Bird Ringing Station is situated in Central Hungary (N47.2970, E19.2104) in the Duna-Ipoly National Park in the immediate vicinity of Ócsa town. The study site is characterized by a post-glacial peat bog with a mosaic of habitats including open water surfaces, reedbeds, bushy vegetation and forests. It is situated in a humid continental transitional climate zone (for further details see Csörgő *et al.* 2016, ocsabirdringing.org). Birds were trapped with standard mistnets placed at standard locations throughout the study period. Trapping effort is seasonal and changed over the years (see Csörgő *et al.* 2016 for details).

The day of the year of first capture in spring and in autumn were considered as arrival (migration) timing of individual birds. Stopover duration was calculated as the difference of within season last and first captures excluding within day recaptures. Biometric measurements were taken following strictly standardized methods (Szentendrey *et al.* 1979, EURING 2015). Only data of the first captures were used in the analysis. We distinguished first calendar year birds (juveniles) from adults upon plumage characteristics (Cramp 1988, Svensson 1992, Demongin 2016), and we present all results according to these groups. We present data for spring , breeding and autumn migratory seasons separately; birds caught after the 60th and before the 120th day of the year were considered to be spring migrants and birds caught after the 230th and before the 320th day of the year were considered to be autumn migrants. A total of 4137 Song Thrushes were captured and ringed between February and November; 1296 in spring, 211 adults and 1016 juveniles in the breeding season and 140 adults and 1376 juveniles in autumn (the rest of the birds was not aged) in the study period of 1984–2016. This total value constitutes ca. 12% of the 34315 Song Thrushs ringed in Hungary in this period.

Statistical methods

To describe daily and yearly capture frequencies and the cumulative distribution of the date of first captures with recaptures, we used the functions of the `ringR` package (Harnos *et al.* 2015). Descriptive tables (mean, median, standard deviation (SD), minimum (min), maximum (max) values and sample size (N)) on the timing of migration, stopover duration, the length of wing, third primary and tail, and body mass were created by the `data.table` package (Dowle *et al.* 2013), which is highly effective in calculating summary statistics for different groups and subsets. The annual mean values of timing, body mass, wing-, third primary and tail lengths are plotted against time (year) on scatterplots. Loess smooth lines were fitted to highlight trends (Cleveland *et al.* 1992). The distribution of the same variables were represented with histograms and overlaied smooth histograms. Boxplots were used to show the body mass distributions by fat score categories. Fat and muscle score frequencies are shown using barplots. We distinguished seasons and age groups throughout the analyses. For more details on the analysis, please visit ocsabirdringing.org. All analyses were carried out in R 3.4.0 (R Core Team 2017).

Results

A total of 284 foreign recaptures were recorded between 1951 and 2016 in relation to Hungary *(Figure 1)*. Annual capture and recapture frequencies at the study site are shown in *Figure 2*. Within-year capture and recapture frequencies, together with cumulative distributions of individual first and last captures are depicted in *Figure 3*, while their respective descriptive statistics are presented in *Table 1–2*. Changes in annual mean arrival dates throughout the study period and the distribution of within-year migration timing according to season and age are presented in *Figure 4*. The trend of annual mean wing lengths and the distributions of wing length measurements according to season and age are shown in *Figure 5*, while their respective descriptive statistics are presented in *Table 3*.

Third primary length *(Figure 6, Table 4)*, tail length *(Figure 7, Table 5)* and body mass *(Figure 8, Table 6)* are presented in a similar fashion. Body mass in relation to season and age and fat scores are visualized with boxplots in *Figure 9 a,c,e,g,i*. Finally, the distributions of fat and muscle scores grouped by season and age can be found in *Figure 9 b,d,f,h,j*, and *Figure 10*.

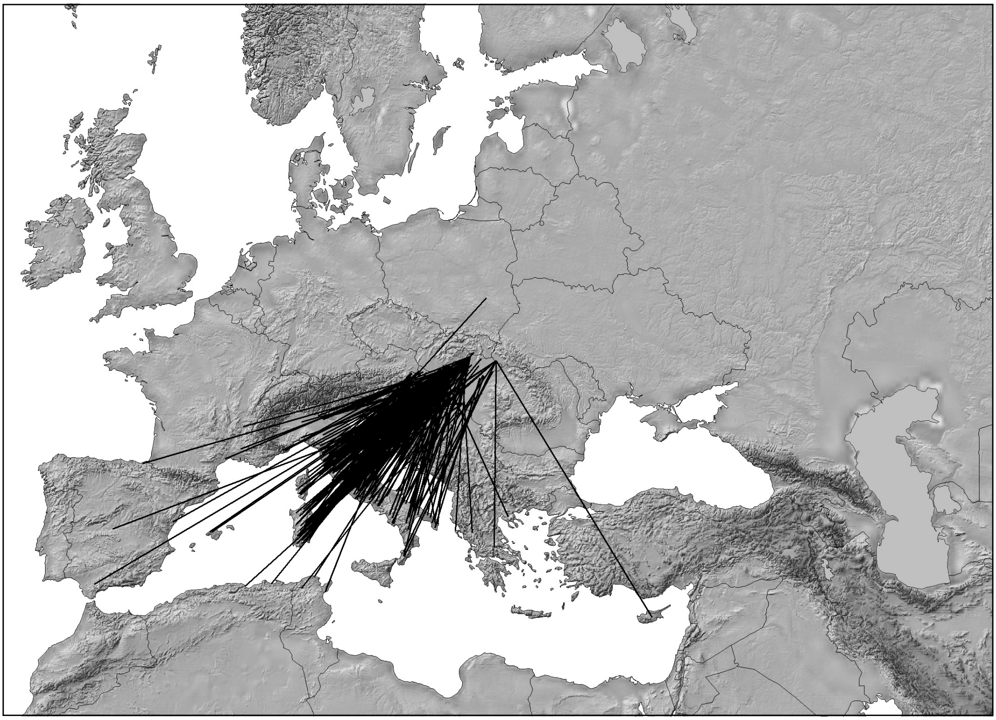


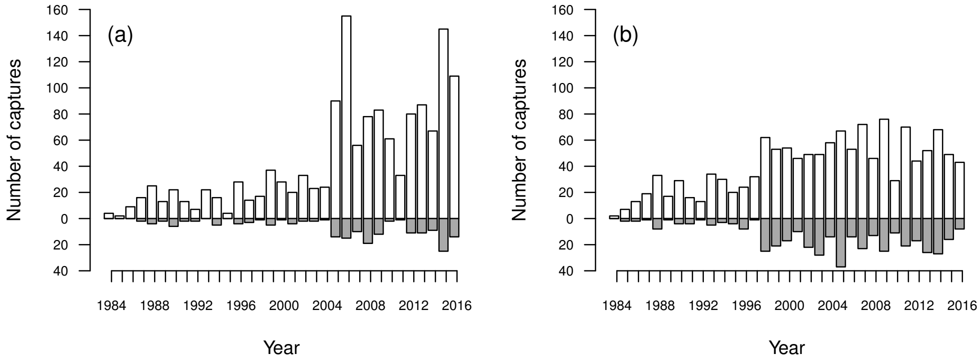
Figure 1. Foreign ring recoveries of Song Thrushes. The data of birds ringed in Hungary and recovered abroad and the birds ringed abroad and recovered in Hungary are depicted
1. ábra Magyarországon jelölt és külföldön megkerült, illetve külföldön jelölt és Magyarországon megfogott énekes rigók

Table 1. Descriptive statistics of migration timing (day of the year)
1. táblázat A vonulás időzítés (év napja) leíró statisztikái

Season	Age	Mean	Median	SD	Min	Max	N
spring	adult	88.7	89	9.9	61	120	1296
breeding	adult	187.7	193	27.5	121	243	211
breeding	juvenile	203.9	203	22.2	135	244	1016
autumn	adult	277.1	277	12.4	246	309	140
autumn	juvenile	276.3	277	14.5	245	319	1376

Table 2. Descriptive statistics of stopover duration (day)
2. táblázat A tartózkodási idő (nap) leíró statisztikái

Season	Age	Mean	Median	SD	Min	Max	N
spring	adult	10.7	8.5	10.2	1	45	116
autumn	adult	9.2	6.0	9.0	1	26	6
autumn	juvenile	6.6	5.0	5.5	1	23	72



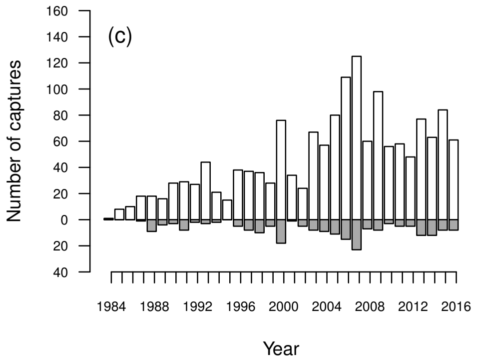


Figure 2. Annual capture (white bars) and recapture (grey bars) frequencies in spring (a), in the breeding period (b), and in autumn (c)

2. ábra Éves fogás (fehér oszlopok) és visszafogás (szürke oszlopok) gyakoriságok tavasszal (a), a költési időszakban (b) és ősszel (c)

Table 3. Descriptive statistics of wing length (mm)
3. táblázat A szárnyhossz (mm) leíró statisztikái

Season	Age	Mean	Median	SD	Min	Max	N
spring	adult	116.7	117	2.7	107	125	1232
breeding	adult	115.7	116	2.8	110	122	89
breeding	juvenile	115.7	116	2.7	105	125	936
autumn	adult	117.3	117	3.0	107	125	132
autumn	juvenile	116.4	116	2.8	107	125	1322

Table 4. Descriptive statistics of third primary length (mm)
4. táblázat A harmadik evező hosszának (mm) leíró statisztikái

Season	Age	Mean	Median	SD	Min	Max	N
spring	adult	88.6	89.0	2.4	80	96	1180
breeding	adult	87.7	88.0	2.3	82	93	81
breeding	juvenile	87.5	87.0	2.5	80	98	901
autumn	adult	89.2	90.0	2.7	80	96	128
autumn	juvenile	88.3	88.0	2.3	79	96	1288

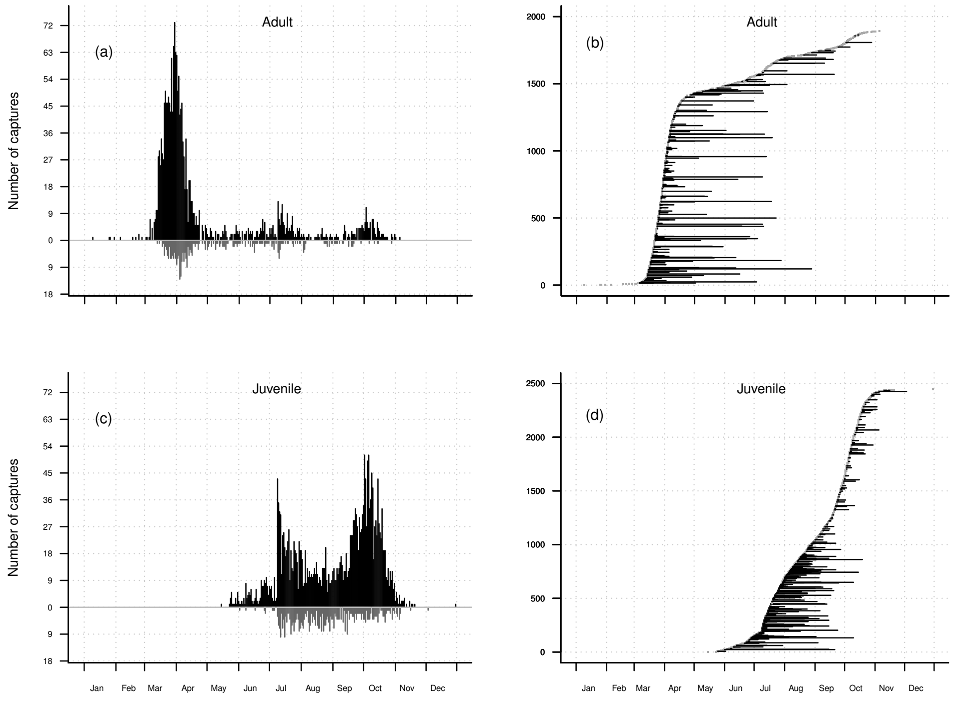


Figure 3. Within-year capture (black bars) and recapture (grey bars) frequencies (a,c) and cumulative distributions of individual first capture dates (b,d) according to age groups (horizontal lines: stopover durations)

3. ábra Éven belüli fogás (fekete oszlopok) és visszafogás (szürke oszlopok) gyakoriságok (a,c) és az egyedek első megfogási idejének kumulatív eloszlása (b,d) korcsoportonként (vízszintes vonalak: tartózkodási idők)

Table 5. Descriptive statistics of tail length (mm)
5. táblázat A farokhossz (mm) leíró statisztikái

Season	Age	Mean	Median	SD	Min	Max	N
spring	adult	83.2	83	3.4	73	95	1210
breeding	adult	83.3	83	3.3	76	92	86
breeding	juvenile	83.2	83	3.3	70	93	913
autumn	adult	83.9	84	3.5	72	93	129
autumn	juvenile	82.9	83	3.6	70	93	1288

Table 6. Descriptive statistics of body mass (g)
6. táblázat A testtömeg (g) leíró statisztikái

Season	Age	Mean	Median	SD	Min	Max	N
spring	adult	66.5	66.0	5.2	51.0	93.3	1276
breeding	adult	66.4	66.0	5.0	56.0	89.6	206
breeding	juvenile	65.3	65.0	4.9	50.5	87.8	993
autumn	adult	68.6	67.5	5.8	57.7	86.2	139
autumn	juvenile	68.2	67.5	5.5	49.0	94.0	1357

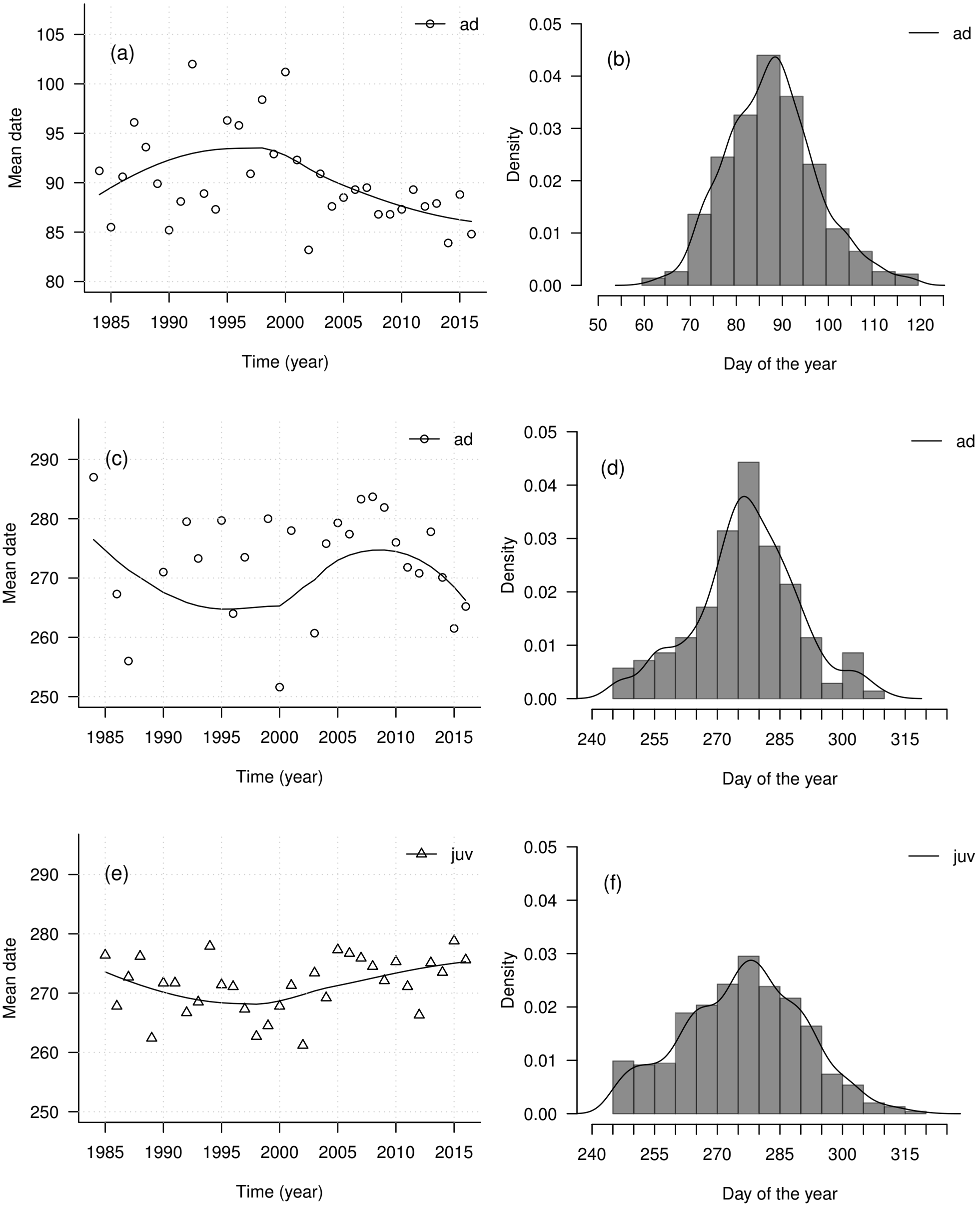
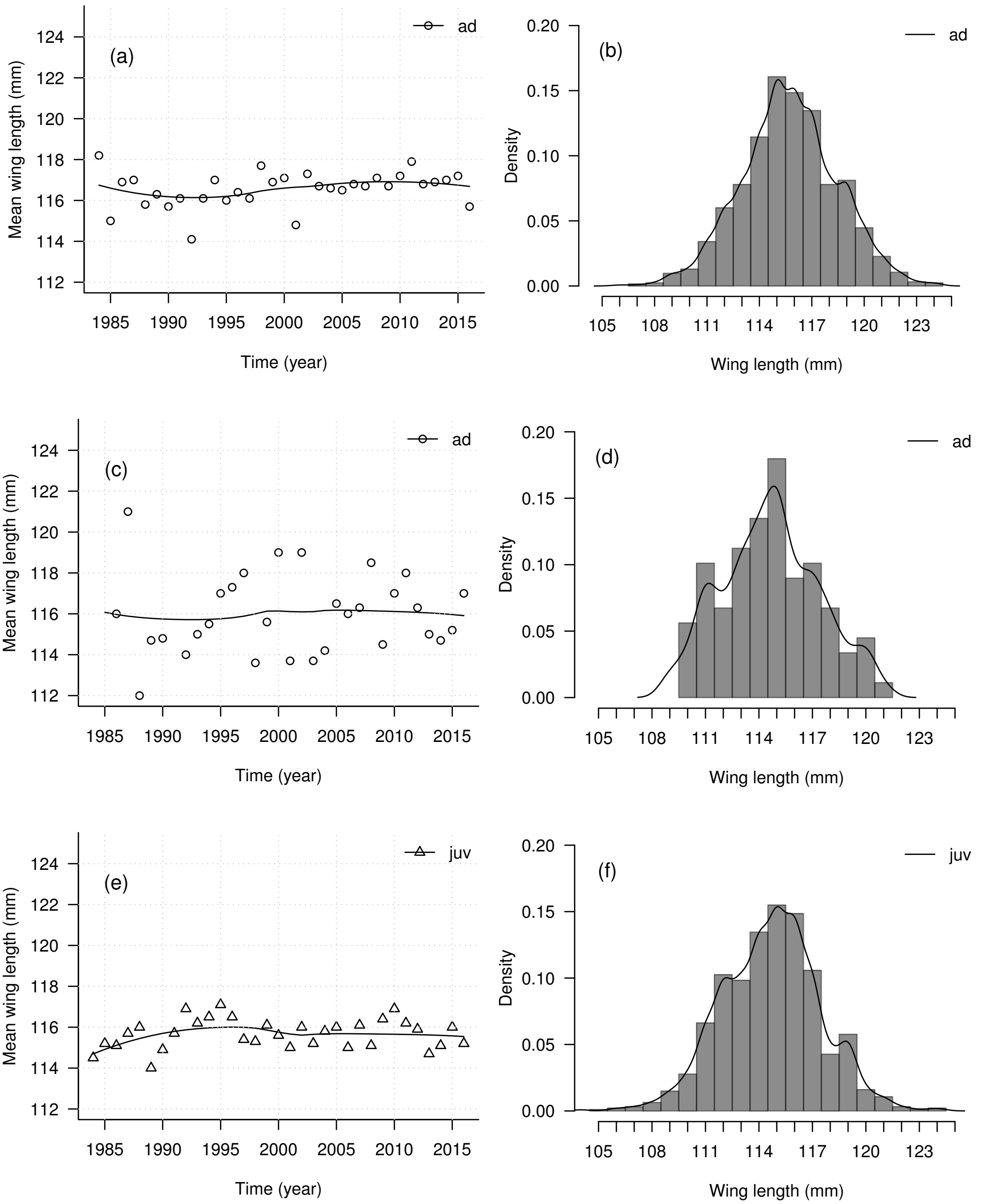


Figure 4. Annual mean migration timing (day of the year) throughout the study period and histograms/smoothed histograms of timing in spring (a–b) and in autumn (c–f)

4. ábra Az éves átlagos vonulás időzítés (év napja) a vizsgálati időszakban és az időzítés hisztogramja/simított hisztogramja tavasszal (a–b) és ősszel (c–f)


(a)
ad
Mean wing length (mm)
124
122
120
118
116
114
112
1985 1990 1995 2000 2005 2010 2015
Time (year)
(b)
ad
Density
0.20
0.15
0.10
0.05
0.00
105 108 111 114 117 120 123
Wing length (mm)
(c)
ad
Mean wing length (mm)
Time (year)
(d)
ad
Density
Wing length (mm)
(e)
juv
Mean wing length (mm)
Time (year)
(f)
juv
Density
Wing length (mm)

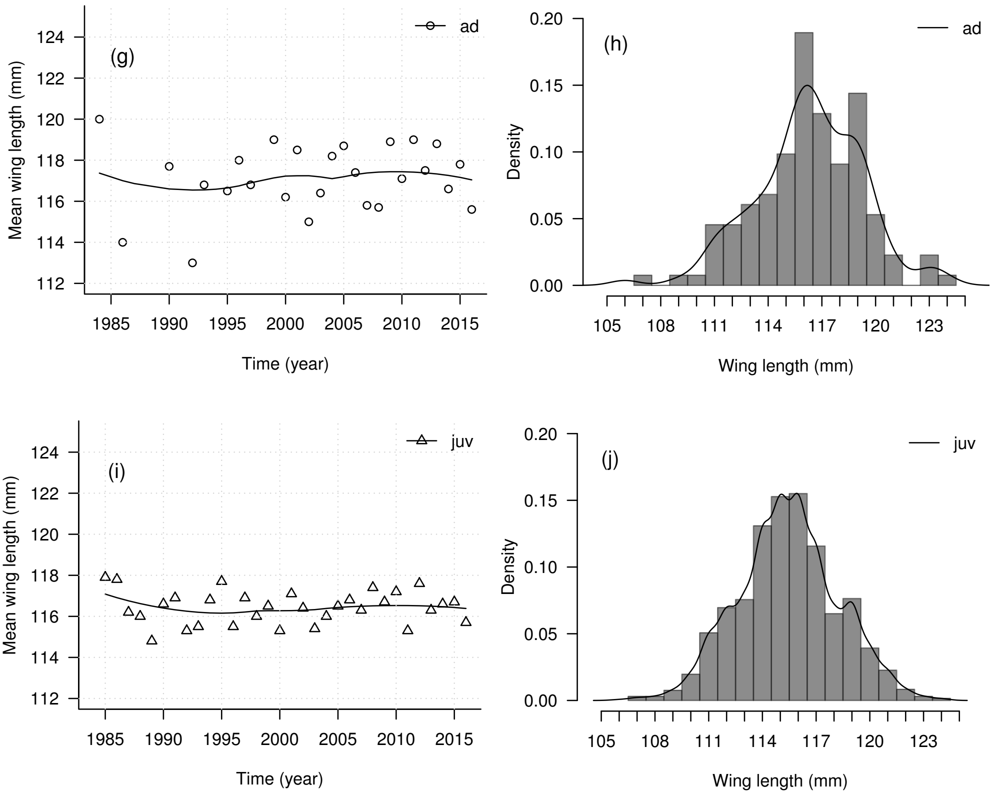
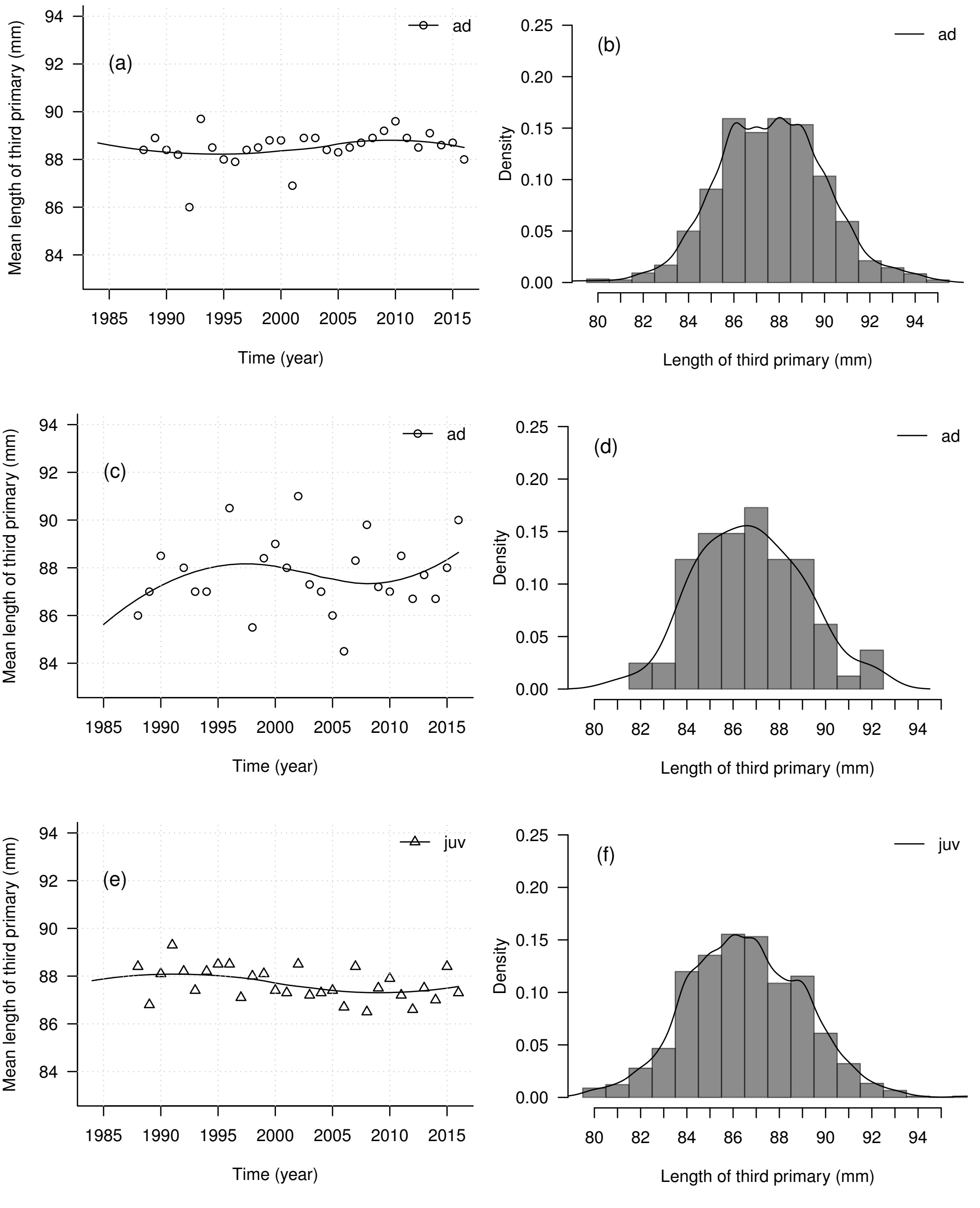


Figure 5. Annual mean wing length (mm) throughout the study period and histograms/smoothed histograms of wing length in spring (a–b) in the breeding period (c–f) and in autumn (g–j)

5. ábra Az éves átlagos szárnyhossz (mm) a vizsgálati időszakban és a szárnyhossz hisztogramja/simított hisztogramja tavasszal (a–b), a költési időszakban (c–f) és ősszel (g–j)


(a)
(b)
(c)
(d)
(e)
(f)
ad
juv
Mean length of third primary (mm)
Time (year)
Density
Length of third primary (mm)
94
92
90
88
86
84
1985
1990
1995
2000
2005
2010
2015
0.25
0.20
0.15
0.10
0.05
0.00
80
82
84
86
88
90
92
94

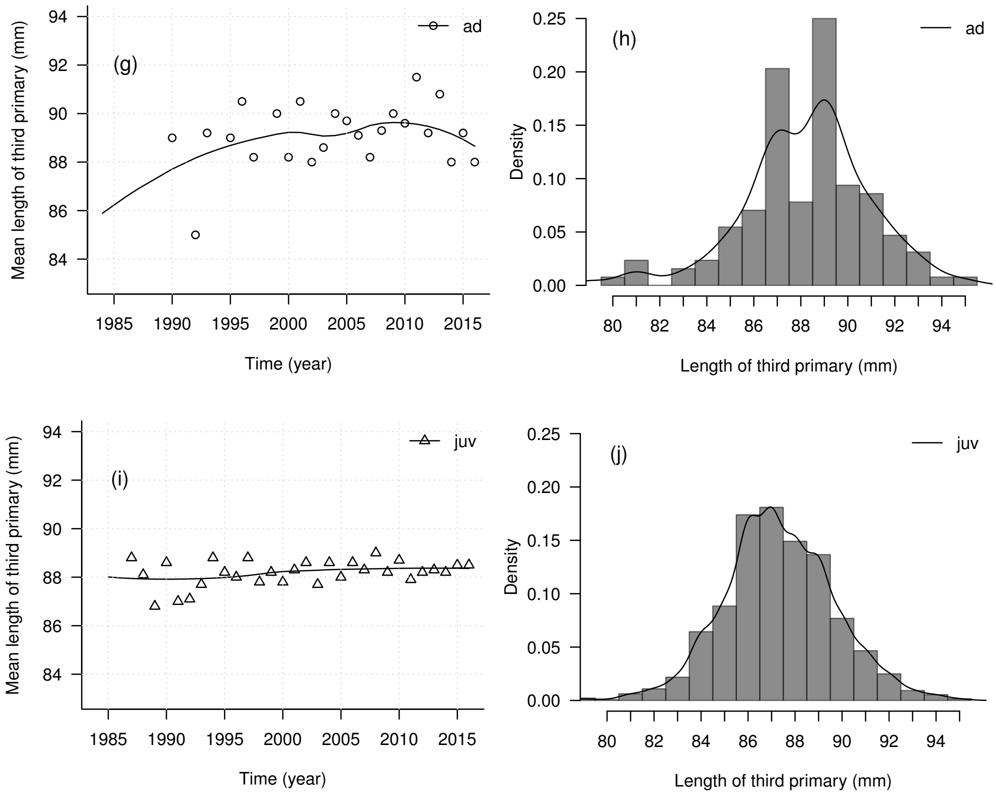
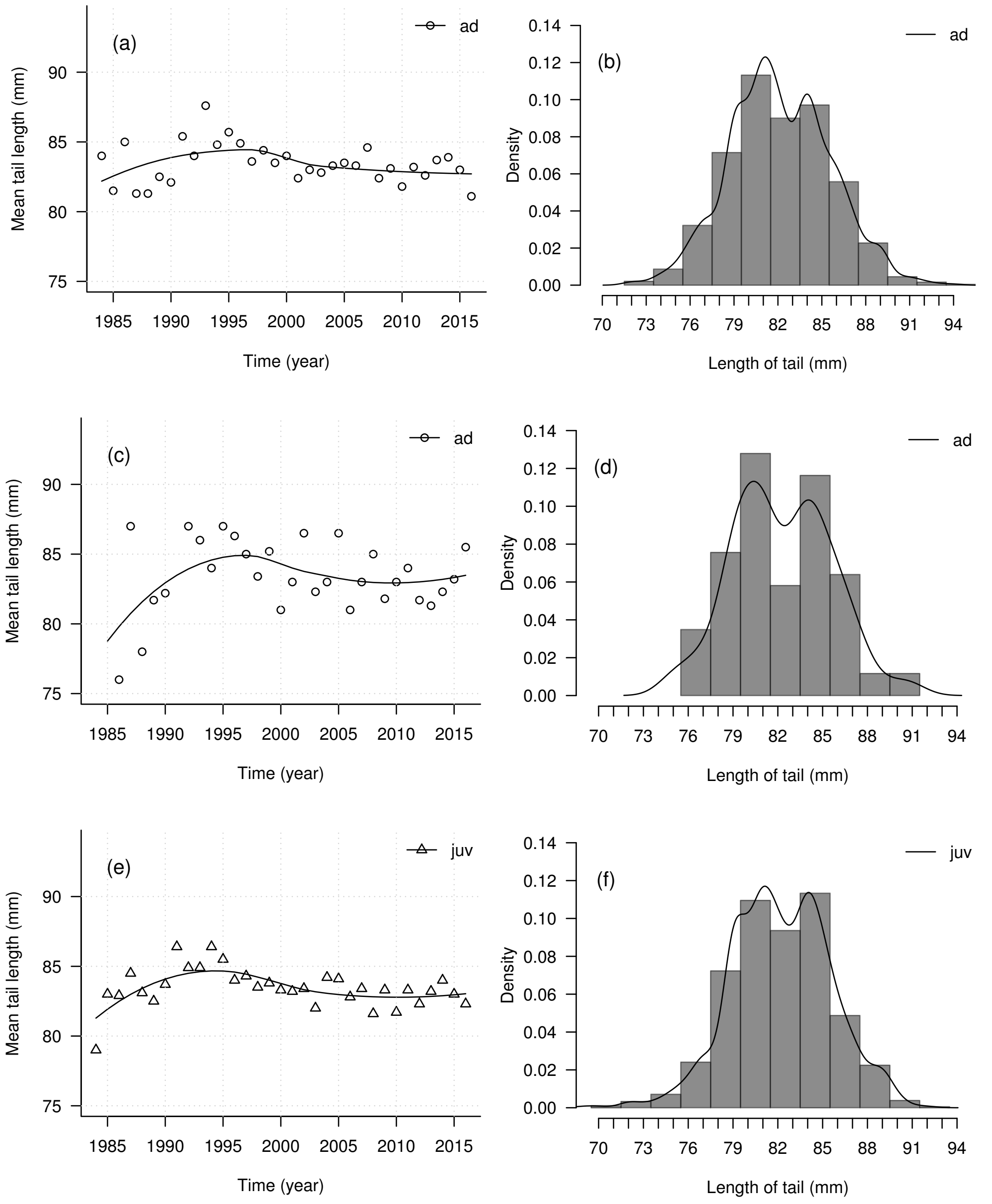


Figure 6. Annual mean third primary length (mm) throughout the study period and histograms/smoothed histograms of third primary length in spring (a–b) in the breeding period (c–f) and in autumn (g–j)

6. ábra Az éves átlagos harmadik evező hossz (mm) a vizsgálati időszakban és a harmadik evező hosszának hisztogramja/simított hisztogramja tavasszal (a–b), a költési időszakban (c–f) és ősszel (g–j)


(a)
ad
Mean tail length (mm)
75
80
85
90
1985 1990 1995 2000 2005 2010 2015
Time (year)
(b)
ad
Density
0.00 0.02 0.04 0.06 0.08 0.10 0.12 0.14
70 73 76 79 82 85 88 91 94
Length of tail (mm)
(c)
ad
Mean tail length (mm)
75
80
85
90
1985 1990 1995 2000 2005 2010 2015
Time (year)
(d)
ad
Density
0.00 0.02 0.04 0.06 0.08 0.10 0.12 0.14
70 73 76 79 82 85 88 91 94
Length of tail (mm)
(e)
juv
Mean tail length (mm)
75
80
85
90
1985 1990 1995 2000 2005 2010 2015
Time (year)
(f)
juv
Density
0.00 0.02 0.04 0.06 0.08 0.10 0.12 0.14
70 73 76 79 82 85 88 91 94
Length of tail (mm)

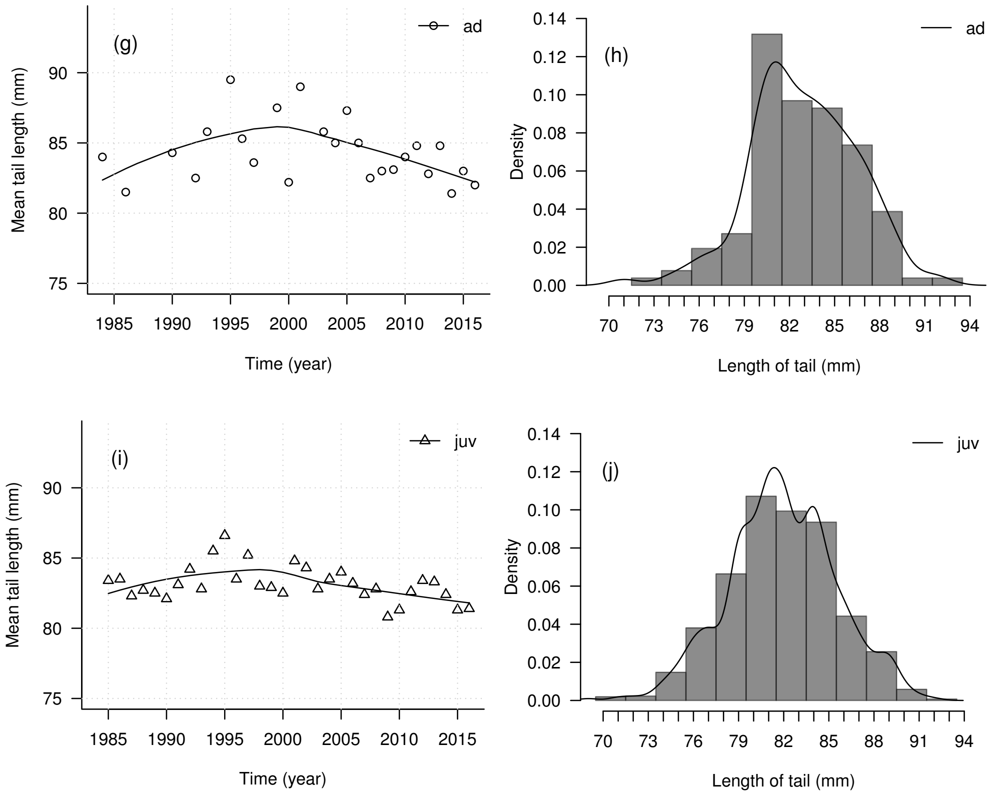
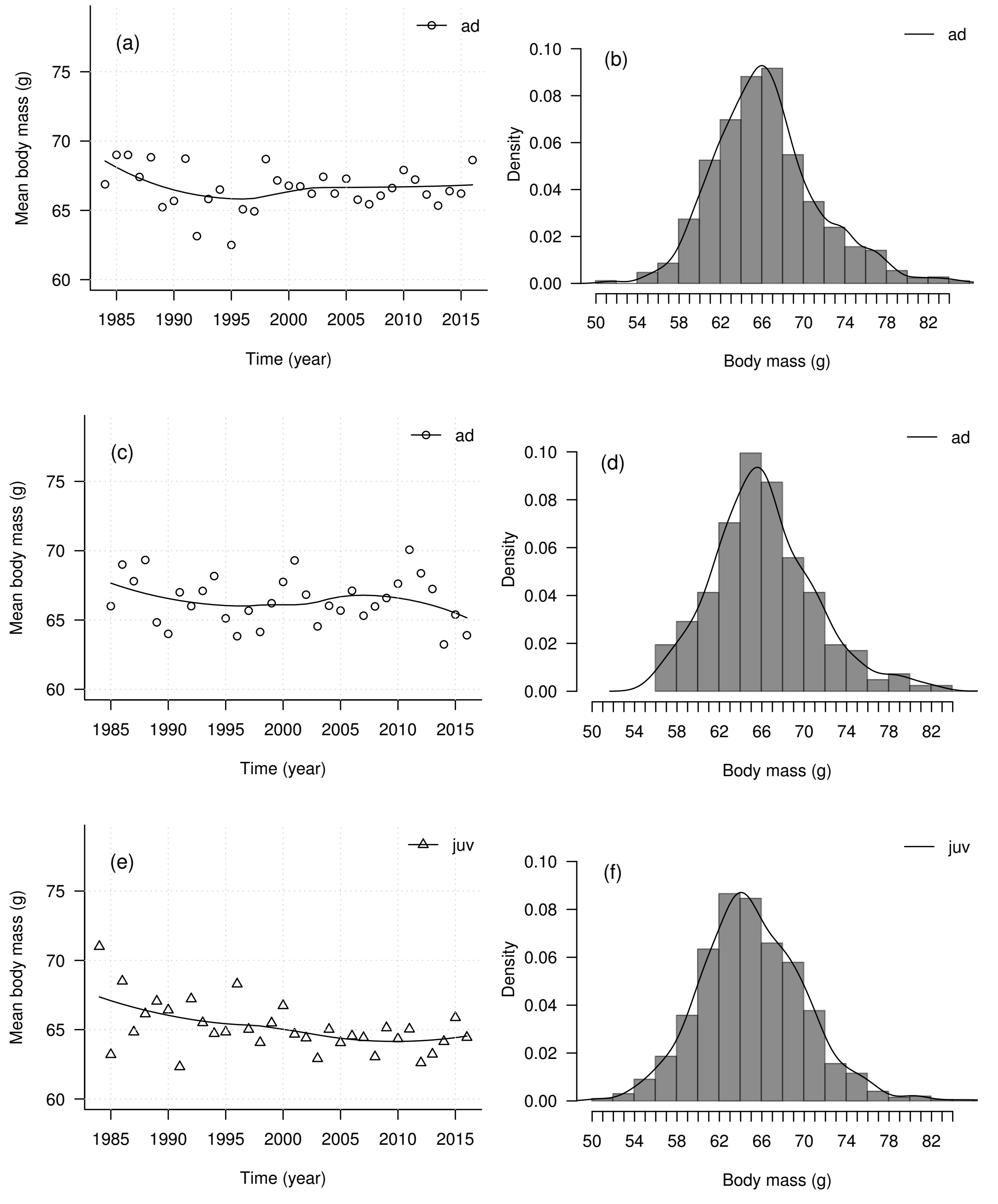


Figure 7. Annual mean tail length (mm) throughout the study period and histograms/smoothed histograms of tail length in spring (a–b) in the breeding period (c–f) and in autumn (g–j)

7. ábra Az éves átlagos farokhossz (mm) a vizsgálati időszakban és a farokhossz hisztogramja/simított hisztogramja tavasszal (a–b), a költési időszakban (c–f) és ősszel (g–j)


(a)
ad
Mean body mass (g)
Time (year)
(b)
ad
Density
Body mass (g)
(c)
ad
Mean body mass (g)
Time (year)
(d)
ad
Density
Body mass (g)
(e)
juv
Mean body mass (g)
Time (year)
(f)
juv
Density
Body mass (g)

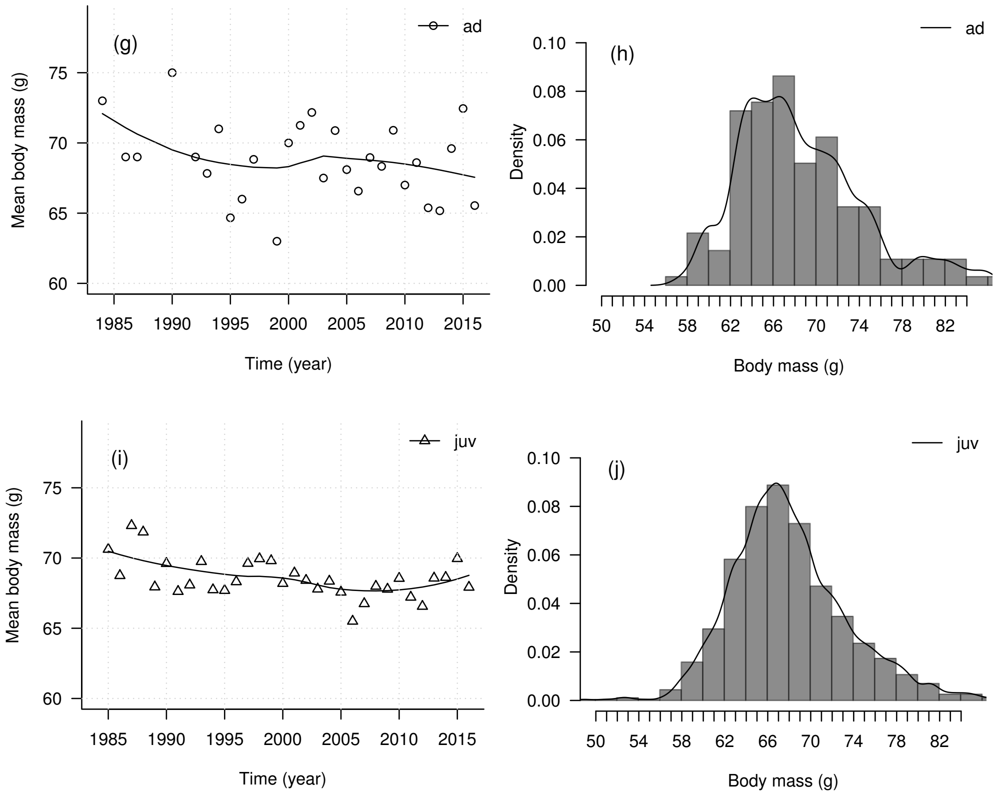
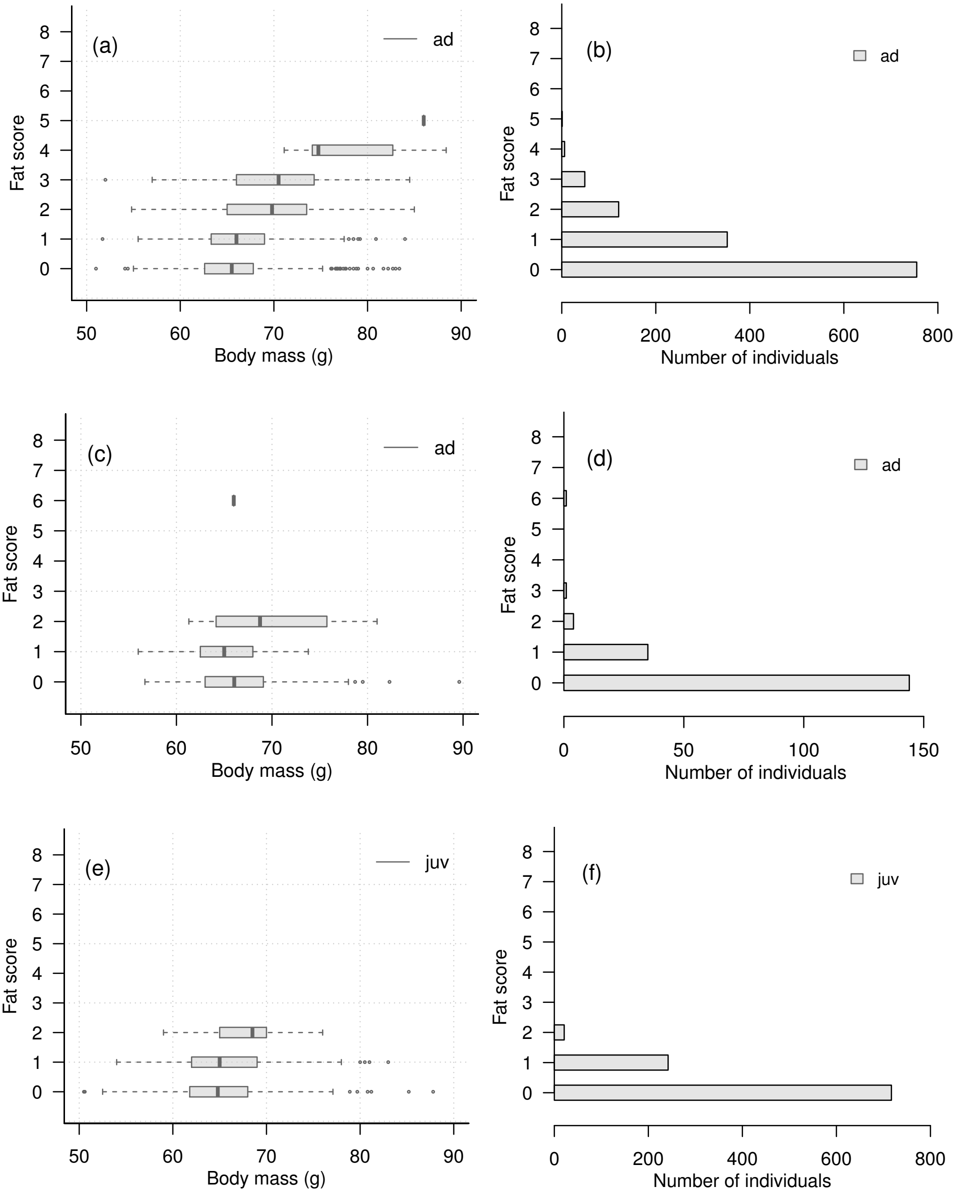


Figure 8. Annual mean body mass (g) throughout the study period and histograms/smoothed histograms of body mass in spring (a–b) in the breeding period (c–f) and in autumn (g–j)

8. ábra Az éves átlagos testtömeg (g) a vizsgálati időszakban és a testtömeg hisztogramja/simított hisztogramja tavasszal (a–b), a költési időszakban (c–f) és ősszel (g–j)


(a)
ad
Fat score
0 1 2 3 4 5 6 7 8
Body mass (g)
50 60 70 80 90
(b)
ad
Fat score
0 1 2 3 4 5 6 7 8
Number of individuals
0 200 400 600 800
(c)
ad
Fat score
0 1 2 3 4 5 6 7 8
Body mass (g)
50 60 70 80 90
(d)
ad
Fat score
0 1 2 3 4 5 6 7 8
Number of individuals
0 50 100 150
(e)
juv
Fat score
0 1 2 3 4 5 6 7 8
Body mass (g)
50 60 70 80 90
(f)
juv
Fat score
0 1 2 3 4 5 6 7 8
Number of individuals
0 200 400 600 800

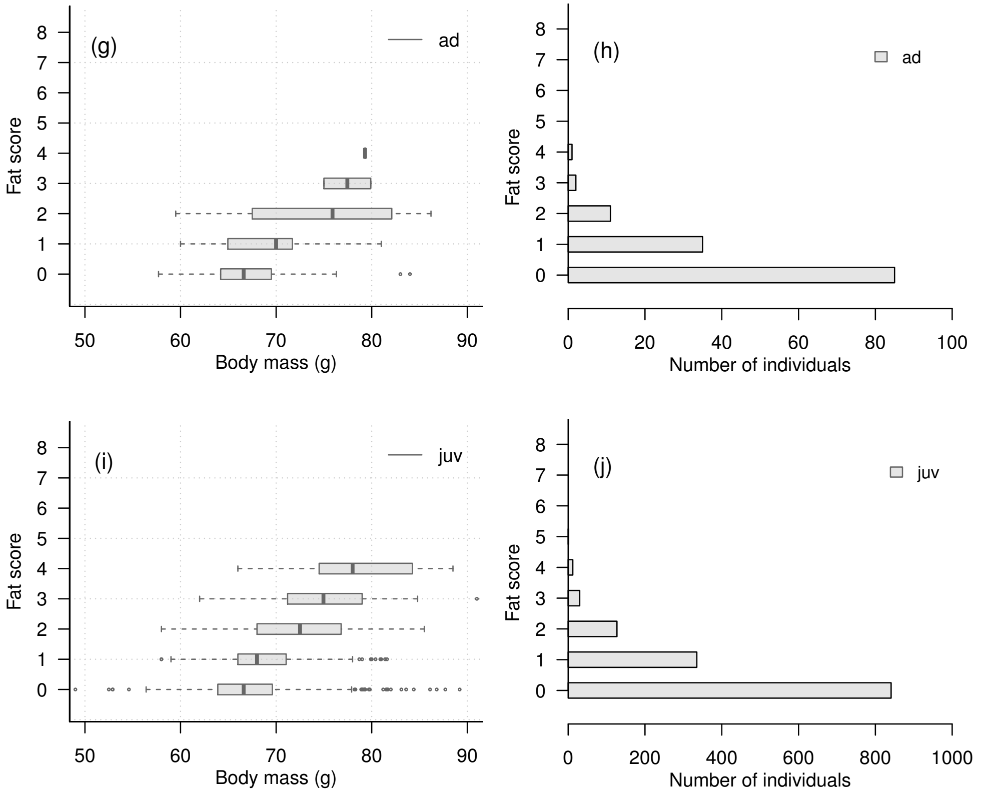


Figure 9. Boxplots of body mass according to fat score, and fat score frequencies in spring (a–b) in the breeding period (c–f) and in autumn (g–j)

9. ábra A testtömeg boxplot-ja zsírkategóriánként és a zsírkategóriák gyakoriságai tavasszal (a–b), a költési időszakban (c–f) és ősszel (g–j)

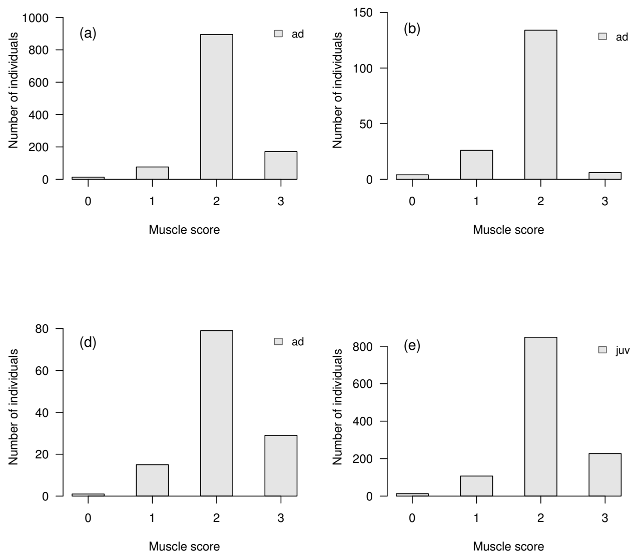


Figure 10. Muscle score frequencies in spring (a) in the breeding period (b–c) and in autumn (e–f)
10. ábra Izom kategória gyakoriságok tavasszal (a), a költési időszakban (b–c) és ősszel (e–f)

Discussion

Our exploratory and descriptive statistics of 33 years of Song Thrush ringing data show several intriguing patterns. Foreign capture-recapture patterns indicate that the orientation of large scale movement patterns are generally southwest-northeast. Recoveries from countries north of Hungary are practically absent (only a single Polish, and two Slovakian recaptures both ringed close to the border, inside the Carpathian Basin) *(Figure 1)*, despite the vast number of birds ringed in Poland, the Baltic States and Fennoscandia (Wozniak 1997, Bønløkke *et al.* 2006, Fransson & Hall-Karlsson 2008, Klvaňa 2008, Bairlein *et al.* 2014, Valkama *et al.* 2014). Birds ringed in the breeding period have been recovered in a relatively limited range in the Central Mediterranean, contrasting with the birds ringed during passage that have been recovered on a much wider range. This pattern suggests that the trans-migrant population in the Carpathian Basin originates from more eastern areas, where ringing activity is sporadic (Csörgő & Gyurácz 2009, BirdLife Hungary 2017).

Apparently, there is considerable variation in inter-annual capture frequencies during migratory seasons *(Figure 2 a,c)*. In general, more birds were captured per season in the second half of the study period *(Figure 2 a,b,c)*. Song Thrushes migrate early in the season (March), when ringing activity was less intensive prior to 2005, therefore this pattern may be caused by bias in ringing effort and not necessarily by changes in bird behaviour.

Overall, more adult birds are captured in spring than in autumn suggesting loop migration of the trans-migrant population at the Ócsa Bird Ringing Station *(Figure 3 a)*. In autumn the number of captured juveniles is remarkably high *(Figure 3 c, Table 1)*, far over the proportion of juveniles expected from the local reproductive output.

The stopover duration of juveniles is seemingly shorter than that of the adults' in spring *(Figure 3 b,d, Table 2)*.

While the spring migration timing of the adults appears to be decreasing in the second half of the study period *(Figure 4 a)*, the autumn timing appears to be delaying *(Figure 4 c)*. Timing of the adults and the juveniles in the autumn are rather similar *(Figure 4 c–f)*. The distributions of arrival timing in both seasons are seemingly unimodal *(Figure 4 b,d,f)*.

Considering morphometrics, there is no indication of sexual dimorphism *(Figures 5–8 b,h,j)*, and no indication of changes in these parameters within the study period *(Figures 5–8 a,g,i)*. However, adult birds apparently tend to have longer mean wing, third primary, and tail lengths and body mass compared to juveniles during migration*(Tables 3–6)*. Body mass is seemingly larger in both age groups in autumn *(Table 6)*, yet fat scores are apparently higher in spring *(Figures 9 b,h,j)*. In autumn, Song Thrushes forage on elderberries *(Sambucus nigra)* and other high water content fruits at the study site, potentially filling their digestive tracts, hence causing the observed difference.

Our results show that comprehensive exploratory analyses may reveal intriguing patterns, which may be investigated in more detail in the future. However, we emphasize that although the temporal extent of the data reported here is considerably large, all information presented here derives from a single location and thus has to be interpreted accordingly. Nonetheless, we hope that our results will help researchers conducting comparative or meta-analyses with baseline data and may also encourage others to report their data in a similar fashion. We also seek cooperation with interested parties and are willing to share all data reported here. Please contact the corresponding author for details.

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