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Exploratory analyses of migration timing and morphometrics of the Dunnock *(Prunella modularis)*

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Abstract Ornithological studies often rely on large temporal scale ringing datasets as source of information. However, basic descriptive statistics of collected data are rarely provided. In order to fill this gap, here we present the second 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 (1984–2015). First, we give a concise description of foreign ring recoveries of the Dunnock in relation to Hungary. We then shift focus to data of 11,617 individuals deriving 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 we present the cumulative distribution 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 distribution of individual fat and muscle scores, and the distribution of body mass within each fat score category. We distinguish migration periods (spring and autumn), 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 draw attention to interesting patterns, that may be worth exploring in detail. Data used here are available upon request for further analyses.

Keywords: Hedge Accentor, Hedge Sparrow, Hedge Warbler, 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 indítunk, melyben egy közép-magyarországi gyűrűző állomáson leggyakrabban előforduló énekesmadár fajok vonulás időzítésének és testméreteinek exploratív elemzéseit közöljük (1984–2015). A sorozat második tagjaként szolgáló jelen cikkben először áttekintjük az erdei szürkebegy magyar gyűrűs külföldi és külföldi gyűrűs magyarországi megkerüléseit, majd rátérünk a faj egy magyarországi, 1984 óta standard módszerekkel dolgozó gyűrűzőállomásról származó 11 617 egyedétől származó adatának 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. Ábrákon bemutatjuk ezen változók éves átlagait, a zsír- és izomkategóriák gyakorisági eloszlását, valamint a testtömegek eloszlását zsírkategóriák szerinti bontásban. Az elemzésben elkülönítjük az egyes vonulási időszakokat (tavasz, ősz) 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 volume 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 must apply the most appropriate statistical methodologies (Harnos *et al.* 2015, 2016). The bulk of currently available ringing data is often derived from large temporal scale projects like permanent ringing stations, where massive amount of individuals of various species are trapped simultaneously (Csörgő *et al.* 2016). These projects generally apply standardized and similar 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 Dunnock between 1984–2015 from a Central European ringing station (Ócsa Bird Ringing Station, Hungary, see Csörgő *et al.* 2016 for details).

The Dunnock is a small, sexually monomorphic omnivorous passerine of the Prunellidae family. The plumage on the chest and on the head is mostly blueish-gray. The back, and the sides of the breasts are brown with dark streaks, although individuals can differ a lot in their looks. The juveniles are similar in appearance, but the gray parts are paler while the striations are more dominant (Cramp 1988, Svensson 1992, Demongin 2016).

The Dunnock is polytipical, with 8 descriped subspecies, namely *P. m. modularis, P. m. hebridium, P. m. occidentalis, P. m. mabbotti, P. m. meinertzhageni, P. m. fuscata, P. m. euxina, P. m. obscura*. The subspecies are quite similar in their appearance, making the identification of a single individual almost impossible. Wing morphology slightly differs among the subspecies, migratory ones tend to have longer, skewer, more pointed wings compared to the residents' shorter, rounded wings (Cramp 1988, Svensson 1992, Demongin 2016).

It's breeding distribution ranges across mainly in the temperate and marginally in the subarctic and boreal zones of the Palearctic Region (Cramp 1988). The nominate subspecies occupies the majority of the breeding range. *P. m. hebridium* breeds in the Inner, Outer Hebrids and Orkney, *P. m. occidentalis* in the British Isles, *P. m. mabotti* in the Iberian Peninsula, in South France and in South Italy. *P. m. meinertzhageni* can be found in the Balkans, *P. m. fuscata* in the Crimean Peninsula, *P. m. euxina* in the north-western parts of the Anatolian Peninsula, while *P. m. obscura* breeds in the Eastern-Anatolian Peninsula, besides Northern-Iran, Caucasus and the Crimean Peninsula. The breeding range of the *P. m. modularis* is apparently expanding north in Fennoscandia, presumably due to modern forestry practices (Vogel & Tuomenpuro 1997, Fransson & Hall-Karlsson 2008). The species was also introduced to New Zealand (Cramp 1988, Hatchwell 2005).

The Dunnock is classified as Least Concern in the IUCN Red List, however the European population is moderately decreasing (BirdLife International 2016).

In Hungary, the first record of the nominate subspecies was recorded in 1934 (Studinka 1931–34 in Magyar *et al.* 1998, Hadarics & Zalai 2008), but it is known as regular breeder only since the early 1960's (Rapos 1962, Szabó 1962 in Magyar *et al.* 1998, Hadarics & Zalai 2008). Today the Hungarian population shows a moderate decrease and is estimated to 1200–1500 pairs. The species is protected in Hungary (BirdLife Hungary 2016).

Breeding habitats of Dunnock is deciduous and coniferous woods with dense undergrowth (Cramp 1988). Their mating system is complex, both monogamy and various forms of poligamy (poliandry, poligyny, poligynandry) may occur (Davies & Lundberg 1984, Davies 1985, 1986, Davies & Houston 1986, Hatchwell & Davies 1990, 1992, Santos & Nakagawa 2013).

Various migratory strategies can be found among the subspecies (resident, altitudinal migrant, partial or obligatory migrant). The *P. m. hebridium* and the *P. m. mabotti* are residents. The *P. m. occidentalis* makes short, dispersive movements, although a few indviduals originated from the British Isles were found in Northern France, Belgium, the Netherlands, Denmark, Germany and Norway (Hartly 2002). The *P. m. euxina* and the *P. m. obscura* are residents or partial migrants. The nominate subspecies is an obligatory migrant in the northern parts of its breeding area, and partial migrant in the south (Cramp 1988). The speed of the migration is relatively slow (34.5 km/day on average; Fransson & Hall-Karlsson 2008), they take small steps, mostly at dawn (Dorka 1966 in: Bingman & Wiltschko 1988). Although the species migrates on a broad front, individual populations use narrow, defined routes (Zaniewicz & Busse 2008). The general bearing of the autumn migration is south-west across the whole breeding range. North-eastern populations (Finland, Valkama *et al.* 2014) are the first to depart in mid-September, while the north-western birds take off in late September, early October (Bønløkke *et al.* 2006, Fransson & Hall-Karlsson 2008). These populations migrate through the Baltic Sea (Sokolov *et al.* 1999, Zaniewicz & Busse 2008). Arriving to the wintering grounds takes place between September and November depending on the location of the breeding and wintering sites (Schubert *et al.* 1986, Pons 2001, Spina & Volponi 2009).

Migrating populations overwinter mostly in southern Europe (Malczewski & Pukinsky 1983, Cramp 1988, Fransson & Hall-Karlsson 2008, Spina & Volponi 2009, Barišić 2013, Valkama *et al.* 2014), a few recaptures were reported from Morocco and Algeria (Bairlein *et al.* 2014). Qualitative overview of the recapture patterns of Dunnocks from Russia (Malczewski & Pukinsky 1983), Finland (Valkama *et al.* 2014), Sweden (Fransson & Hall-Karlsson 2008), Denmark (Bønløkke *et al.* 2006), Germany (Bairlein *et al.* 2014), Czech Republic (Hromádko 2008), Croatia (Barišić 2013), Italy (Spina & Volponi 2009) revealed, that there is strong migratory connectivity of breeding populations. The breeding range of the Swedish birds ranges from Denmark to North Spain. Their recovery patterns further indicates that in the last decades the wintering range gradually shifted north for this population (Fransson & Hall-Karlsson 2008). Individual inter-annual wintering site fidelity is high, especially in the southern regions (Benvenuti & Ioalè 1980, Ioale & Benvenuti 1983, Schwabl *et al.* 1991, Pons 2001, Spina & Volponi 2009, Barišić 2013). In winter, Dunnocks hold feeding territories (Birkhead 1981) and they have high within and between season site fidelity in winter (Pons 2001, Spina & Volponi 2009).

In Hungary, the ratio of overwintering and passage migrant Dunnocks vary considerably between years. Csörgő *et al.* (2001) showed that the migration was unimodal in autumn at the study site. The majority of migrant birds arrived during the first half of the migratory period and their stopover duration was short. Later arriving birds spent the whole winter in Ócsa in some years while not in others depending on the weather of previous year. In mild winters, birds remaining in the Carpathian Basin instead of migrating further south-west, may have selective advantage, since they could reach the breeding area earlier and could occupy better territories resulting higher numbers on the next winter. On the other hand, after cold winters, due to the high mortality of birds remaining in the Carpathian basin, the passage migrants had advantage. Costs and benefits of the two strategies change year by year as the winter weather condition fluctuate resulting in the coexistence of two alternative strategies.

In spring, Dunnocks presumably use the same routes as in autumn with no indication for loop migration. (Cramp 1988, Bairlein *et al.* 2014). The migration timing of Swedish Dunnocks shifted earlier (Fransson & Hall-Karlsson 2008).

In Hungary, it is a common passage migrant from March to April in spring and from late September until early November in autumn (Hadarics & Zalai 2008, Csörgő & Kováts 2009). Dunnocks in Hungary may overwinter.

The Dunnocks are regular and common passage migrants at the Ócsa Bird Ringing Station, the source of data analysed in this paper.

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 mosaic of habitats that include 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 located in 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 separately was 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 and autumn migratory seasons separately; birds caught before the 120th day of the year were considered to be spring migrants. A total of 11,617 Dunnocks were captured and ringed between March and November; 3144 in spring and 1734 adult and 6102 juvenile in autumn (the age of the rest of birds was not defined) in the study period of 1984–2015. This total value constitutes ca. 36% of the 31,900 Dunnocks 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 overplotted smooth histograms. Boxplots were used to show the body mass distribution by fat score categories. Fat and muscle score frequencies are shown using barplots. We distinguished seasons, and age groups

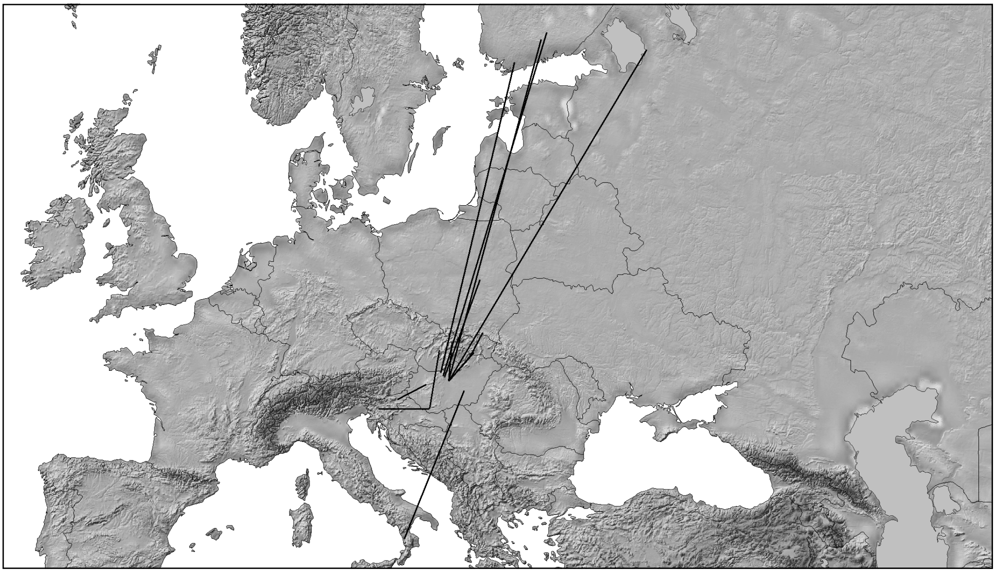

Figure 1. Foreign ring recoveries of Dunnocks. The data of birds ringed in Hungary and recovered abroad and the birds ringed abroad and recovered in Hungary are depicted
1. ábra Magyarországon jelölt és külföldön megkerült, illetve külföldön jelölt és Magyarországon megfogott erdei szürkebegyek

throughout the analyses. For more details on the analysis, please visit ocsabirdringing.org. All analyses were done in R 3.2.2 (R Core Team 2015).

Results

A total of 14 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 distribution 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 distribution 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*. Finally, the distribution of fat and muscle scores grouped by season and age can be found in *Figure 9 b,d,f* and *Figure 10*.

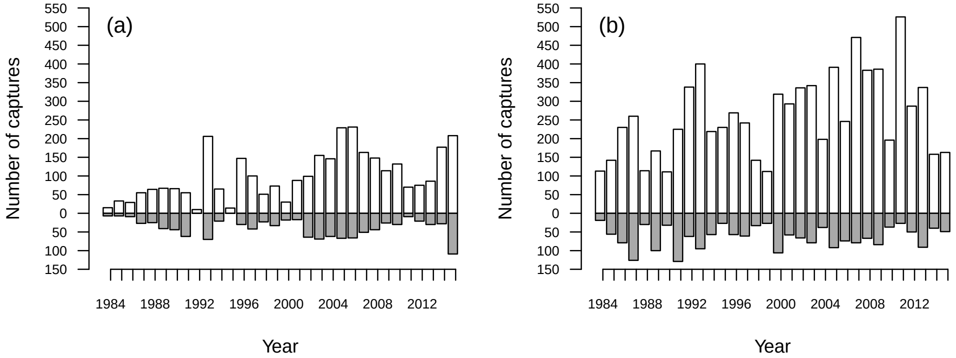

Figure 2. Annual capture (white bars) and recapture (grey bars) frequencies in spring (a), and in autumn (b)

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

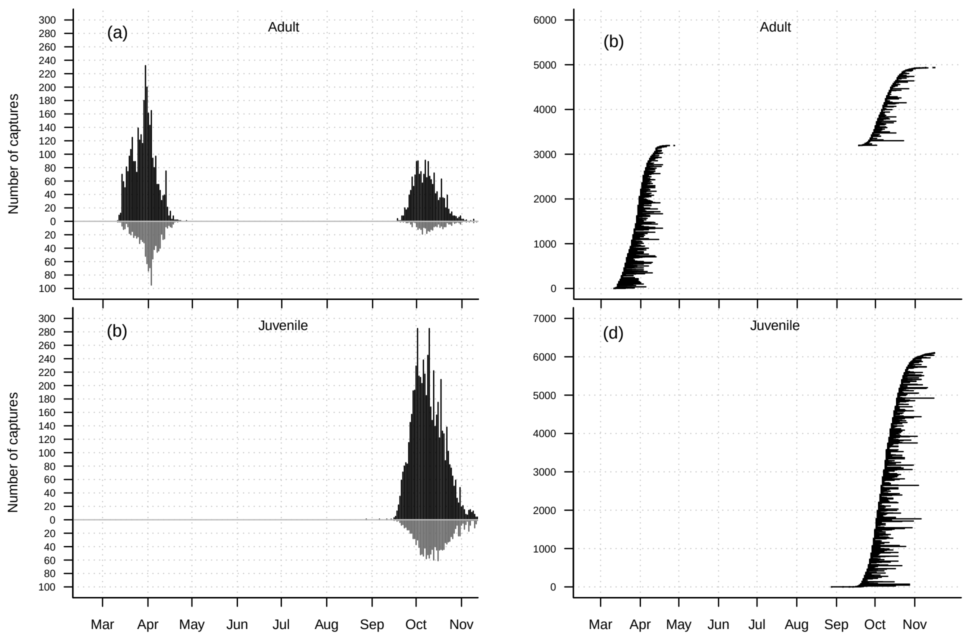

Figure 3. Within-year capture (black bars) and recapture (grey bars) frequencies (a, c) and cumulative distributions of individual first capture dates (b, d) according to age groups (horizontal lines: stopover durations)

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 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	87.9	88	7.8	70	117	3144
autumn	adult	281.1	280	8.8	261	320	1734
autumn	juvenile	282.4	282	10.6	240	320	6102

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	5.2	4	4.4	1	23	682
autumn	adult	4.9	3	4.6	1	30	252
autumn	juvenile	5.6	4	5.4	1	39	891

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	68.7	69	2.1	61	76	3033
autumn	adult	69.3	69	2.0	62	76	1699
autumn	juvenile	68.4	68	1.9	62	75	5974

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	52.1	52	1.8	45	59	2883
autumn	adult	52.4	52	1.8	47	59	1628
autumn	juvenile	51.6	52	1.7	45	59	5534

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	58.5	58	2.7	50	70	2975
autumn	adult	59.7	60	2.7	51	69	1689
autumn	juvenile	58.5	58	2.7	50	70	5885

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	18.9	18.8	1.6	14.5	26.1	3077
autumn	adult	19.1	19.0	1.6	15.3	25.1	1709
autumn	juvenile	19.2	19.0	1.7	14.6	27.0	6001

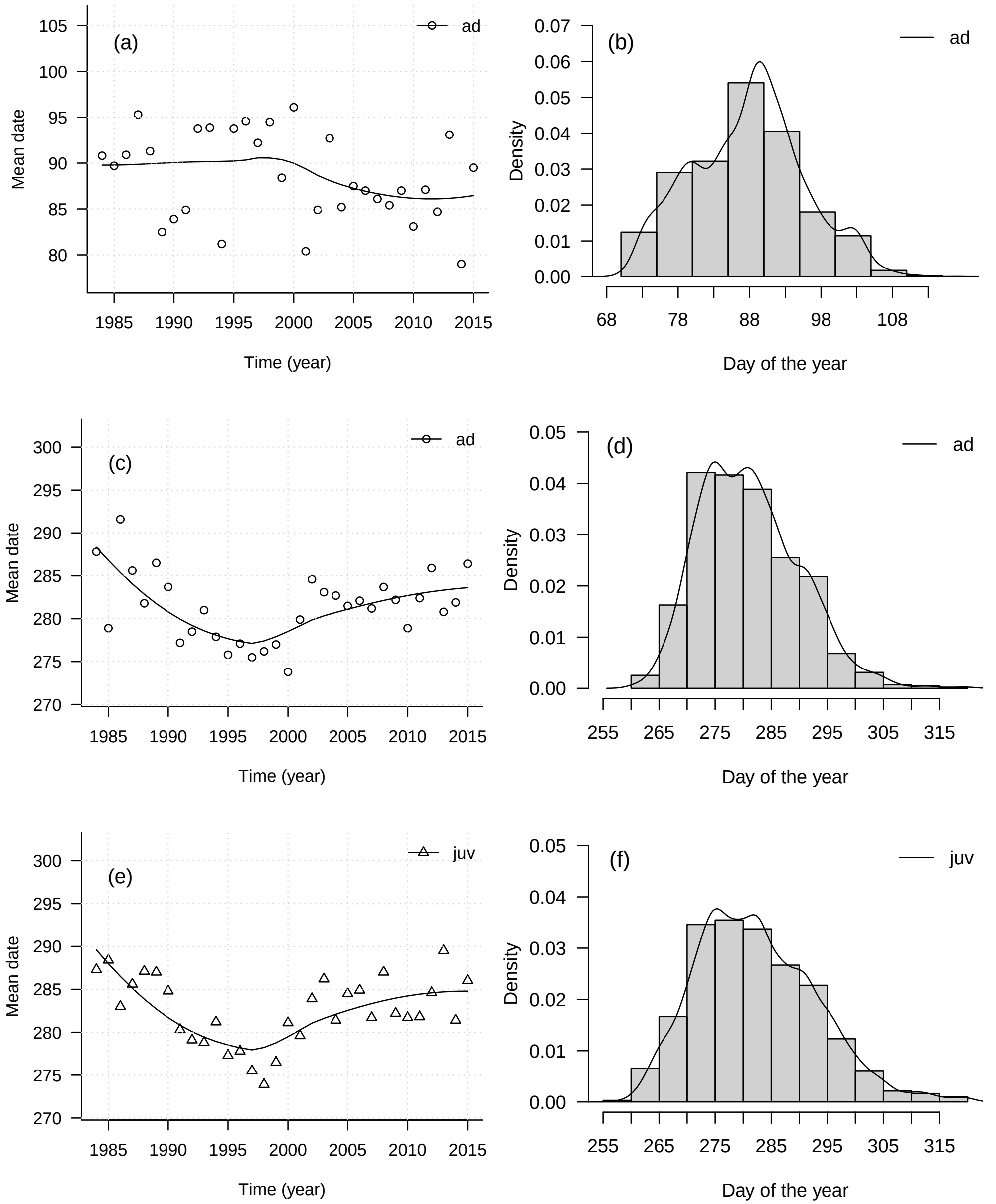

Figure 4. Annual mean migration timing (day of the year) throughout the study period and histograms/smoothed histograms of timing in spring (a–b) and in autumn (c–f)

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)

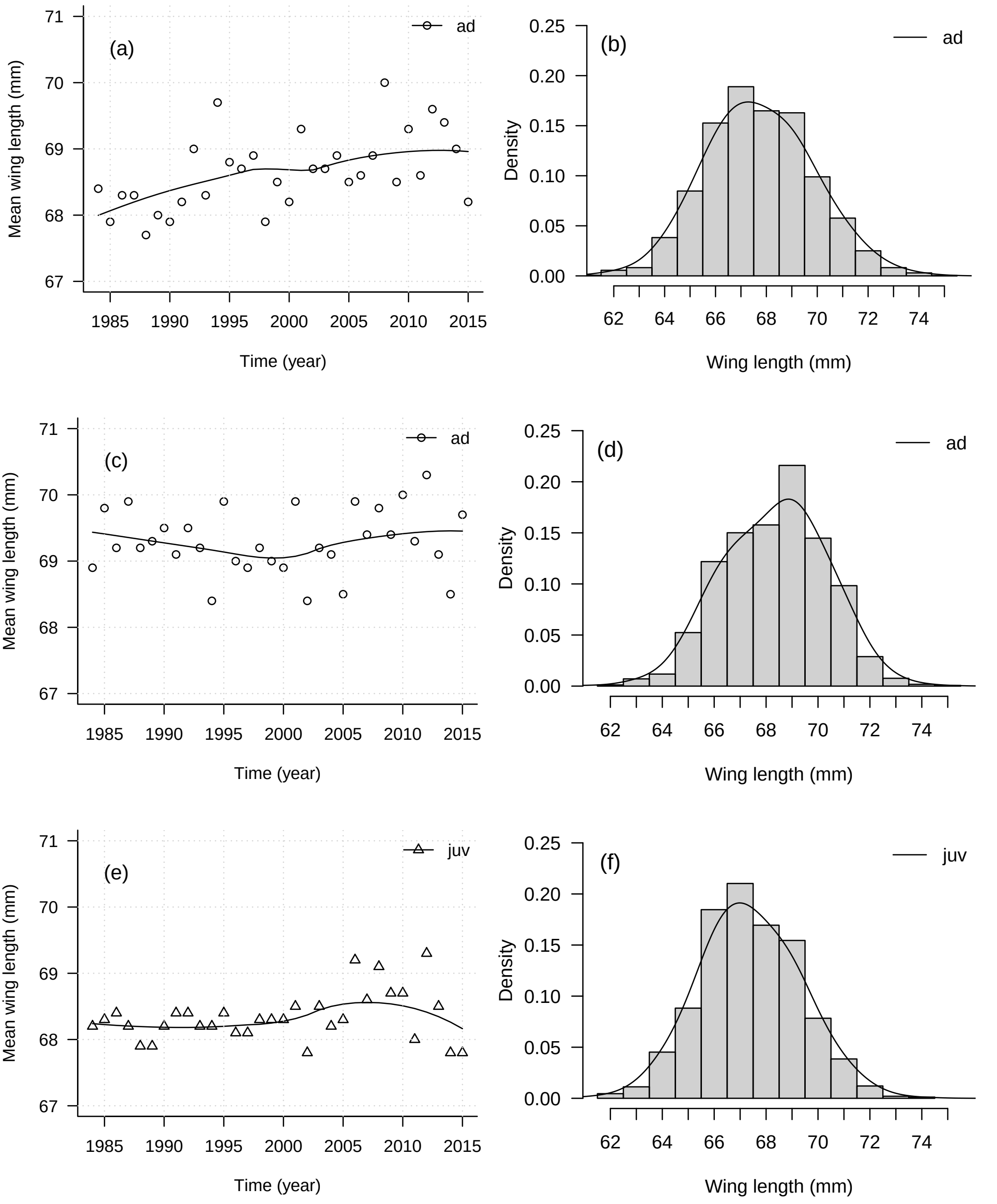

Figure 5. Annual mean wing length (mm) throughout the study period and histograms/smoothed histograms of wing length in spring (a–b) and in autumn (c–f)

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

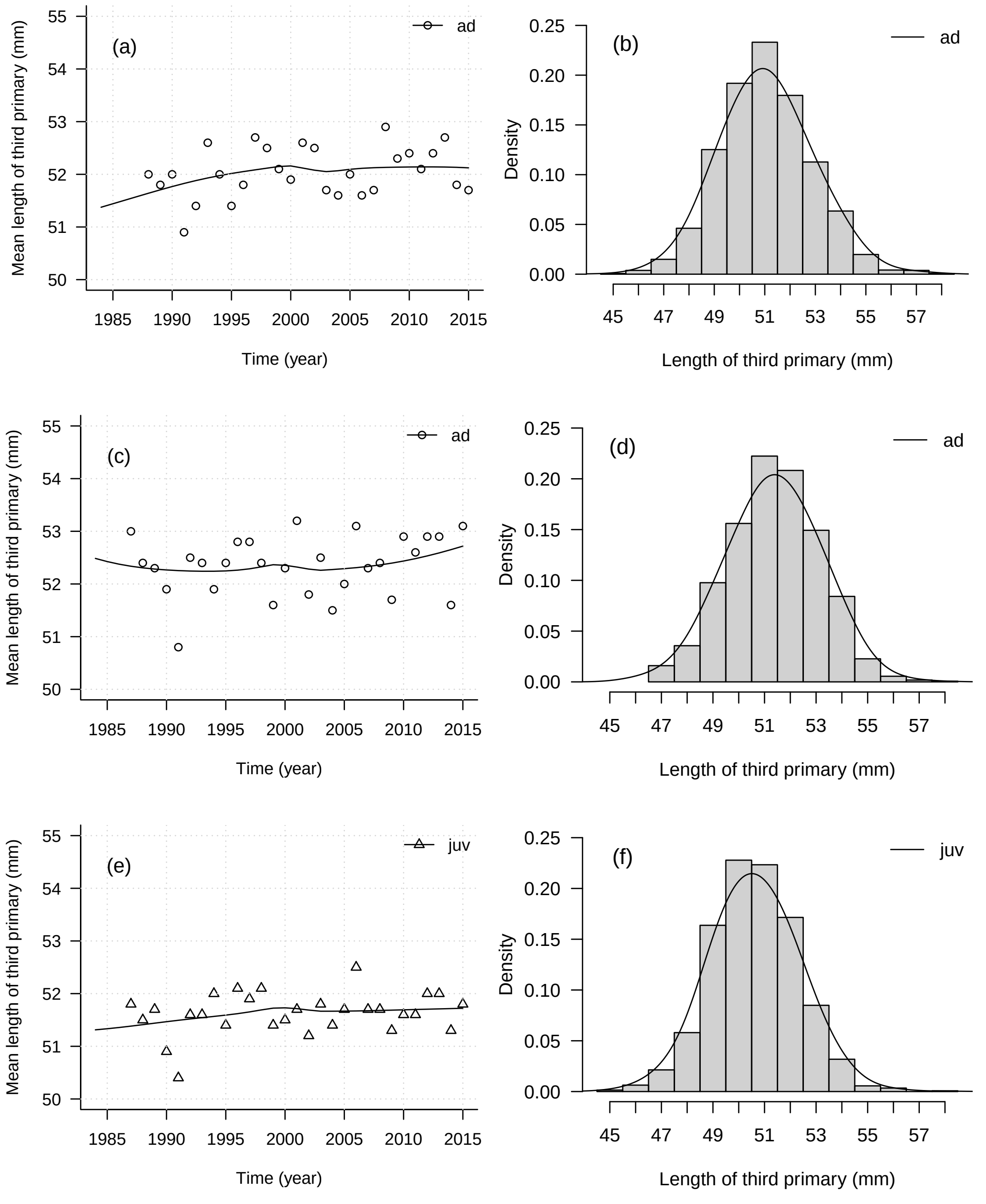

Figure 6. Annual mean third primary length (mm) throughout the study period and histograms/smoothed histograms of third primary length in spring (a–b) and in autumn (c–f)

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

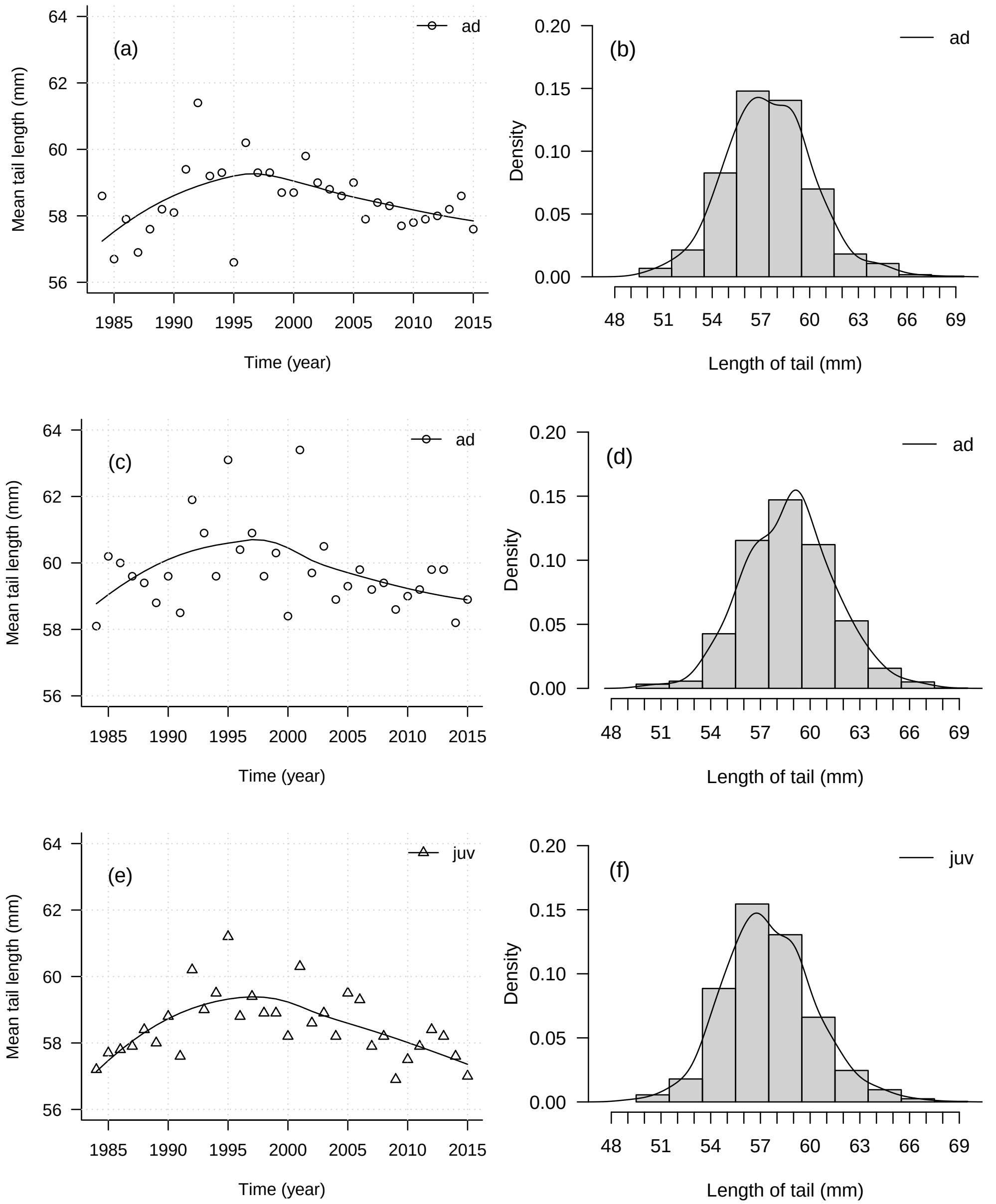

Figure 7. Annual mean tail length (mm) throughout the study period and histograms/smoothed histograms of third primary length in spring (a–b) and in autumn (c–f)

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

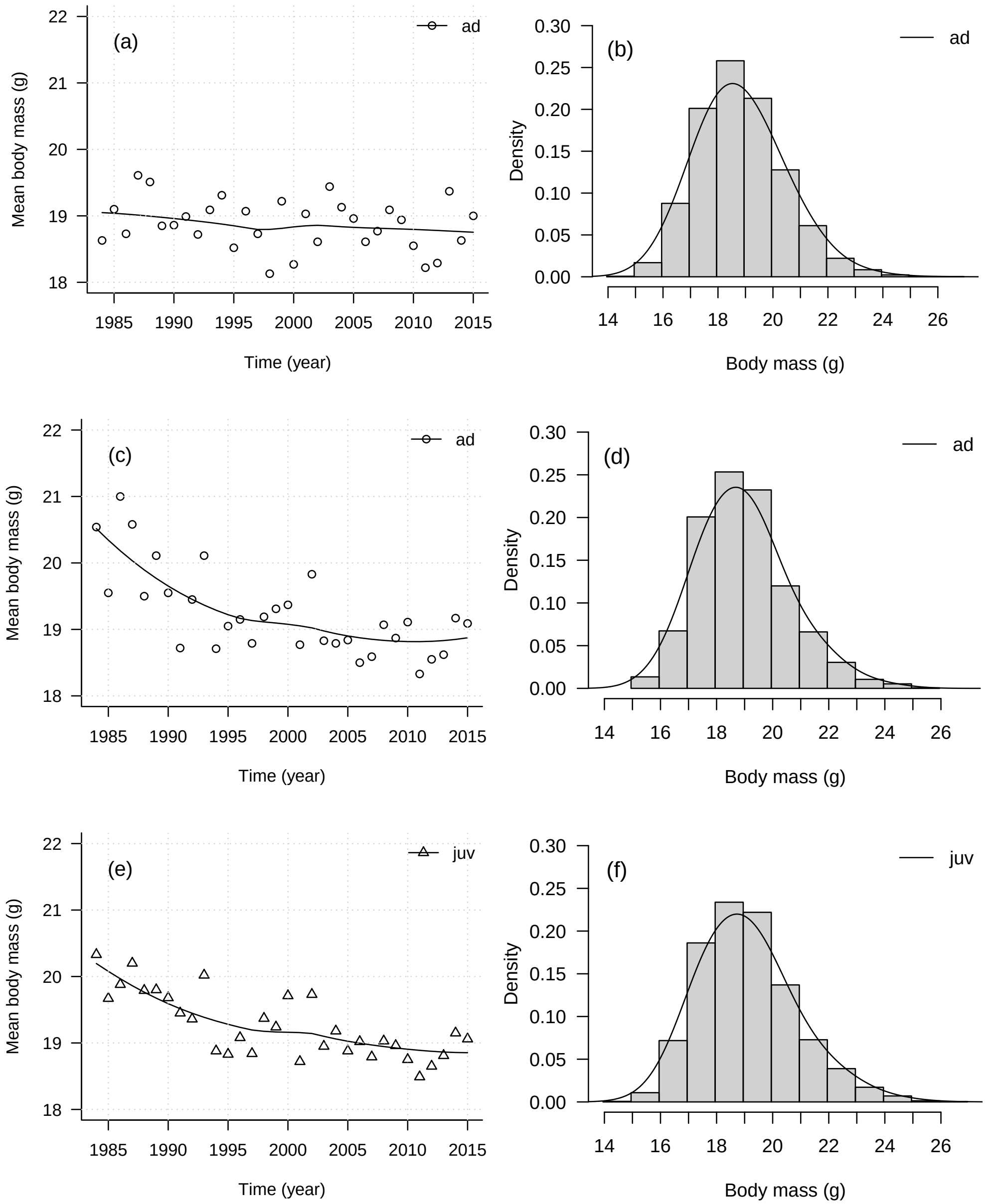

Figure 8. Annual mean body mass (g) throughout the study period and histograms/smoothed histograms of body mass in spring (a–b) and in autumn (c–f)

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

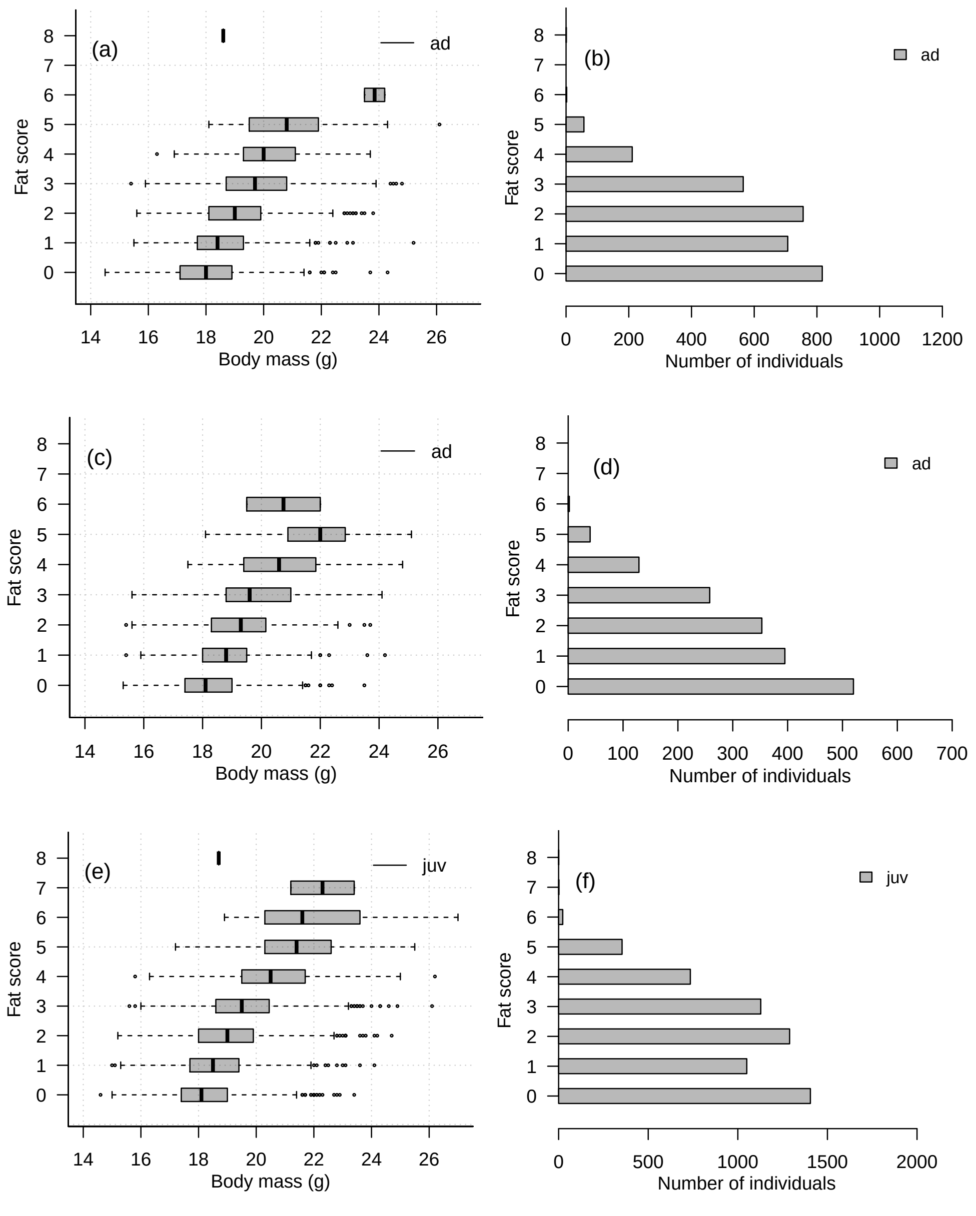

Figure 9. Boxplots of body mass according to fat score, and fat score frequencies in spring (a–b) and in autumn (c–f)

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

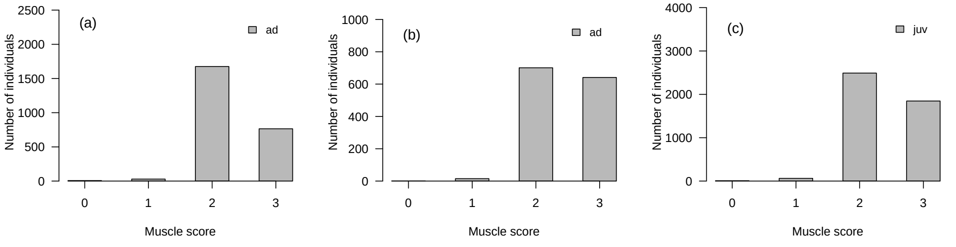

Figure 10. Muscle score frequencies in spring (a) and in autumn (b–c)
10. ábra Izom kategória gyakoriságok tavasszal (a) és ősszel (b–c)

Discussion

The exploratory analyses of timing and morphometrics of the Dunnock revealed several patterns of interest. Apparently, there is considerable variation in inter-annual capture and recapture frequencies *(Figure 2 a,b)* with disproportionally more recaptures *(Figure 2 a)* in spring. The stopover durations are similar in all cases *(Figure 3 b,d, Table 2)*.

The birds appear in greater numbers during the autumn migration, when the amount of juveniles greatly exceeds the amount of the adults. Evidently, the lack of captures of all age groups during the breeding season corroborates that there is no local breeding population at the study site *(Figure 2 a,b)*.

While the spring migration timing appears to be more or less constant (with a slight decrease in the last decade *(Figure 4 a)*, the autumn timing hits a bottom in the late 1990's. Timing of the adults and the juveniles in the autumn are rather similar *(Figure 4 c,e)*. The distribution of arrival timing in both seasons are seemingly unimodal *(Figure 4 b,d,f)*. There is no apparent, relevant trends over the years neither in the wing length nor in the third primary length of the birds *(Figures 5–6 a,c,e)*.

Tail length seems to peak around the late 1990's, although with a considerable inter-annual variation *(Figure 7 a,c,e)*. The mean body mass seems to be constant over the years *(Figure 8 a)*, however a decreasing trend can be observed during the autumn season *(Figure 8 c,d)*.

All the biometric variables have unimodal distribution indicating that there is no considerable size difference between the sexes *(Figure 5–8 a,c,e)*.

The fat and muscle score distributions suggest that the birds build their muscles rather than accumulate fat reserves *(Figures 9–10)*.

Our results show that comprehensive exploratory analyses may reveal intriguing patterns, which may be investigated in more detail in the future. We however 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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