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Migration of Firecrest *(Regulus ignicapilla)* in Hungary

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Abstract The Firecrest *(Regulus ignicapilla)* is a regular, but small-number breeder in spruce and coniferous forests in the mountainous and hilly areas of Hungary, but is found in all parts of the country during migration. Despite this, only sporadic field observation data and ringing results in Western Hungary have been published so far. The aim of this study was to investigate the migration of this species on a national scale. In our work, we processed field observation data collected on the Csanádi-hát and capture-recapture data from three bird ringing stations (Szalonna, Tömörd and Ócsa) from the second half of the 1980s to 2021. We also used archive published field observation data from different parts of Hungary. Our results show that the spring migration of the species in the study areas took place between mid-March and late April – early May, and its timing did not differ significantly between regions. In contrast, the autumn migration was earlier in mountainous areas than in lowland areas. The small numbers and short duration of recaptured birds suggested a rapid migration in both periods. In autumn, we obtained a significant difference between the annual number of birds captured in Tömörd and Szalonna. In both periods, males were caught in greater numbers than females. In southern Hungary, the timing of migration in spring has not changed, but in autumn the species migrated earlier than a few decades ago.

Keywords: Firecrest, passerine migration, Carpathian Basin, bird ringing, field observations

Összefoglalás A tüzesfejű királyka *(Regulus ignicapilla)* Magyarország hegy- és dombvidéki lucosainak és luccal elegyes fenyveseinek rendszeres, de csak kisszámú fészkelője. Vonuláskor azonban az ország egész területén előfordul. Ennek ellenére a fajról eddig csak szórványos terepi megfigyelési adatokat, illetve nyugat-magyarországi gyűrűzési eredményeket publikáltak. Jelen dolgozatban az volt a célunk, hogy országos szinten vizsgáljuk meg a faj vonulását. Munkánk során a Csanádi-háton gyűjtött terepi megfigyelési adatokat, valamint három madárgyűrűző-állomás (Szalonna, Tömörd és Ócsa) gyűrűzés–viszafogási adatait dolgoztuk fel az 1980-as évek második fele és 2021 közötti időszakból. Emellett ennél korábbi, Magyarország különböző részeiről származó, publikált megfigyelési adatokat is felhasználtunk. Eredményeink szerint a faj tavaszi vonulása a vizsgálati területeken március közepe és április vége – május eleje között zajlott, és annak időzítése nem különbözött szignifikánsan a régiók között. Ezzel szemben ősszel a hegyvidéki területeken korábban vonult át a faj, mint síkvidéken. A kisszámú visszafogás és a visszafogott madarak rövid tartózkodási ideje alapján mindkét időszakban gyors vonulásra következtettünk. Ősszel Tömördön és Szalonnán szignifikáns különbséget kaptunk az évente fogott madarak számában. A hímek mindkét időszakban gyakrabban akadtak hálóba, mint a tojók. Dél-Magyarországon tavasszal nem változott a faj vonulásának időzítése, ugyanakkor ősszel hamarabb vonult át a faj napjainkban, mint néhány évtizeddel korábban.

Kulcsszavak: tüzesfejű királyka, énekesmadár-vonulás, Kárpát-medence, madárgyűrűzés, terepi megfigyelések

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Introduction

The Firecrest – *Regulus ignicapilla* (Temminck, 1820) – is a polytypic species with four subspecies occurring from Western Europe to the Caucasus and North Africa (Martens & Päckert 2020). In Hungary, it is a regular, but only a small-number breeder (Hadarics & Zalai 2008). Its first breeding in Hungary was recorded in the Őrség region (Barbácsy 1978), and subsequently it has been recorded nesting in Börzsöny Hills (Varga 1980), Kőszeg Hills (Barbácsy 1981), Bükk Hills (Kasza 1981) and Sopron Hills (Varga 1982). It mainly breeds in homogeneous or mixed spruce forests (Haraszthy 2019), but it can also colonise urban parks (Barbácsy 2000). During the 2010s, probable or confirmed breeding was recorded in the Alpokalja, Zala Hills, Kemeneshát, Mecsek and the Northern Hills (Csörgő & Gyurácz 2021). In some years, the number of nesting pairs may increase in certain areas (Haraszthy 2019), but since the 2000s the population has declined mainly due to the destruction of spruce forests caused by climatic factors (Varga 2008, Gyurácz & Csörgő 2009). The Hungarian population was estimated at 400–500 pairs between 2014 and 2018 (Csörgő & Gyurácz 2021). In Italy, the number of ringed birds increased between 1982 and 2003 (Spina & Volponi 2009). During its expansion in the 20th century, the species colonised the British Isles, and the breeding population increased in Belgium, the Netherlands and Denmark (Martens & Päckert 2020). Over the past two decades, it has expanded significantly northwards into the British Isles, Sweden and the Baltic countries (Wilk & Knaus 2019).

Central and Eastern European populations are partial migrants, with a small proportion overwintering in mild winters (Cramp & Brooks 1992). They begin their autumn migration at the earliest 7–8 days after the summer molt is completed. In Central Europe they leave the breeding areas by the end of July. Their wintering areas are mainly on the Mediterranean coast and in Western Europe and the British Isles (Martens & Päckert 2020), where they may arrive as early as September, but typically only in November–December (Cramp & Brooks 1992). In Denmark, it is a rare breeding species and passage migrant in March – April and September–October (Bønløkke *et al.* 2006). In Italy, it migrates in spring, between mid-March and mid-April, when it is much more numerous than in autumn. The autumn migration takes place between September and November, with fairly extended movements in Northern and Central Italy based on recaptures (Spina & Volponi 2009). In Croatia, it migrates in March in spring and in September and October in autumn (Kralj 2013).

In Hungary, they can be found in almost any woody and shrubby habitat during migration, even in lowland areas (Hadarics & Zalai 2008). They typically move in small groups, often with Goldcrests *(Regulus regulus)* (Gyurácz & Csörgő 2009). The origin and wintering areas of migrants are unknown due to lack of recaptures (Gyurácz & Csörgő 2009). In spring, birds migrate between late February and early May, with a peak in late March and early April, while in autumn, migrating Firecrests can be seen between late August and early December, with a peak in early October (Gyurácz & Csörgő 2009). Based on 311 individuals ringed in Tömörd, Western Hungary, between 1998 and 2007, the average start of autumn migration was on 16 September, the median on 6 October and end on 5 November. The earliest date of capture was on 17 August and the latest on 7 November (Gyurácz & Bánhidi 2008). The birds migrate quickly, with medium fat reserves and developed pectoral muscles,

and spend only a short time at the stopover sites (Gyurácz & Csörgő 2009). In the period between 1998–2007, birds spent 2–4 days in the stopover sites (Gyurácz & Bánhidi 2008).

In Hungary, regarding to their migration, only sporadic field observations are known, and some of these are from the known breeding sites. Csaba (1955), Anon. (1980), Varga and Király (1981), Varga (1982, 1996, 2003), Molnár (1983, 1985, 1988) and Kelemen (2003) mentioned data from the Őrség, Sopron Hills and Kőszeg Hills. Homoki-Nagy (1981) reported it as a rare, but regularly occurring species from the Börzsönyi Landscape Protection Area. From the Bükk, Moskát (1975), Barta (1978) and Anon. (1979a) published field observation data, while in the Karancs–Medves area two ringed individuals were reported by Varga (1978). Numerous published records are known from and near Budapest (Dénes 1979, Anon. 1981, Schmidt 1983, Molnár, 1988, Bajor 1994), as well as from the Gerecse (Beretzk 1963), Hévíz (Keve 1976), Hanság (Molnár 1982a) and Dombóvár (Nagy 1982).

In the lowlands, it was also seen regularly during the migration period. Most of the published data come from Szeged and its sorroundings, where it was observed during both the spring and autumn migration (Anon. 1978a, 1979b, Molnár 1982b, 1984b, 1985, 1988, Kasza 1981, 1989). Here, the species regulary overwintered (Kasza 1981, 1989). Overwintering individuals have also been recorded in Zsombó (Csongrád-Csanád County), and it is noteworthy that they were more frequently observed here in the 1980s than from the mid-1990s (Mészáros 2000). In the Fertő-Lapistó area of Szentes, it was a rare migrant in the period between 1968 and 1998 (Tóth 2000). Pásti (2000) describes it as an occasional migrant in the Tócó valley in Debrecen, and here was an overwintering individual too. It has also been recorded in Berettyóújfalu and Császárszállás (Anon. 1979b), Gödöllő (Molnár 1982a), Balmazújáros, Tömörkény and Tápiószecső (Molnár 1984a), Zagyvaróna, Mezőkövesd and Hajdúnánás (Molnár 1985). It is not rare in Békés County either. It is mentioned as a "sparse" species in the Biharugrai fishponds as early as the 1950s (Nagy 1961). In Biharugra, Vasas (1999) saw one individual on 22 October 1999, while Vasas and Zalai (1998) described it as a regular migrant in April. In 2002, a small number of migrants were seen in mid-March (Tőgye 2002), and in 2003, one observation was made on 5 April (Tőgye 2003). Two birds were seen in Körösladány on 2 April 1978 (Anon. 1978b), two in Sarkadremete on 26 November 1978 (Anon. 1979b), one in Békéscsaba in March 1979 (Molnár 1982d), and 2–4 in the Gulyagyep, Battonya on 9 April 2000 (Csathó 2009). An occasional migrant was observed along the Kettős-Körös river in 2005, where one individual was observed on 22 February 2009 (Durkó 2009). It was a regular spring (late March – mid-April) and autumn (late September – early November) migrant in Kevermes between 2004 and 2017 (Bozó 2017).

A detailed study of the migration of Firecrest in Hungary has only been carried out in Tömörd, and only sporadic data are known from other parts of the country (Gyurácz & Csörgő 2009).

In the present study, we investigated the migration of the species based on data collected in Tömörd in Western Hungary, Ócsa in Central Hungary, Szalonna in Northern Hungary and in the Csanádi-hát region in Southeastern Hungary. On the basis of data published in the literature, we also looked at when the species migrates through different parts of the country, and whether there are differences in the timing of migration between geographical regions? We also compared our own data with these datasets. Our work is intended to contribute to

a better understanding of the migration of the Firecrest, of which migration, although not a rare species, is very poorly known in Central Europe.

Material and Methods

The dataset based on field observations is available from the area of the Csanádi-hát, a small geographical area in the southern part of Békés County. Regular observations were carried out in two settlements, Kevermes and Battonya, while data from the other settlements were collected only during occasional field visits. Data series are available from Battonya since 1996 and from Kevermes since 2004.

Today, the landscape is dominated by agricultural land, which typically accounts for around 90% of the total area with the exception of a few more forested settlements, such as Mezőhegyes (Hevesi 2005). Along the banks of the meandering Száraz-ér, along artificial drainage channels and mining lakes, and in populated areas, wooded shrub habitats are found, all of which are artificially planted, dominated by euro-american hybrid poplar *(Populus × euramericana)*, black locust *(Robinia pseudoacacia)*, common hackberry *(Celtis occidentalis)* and black elder *(Sambucus nigra)*, but also by elm (*Ulmus* spp.). Ash (*Fraxinus* spp.), wild pear *(Pyrus pyraster)*, walnut *(Juglans regia)* and common oak *(Querqus robur)* are also present (Bozó 2018). The observations were made by walking around the area, using binoculars and a camera. The presence of the birds was usually indicated by their distinctive call, but this was not always sufficient to distinguish them from the Goldcrest, so only those individuals that were seen with certainty were recorded as Firecrests. Given that in autumn the leaves are still on the trees when the species migrates, it was necessary to leave several *Regulus* species moving in the canopy undetermined. We considered spring to be between 15 February and 10 May and autumn between 1 September and 30 November.

In addition to the field observation data, we also used ringing data from 3 Actio Hungarica camps (Szalonna, Tömörd, Ócsa) in our analysis. For descriptions of the three sites and the ringing work see Farkas *et al.* (2014), Csörgő *et al.* (2016) and Gyurácz *et al.* (2017). When defining migration periods, only new ringings were considered, not recaptures (Szalonna: 920, Tömörd: 768, Ócsa: 167 individuals).

In the case of the autumn data for Tömörd and Szalonna, it was also possible to compare the differences in the number of birds captured between years. To do this, we used Kruskal–Wallis test. We also used the Kruskal–Wallis test to detect differences in the timing of migration between study sites.

The average of the start of autumn and spring migration was taken as the average of the dates on which the species was first observed in autumn and spring, respectively.

In addition to current data, we have also collected available archive data. For this, we searched for data in the journal Cinege (Kelemen 2005, Varga 1996, 2003), the Aquila (Csaba 1955, Beretzk 1963, Sterbetz 1972, Keve 1976, Schmidt 1976, Rékási 1992), the Madártani Tájékoztató (Anon. 1978a, 1978b, 1979a, 1979b, 1980, 1981, Barta 1978, Simig 1978, Varga 1978, 1982, Dénes 1979, Kasza 1981, 1989, Varga & Király 1981, Molnár 1982a, 1982b, 1982c, 1982d, 1983, 1984a, 1984b, 1985, 1988, Nagy 1982, Schmidt 1983, Bajor 1994), the

Túzok (Hadarics 1996a, 1996b, 1996c, 1996d, 1997a, 1997b, 1997c, 1997d, 1998a, 1998b, 1998c, 1999a, 1999b, 1999c, 2000a, 2000b, 2000c, 2001a, 2001b), and the A Puszta (Vasas 1999, Tőgye 2003, Csathó 2009, Durkó 2009, 2015). Data were collected at regional level (Southern Great Hungarian Plain, Northern Great Hungarian Plain, Northern Hills, Budapest area, Southern Transdanubia, Northern Transdanubia, Western Transdanubia), and they were compared with each other. Since the migration peak was defined by its median value, we performed a Kruskal-Wallis test for comparisons. If the Kruskal–Wallis test indicated significant differences, we applied Dunn's post hoc test to find the exact differences among groups. We also compared our present data from the Csanádi-hát with the archive data from the southeastern part of the Greater Hungarian Plain by the use of Mann-Whitney U test. For statistical analysis, we used the Past statistical program (Hammer *et al.* 2001).

Results

Csanádi-hát

In spring, we observed 102 individuals on 71 occasions, while in autumn, 42 individuals on 32 occasions. The spring migration took place between mid-March (earliest sighting: 15 March 2020, Battonya) and the second half of April (latest sighting: 27 April 2016, Kevermes), with a median date on 31 March *(Figure 1)*.

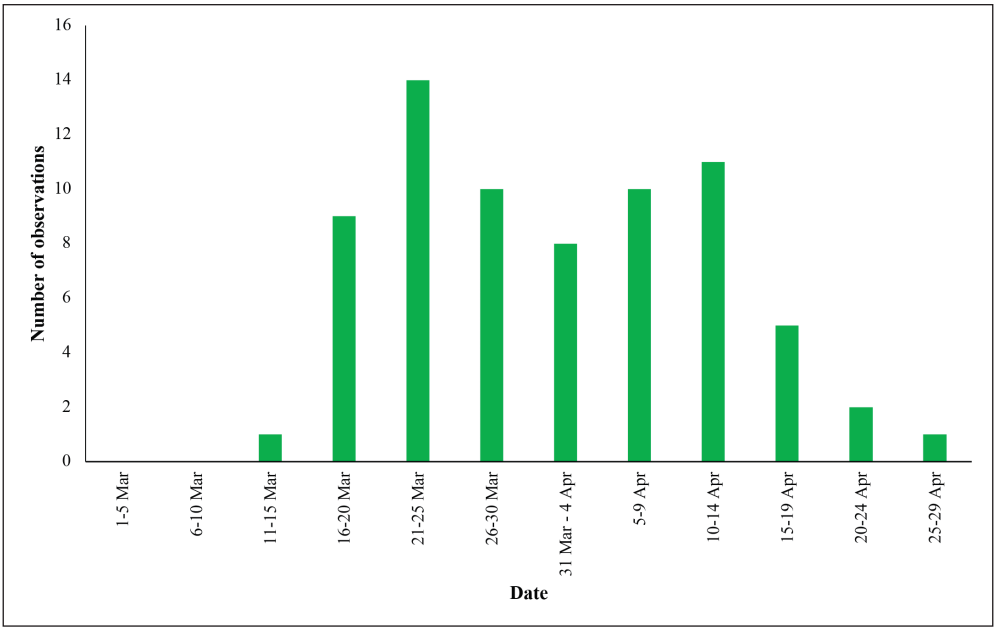

Figure 1. Numbers of Firecrest during the spring migration in the Csanádi-hát (SE Hungary)
1. ábra A tüzesfejű királyka megfigyelései a tavaszi vonulás alkalmával a Csanádi-háton (Délkelet-Magyarország)

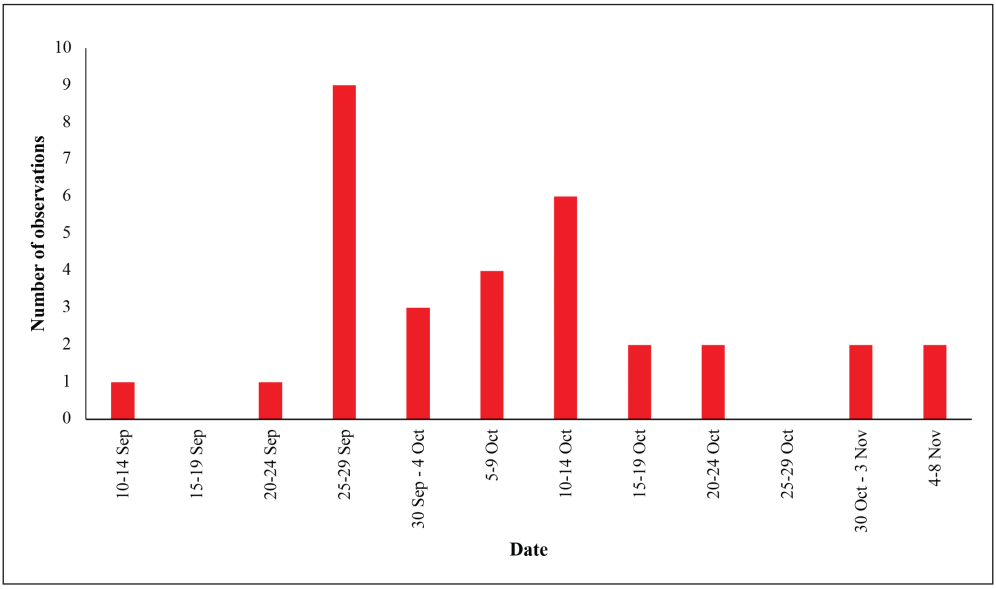

Figure 2. Numbers of Firecrest during the autumn migration in the Csanádi-hát (SE Hungary)
2. ábra A tüzesfejű királyka megfigyelései az őszi vonulás alkalmával a Csanádi-háton (Délkelet-Magyarország)

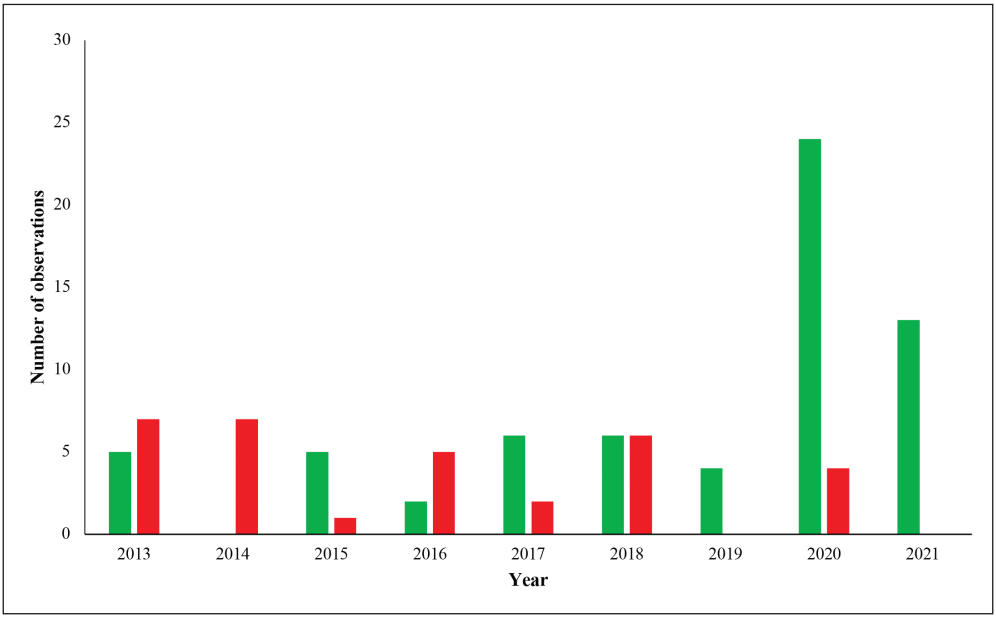

Figure 3. Number of annual observations of the Firecrests in the Csanádi-hát between 2013 and 2021. Green bars indicate spring data and red bars indicate autumn data
3. ábra A tüzesfejű királyka éves megfigyeléseinek száma a Csanádi-háton 2013 és 2021 között. A zöld szín a tavaszi, a piros szín az őszi adatokat jelöli

In autumn, the species migrated through the area between mid-September (earliest sighting: 11 September 2018, Kevermes) and early November (latest sighting: 8 November 2016, Kevermes), with the median date of migration being on 6 October *(Figure 2)*.

There is only one known winter record in the area: on 4 December 2016, a solitary individual was seen in the centre of Battonya, feeding on spruce trees.

It was not possible to compare the number of birds observed each year using statistical methods, but in the spring of 2020 and 2021 the number of observations increased compared to the previous years *(Figure 3)*.

Szalonna

Bird ringing was conducted only in autumn. Between 1986 and 2020, a total of 920 individuals were ringed and a total of 9 birds were recaptured on 11 different occasions.

The migration took place between 17 August and 3 November, with a median on 28 September. The migration was prolonged, but a peak was observed at the turn of September and October *(Figure 5)*.

Between 1996 and 2020, it was also possible to examine the differences between years, and it was a significant difference among the median values for the different years ($H=105.8$, $P< 0.001$).

The recaptured birds spent 1–6 days in the area, with an average of 3.2 days.

68.8% of the identified sexes were males (577 individuals), while only 31.2% were females (262 individuals).

Tömörd

Between 1984 and 2021, a total of 768 birds were ringed during the study period (spring: 30, autumn: 738), and a total of 59 birds were recaptured on 76 different occasions (spring: 6 birds 9 times, autumn: 53 birds 67 times). In one case, a bird was ringed in December (14 December 1997).

The spring migration took place between 16 March and 2 May, with a median on 27 March *(Figure 4)*. The six recaptured birds spent 1–5 days in the area, with an average of 2 days. In spring, 74.1% of the individuals with a defined sex were males (20 individuals), while only 25.9% were females (7 individuals).

The autumn migration took place between 7 August and 26 November, with a median on 6 October. The migration was prolonged, with similar numbers of birds caught between mid-September and mid-October *(Figure 5)*.

In the autumn period between 1998 and 2020, it was also possible to examine the differences between years regarding to the migration timing, with a significant difference in the median values for the years ($H=44.87$, $P=0.003$).

Recaptured birds spent 1–7 days in the area, with only two individuals staying longer than a week (28 and 55 days). Apart from these two outliers, the average stopover time was 2.4 days. There was also one bird ringed on 14 October 2018 and was trapped again one year later on 10 October 2019.

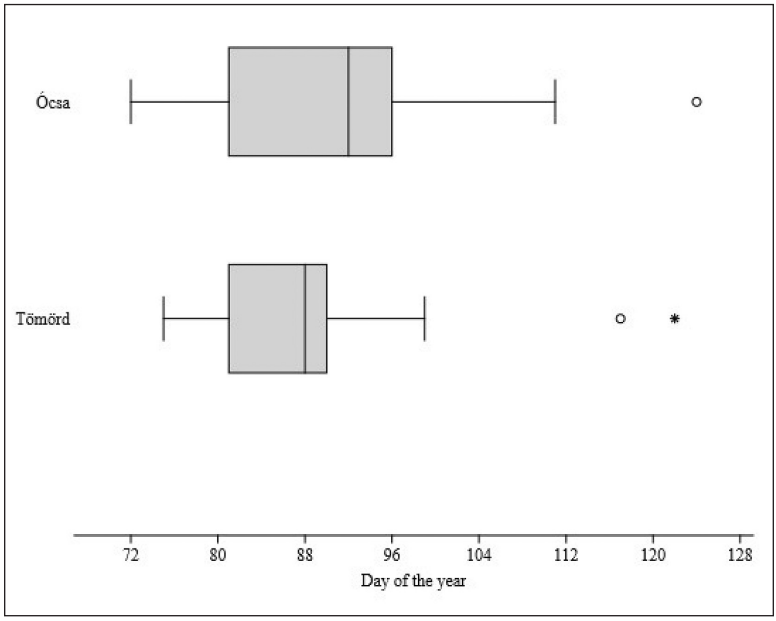

Figure 4. The timing of spring migration of Firecrest in Ócsa (CE Hungary) and Tömörd (W Hungary)
4. ábra A tüzesfejű királyka tavaszi vonulásának időzítése Ócsán (Közép-Magyarország) és Tömördön (Nyugat-Magyarország)

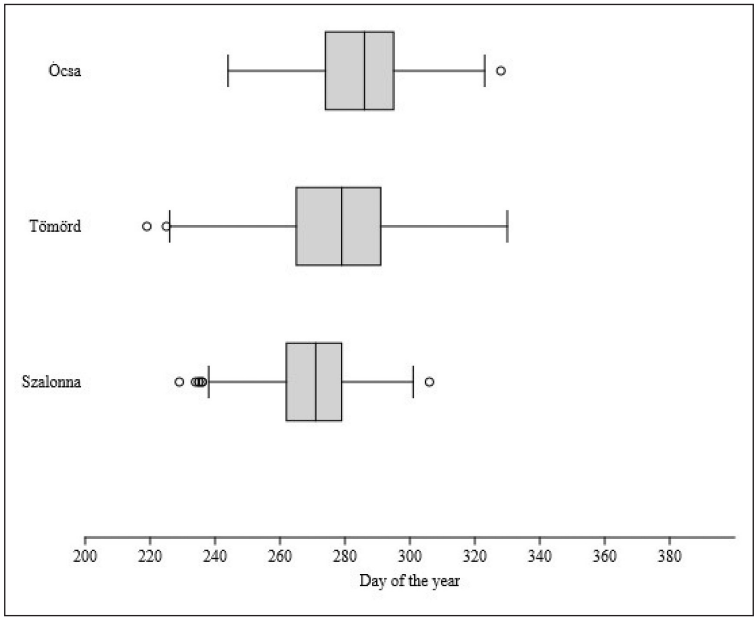

Figure 5. The timing of autumn migration of Firecrest in Ócsa (CE Hungary), Tömörd (W Hungary) and Szalonna (NE Hungary)
5. ábra A tüzesfejű királyka őszi vonulásának időzítése Ócsán (Közép-Magyarország), Tömördön (Nyugat-Magyarország) és Szalonnán (Északkelet-Magyarország)

In autumn, 69.1% of the individuals of the specified sex were males (466 individuals), while the proportion of females was only 30.9% (208 individuals).

Ócsa

Between 1984 and 2021, a total of 167 birds were ringed during the study period (spring: 49, autumn: 118), and a total of 21 birds were recaptured on 24 different occasions (spring: 10 birds 12 times, autumn: 10 birds 11 times). One was trapped in December (3 December 2009) and one in January (7 January 2010).

The spring migration took place between 13 March and 4 May, with a median on 2 April *(Figure 4)*. The 10 recaptured birds spent 1–5 days in the area, with an average of 2.3 days. In spring, 56.5% of the individuals with a defined sex were males (26 individuals), while the proportion of females was 43.5% (18 individuals).

The autumn migration took place between 1 September and 24 November, with a median on 13 October. The migration was prolonged, with similar numbers of birds caught between late September and late October *(Figure 5)*. Recaptured birds spent 1–5 days in the area, with an average of 2.1 days.

In autumn, 58.5% of individuals with a defined sex were males (62 individuals), while the proportion of females was 41.5% (45 individuals).

Among ringing sites, there was no significant difference between the migration timing of spring migration ($H=3.373$, $P=0.185$) (earliest in Tömörd and latest in Ócsa). In contrast, there was a significant difference in the migration timing in autumn ($H=159.2$, $P < 0.0001$) (earliest in Szalonna and latest in Ócsa). The sex ratios were 7:3 in favour of males in Tömörd and Szalonna in autumn and spring, while in Ócsa the ratio was much more equal, 6:4.

Archive data

Based on archive data collected from different regions of the country, the timing of the species' migration in spring differed significantly among regions ($H=9.561$, $P=0.048$). Namely, the timing of migration of birds migrated in Budapest differed significantly from

Table 1. The migration timing of the Firecrest in different regions of Hungary
1. táblázat A tüzesfejű királyka vonulásának időzítése Magyarország különböző régióiban

Region	Median		Minimum		Maximum		N	
	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn
Northern Great Plain	2 Apr	15 Oct	15 Mar	16 Sep	3 May	5 Dec	26	26
Southern Great Plain	3 Apr	18 Oct	14 Feb	17 Sep	26 Apr	10 Dec	25	38
Northern Hills	8 Apr	1 Oct	17 Feb	9 Sep	10 May	14 Nov	18	10
South Transdanubia	–	5 Nov	–	14 Sep	–	30 Nov	5	16
North Transdanubia	–	–	–	–	–	–	1	5
West Transdanubia	3 Apr	6 Oct	8 Mar	14 Sep	30 Apr	8 Dec	52	31
Budapest	29 Mar	11 Oct	18 Feb	14 Sep	15 Apr	21 Nov	40	28

the Southern Great Plain (P=0.029), Northern Hills (P=0.033) and Western Transdanubia (P=0.005). The earliest time of return was in Budapest, while the latest time of return was in the Northern Hills (the difference between the median time of migration was 10 days). In autumn there was also a significant difference among regions (H=10.94, P=0.027), and the timing of migration differed significantly among most regions (P<0.05). At this time, the migration started in the Northern Hills and finished in the South Transdanubian region (difference between the median of migration was 35 days). The latter value may include data from overwintering birds, but the north-south temporal shift is also evident when considering the other areas *(Table 1)*.

Comparing the present data from the Csanádi-hát with the archive data from the Southern Great Plain, we found that there was no significant difference in the timing of migration in spring (Mann–Whitney U test, z=–1.88, P=0.59), but there was in autumn, as the species migrated through the Southern Great Plain earlier in the 1970s and 1980s than today (z= –2.91, P=0.003).

Discussion

The spring migration of the Firecrest in the study areas took place between mid-March and late April – early May, and the timing of the migration did not differ significantly among geographical regions. It means that the species appears almost simultaneously in different parts of the country in spring. The most probable reason for this is that the species migrates rapidly over long distances (Gyurácz & Csörgő 2009), with most birds spending only a short time in a given area. The migration of the Goldcrest is also similar in Northern Europe (Petterson & Hasselquist 1985) and in the Carpathian Basin (Miklay & Csörgő 1998, Gyurácz *et al.* 2003). In Ócsa and Tömörd, we caught far fewer birds in spring than in autumn, but on the Csanádi-hát both the number of observations and the number of birds were much higher in spring. One reason for this phenomenon is probably the detectability of the species, as in spring the species migrated before the trees were leafed out, which made it easier to observe and identify the birds. In autumn, however, more birds had to be left undetermined, as it is often very difficult to see the *Regulus* species at this time of year and identification by sound is not always straightforward. It is worth mentioning that a similar pattern was found in Italy in case of the annual numbers of ringed birds between 1982 and 2003 (Spina & Volponi 2009). In the context of spring migration, it is worth mentioning the late observation and capture data, as the members of the Hungarian populations are already on breeding areas in March and already engaged in nest building in early April (Haraszthy 2019). For this reason, it is likely that most of the migrating Firecrests belong to northern European populations rather than to the Carpathian Basin. In several species, such as the Peregrine Falcon *Falco peregrinus* (Bozó 2021), the Ural Owl *Strix uralensis* (Bozó 2019), the Coal Tit *Periparus ater* (Bozó 2020a) and the Eurasian Siskin *Spinus spinus* (Bozó 2020b) have been assumed that birds occured in the Csanádi-hát from autumn to spring originate from the Apuseni Mountains, and it cannot be excluded that Firecrests also come from that area. However, no evidence of this was

found for this species, as the timing of migration does not differ from that observed in other parts of the country.

In autumn, there was a significant difference in the timing of migration, with migration typically taking place later in lowland areas than in mountainous areas. This was most noticeable in the timing of the occurrance of the first birds, as while the first birds were sometimes seen in Tömörd and Szalonna in mid-August, the first individuals were caught and observed in Ócsa and in the Csanádi-hát about a month later. The reason for this phenomenon is probably that while the species might nests near Tömörd and Szalonna, it does not breed in the Great Plain (Hadarics & Zalai 2008), so that migrating Firecrests may appear earlier in the former areas during post-breeding dispersal. A single long-term recapture was also recorded in Tömörd, which also confirms the hypothesis that the members of the breeding population were also captured during migration periods. Our results for the autumn migration are in agreement with Gyurácz and Csörgő (2009), who found that it is most intense in the first half of October. In autumn, as in spring, we have small numbers of recaptured birds at the ringing sites, and these individuals spent only a short time in the areas. As a result, their autumn migration was as rapid as in spring.

In winter, it was a rare, occasional visitor in each of the study areas, which is consistent with its previously known national status (Hadarics & Zalai 2008).

There was a significant difference in the timing of migration between years in the autumn in Tömörd and Szalonna. This may be mainly due to the weather in the respective years, as it influences both the timing of breeding and migration. If the weather was favourable in a given year, the birds could complete breeding and start migration on time, whereas in the opposite case, the end of breeding and the start of migration could be significantly delayed, even due to additional nesting. Of course, there may also be periods during migration that slow down fat accumulation, so that birds can only leave the stopover site later.

The male birds are generally more likley to be captured than females, but the differences in capture probability do not sufficiently explain why the sex ratio was male-biased (Lovász *et al.* 2018). In spring, male Firecrests were also more likely to be caught than females in both lowland and mountainous areas. The pattern in autumn is similar to that of the Goldcrest, with a twofold difference in favour of males found in this species in Ócsa and Ganda, Italy. In spring, however, the sex ratio was evenly balanced in this species (Miklay & Csörgő 1998), whereas in the present study, males were in a similar predominance in both Tömörd and Ócsa as in autumn. In the case of the Goldcrest, the equalisation of the sex ratio is due to higher mortality of males at wintering sites or on migration routes (Miklay & Csörgő 1998), but in the case of the Firecrest, it is likely to occur on migration routes towards breeding sites, further north of Hungary.

Based on field observations from different parts of the country in the 1970s and 1990s, a clear migration pattern emerged, with the species migrating first to the southern parts of the country in spring and then to the northern parts in autumn. This pattern was not supported by our own data, so it is possible that the migration pattern of the species has changed in recent decades. However, we do not have sufficient data to investigate this precisely.

In the 1970s and 1980s, the species migrated through the Southern Great Hungarian Plain earlier in the autumn than it does today, but there has been no change in the timing of its

spring migration. Changes in migration timing are typically driven by climate change (e.g. Sparks *et al.* 2002, Lehikoinen *et al.* 2004, Van Buskirk *et al.* 2009, Bozó & Csörgő 2020). In this case, however, the pattern obtained may be more an artificial product of low sample size than an effect of climate change. A longer-term, larger sample-sized data set would be needed to determine this.

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