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SHORT REPORT
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Occurrence of Coal Tits *Periparus ater* during non-breeding seasons in the Great Hungarian Plain

Förekomst utanför häckningssäsong av svartmes Periparus ater *på det ungerska slättlandet*

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THE TYPICALLY RESIDENT Coal Tit *Periparus ater*, which is widespread in Eurasia, may migrate from breeding sites in large numbers in certain environmental conditions. I used observations from 2005–2023 in a lowland area of south-eastern Hungary to detect irruptive movements of the species. In total, I observed Coal Tits on 258 different days. In some years, they were absent, while in others they occurred in higher numbers. Comparing my data with literature suggests that the birds occurring in south-eastern Hungary are not of the same origin as the birds migrating more regularly through western Hungary. The birds in the study area instead likely originate from the mountainous areas of Romania or the northern Great Hungarian Plain. I found no correlation between the annual numbers of occurrences in south-eastern Hungary and northern Europe, so northern birds likely do not normally enter the Carpathian Basin. However, in 2018, Coal Tits were present in higher numbers in the Great Hungarian Plain as well as in northern Europe, so it is possible that some northern individuals may appear in eastern Hungary during large northern invasions.

Keywords: Carpathian Basin | bird migration | irruptive migration | escape migration

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Introduction

There are several types of bird migration, of which one is known as escape migration, in which birds are forced to migrate by a change in environmental conditions. A special case of escape migration is known as irruptive migration. Irruptive migration is when a bird species, normally migrating and wintering in small numbers, appear in the same area in large numbers or in areas where they normally do not occur (Alerstam 1993). Typical irruptive bird species are the Bohemian Waxwing *Bombycilla garrulus*, the Brambling *Fringilla montifringilla* and the Fieldfare *Turdus pilaris*, but there are also significant annual differences in the number of migrating birds in many other Eurasian species (Svärdson 1957). Irruptive movements are normally driven by a high breeding success in combination with ensuing lack of food, and therefore, mass migration only occurs at certain periods (Newton 2006). In Scandinavia, Fieldfares typically undergo irruptive movements every three years, while in the Red Crossbills *Loxia curvirostra*, irruptive movements follow the pattern of seed production of the spruce (Svärdson 1957). This affects northern populations more than southern ones, as in the northern regions seed production is more variable (Alonso *et al.* 2017).

In irruptive years, not only the number of birds that appear in specific region increase significantly, but their place of origin can also be different from that of more regular migrants of this species. An excellent example of this are the invasions of the Bullfinch *Pyrrhula pyrrhula* in western Europe in 2004 and the Spotted Nutcracker *Nucifraga caryocatactes* in Hungary in 2008. During these irruptions birds originating from Russia were found alongside those from populations in central and northern Europe (Fox 2006, Newton *et al.* 2006, Pennington & Meek 2006, Zalai 2010).

Irruptive migration is sometimes easier to detect in regions where a species either does not nest or nest only patchily in small numbers. A good example of this is the Coal Tit *Periparus ater*, which is seen during irruptions in large numbers in the lowlands of Hungary, but is less conspicuous in the mountains, where it also breeds (Hadarics & Zalai 2008). The south-eastern part of the Great Hungarian Plain—where the species occurs in small forests and woodlands almost only during migration—is therefore an excellent area for studying its irruptive migration.

The Coal Tit is polytypic with 21 subspecies, out of which nine occur in Europe. Its range extends from north-western Africa through Eurasia to Kamchatka (Gosler & Clement 2020). In central and southern Europe, it breeds mainly in mountainous areas, while in the north its breeding range is more evenly distributed, coinciding with the distribution of evergreen forests. Its most significant European populations are in Ireland, the Alps, the Carpathians and the Caucasus. In recent decades, both range expansion (e.g. in Russia, Finland and Spain) as well as significant population declines (e.g. in France and the Netherlands) has occurred in Europe (Knaus 2020).

In Hungary, it used to breed only in mountain pine *Pinus* spp. forests, but presently it also nests in small numbers in hilly and lowland pine and mixed forests (Haraszthy 2019). In recent years, the nesting population has increased in the country (Gyurácz 2021).

In this study I aimed to analyse the occurrence of the Coal Tit over years. In particular, I sought to answer the question of where birds during irruptions originated from and whether their appearance was influenced by the weather of the given year. My own dataset from the south-eastern part of the Great Hungarian Plain was compared with the annual ringing data published by two bird observatories in northern Europe. The species is typically resident in Europe, with very short-distance dispersal movements of juveniles (Sellers 1984). For this reason, I assumed that the Coal Tits that occur in the study area arrive from the mountainous areas of the Apuseni Mountains. However, I also investigated the possibility that individuals from northern European populations may reach the area in irruptive years, as northern populations have produced long-distance recapture data (Spina *et al.* 2022).

Material and methods

Field observational data were collected in the villages of Kevermes and Lőkösháza, south-eastern Hungary for the period between 1 January 2005 and 31 May 2023 (Figure 1). In total, field observations were made on 2,480 different days. Of these 258 days have at least one Coal Tit observation. In order to make data comparable between years, the number of birds was divided by the number of days spent in the field in the study area each year (Figure 2). This was necessary because there is a

FIGURE 1. The locations for data collection.
— Platser för datainsamling.

significant difference between the number of observations in each year ($\chi^2 = 481.17$, df = 15, $p < 0.001$). This is mainly due to the fact that between January 2010 and September 2012, I spent fewer days in the field than during other years. Similar number of observations was made in each month, all year round in the years included in the study. I defined the migration season as the period between 1 September and 30 April. The migration was considered to be irruptive when either the number of birds observed, or the number of observations, was significantly higher than in other years. Multiple observations should also be taken into account. Unfortunately, with unbanded birds it is impossible to determine if the same individuals were observed repeatedly on different days. However, during the migratory period this is less likely as birds tend to move on quickly. During the winter period however, repeated observations of the same birds over days may be a problem. For this reason, only years when the number of birds or observations was higher than usual during the migration period were considered as irruptive.

To investigate the possible northern origin of the birds, I compared the annual data of two northern European bird observatories with my own. I used the annual reports published on the Gedser Fuglestation (the southernmost point of Denmark) website for the period between 2018 and 2022 (https://www.gedserfuglestation.dk/resultater/fangst/arsresultater-ringmaerkning),

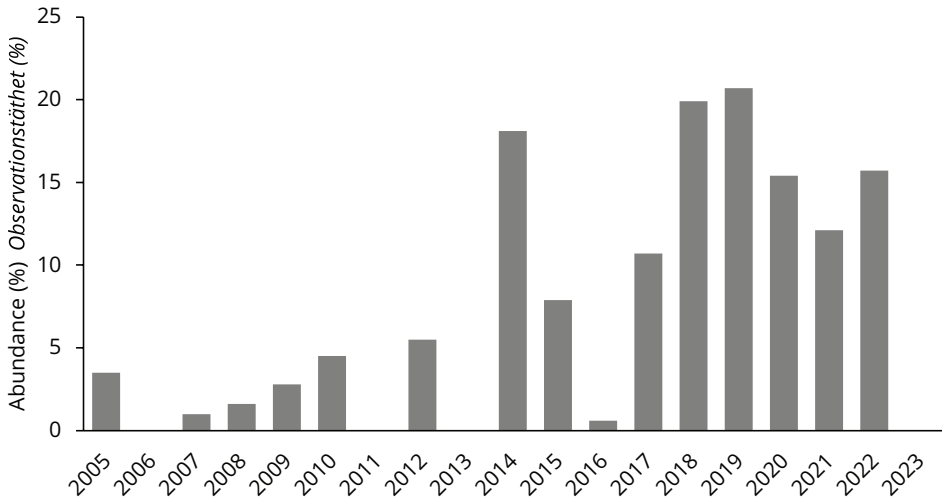

FIGURE 2. Annual abundance of Coal Tit *Periparus ater* observations (N observations/N days in the field).
— *Årlig observationstäthet (antal observationer/antal fältdagar) för svartmes* Periparus ater.

in addition to the earlier data from the same bird observatory published in Kayser (2018). I also used the data available on the website of the Falsterbo Bird Observatory (https://www.falsterbofagelstation.se/ringmarkning/art-alla-ar/index.php?lang=en). The study period covered the years between 2007 and 2022. Since the data were not normally distributed, I used Spearman correlation. I carried out the statistical analyses using Past 1.9. (Hammer *et al.* 2001).

Results

In south-eastern Hungary, the Coal Tit is a rare winter visitor that also may occur in small numbers on migration in autumn and spring. It may be completely absent in certain years and seasons, for example in 2006, 2011, 2013 and in the 2022/2023 season. In 2016 it was observed only once, Figure 2). In several seasons (2014/2015, 2017/2018, 2019/2020, 2021/2022), the number of observations ($\chi^2 = 39.285$, df = 15,

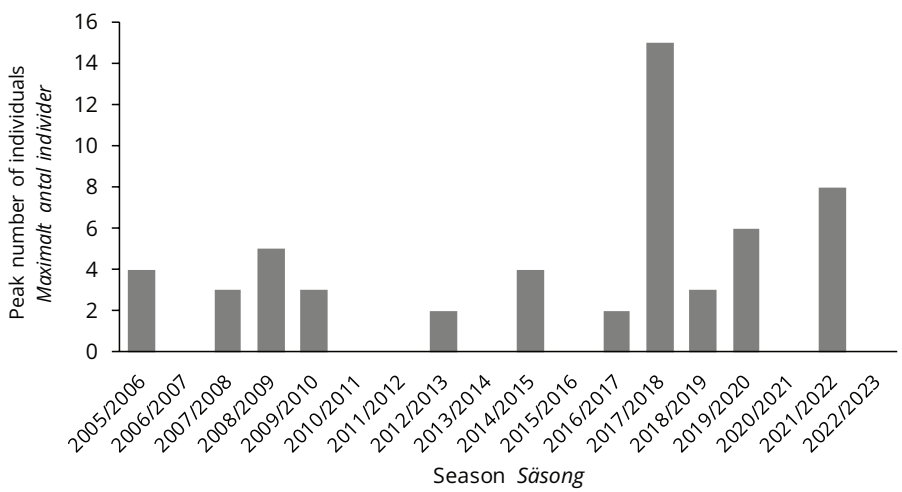

FIGURE 3. Maximum numbers of Coal Tits *Periparus ater* observed seasonally.
— *Det observerade maxantalet av svartmes* Periparus ater *per säsong.*

$p < 0.001$) and the total number of observed individuals ($\chi^2 = 26.319$, df = 15, $p = 0.009$) were significantly higher than in other seasons (Figure 3). However, based on the total number of individuals only the migration in 2017/2018 could be labelled as truly irruptive. In the 2017/2018 season, the first bird appeared on 4 October 2017, after which the species became common during the following week. The highest numbers were recorded in mid-October—for example, on 18 October a flock of about 15 individuals was seen in willows *Salix* spp. at an inland drainage channel. This irruptive occurrence was not reflected in corresponding numbers the following spring, when only a few sightings were made.

The number of observations increased significantly during the whole study period ($p = 0.041$, $R = 0.577$). The migration dynamics of the species are characterised by the first individuals arriving in the second half of September or the first half of October. Migration is most intense in October, with a peak in mid-October (Figure 4). The number of birds definitely decreased by the end of November, after which there were no significant differences in the number of observations and the number of individuals observed until the end of March. The high number of individuals at the end of December could potentially be due to a higher intensity of observations during the holidays. There is no migration in large numbers in spring, but a slight peak in March is noticeable (Figure 4). Occasional migrants can be observed until the first week of May.

The species is not known to nest in the area, but in the summer of 2014 a male sang for an extended period between 29 June and 15 July during the breeding season in a park with Norway spruce *Picea abies* and horse chestnut *Aesculus hippocastanum* trees in the centre of Kevermes (Bozó 2020a). A singing male was also found on 27 May 2022 at the same location.

There was no significant correlation between the number of ringed Coal Tits at either Gedser ($R = 0.407$, $p = 0.117$) or Falsterbo ($R = -0.024$, $p = 0.927$) between 2007 and 2022 and the number of birds I observed in south-eastern Hungary. There was, however, a significant correlation between the annual captures of the two northern European bird observatories ($R = 0.797$, $p = 0.0002$). It should also be noted that, in Falsterbo, the highest number of Coal Tits ringed was in 2018, and in the same year in Gedser the number of captures was also above the average for the period 2007–2022.

Discussion

The Coal Tit is resident in parts of Hungary, but in certain autumns, when the local food sources in breeding areas are depleted, it may also occur in irruptive movements (Farkas 2009). Such irruptive movements have been observed in the Great Hungarian Plain (Endes 1996, Hadarics 1996, Ambrus 2010). Standardised bird ringing carried out between 1998

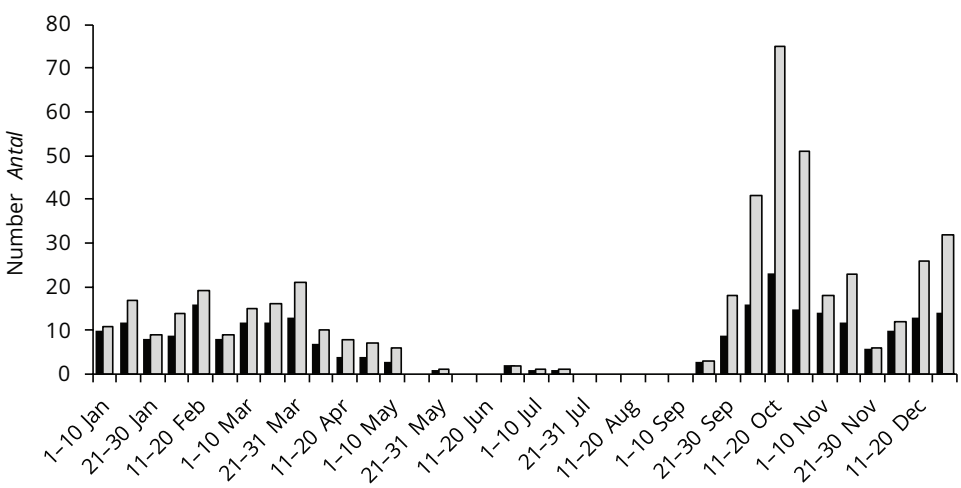

FIGURE 4. Number of observations (black bars) and the number of observed individuals (light grey bars) of Coal Tits *Periparus ater* by ten-day periods. — *Antal observationer (svarta staplar) och individer (ljusgrå staplar) av svartmes* Periparus ater *över tiodagarsperioder.*

and 2016 in Tömörd in western Hungary revealed two irruptive autumns, 2010 and 2012, while in some other years not a single individual was caught (Lukács & Gyurácz 2013, Gyurácz *et al.* 2017). In Hungary, it has been ringed in high numbers in 2004, 2005, 2010, 2012, 2014, 2017 and 2019, which might be considered to reflect invasive movements (BirdLife Hungary 2023). If these data are compared with my own observations this suggests that not all invasions that reach northern Hungary will continue to the Great Hungarian Plain. However, it is possible that these differences may also be caused by a differential migration pattern of the Coal Tit, in accordance with other forest-dwelling species studied in the area (Bozó 2019, Bozó 2020b). Of the Hungarian bird observatories, Tömörd has the highest number of Coal Tits caught, and those birds almost certainly come from the Alps (Lukács & Gyurácz 2013). The birds that occur on migration in south-eastern Hungary, on the other hand, probably breed in the Apuseni Mountains in Romania, as this is the closest breeding area of the species.

As the population of Coal Tit has increased in numbers in lowland pine forests of the Great Hungarian Plain (Hadarics & Zalai 2008; cf. Molnár 1982) since the 1970s, I expected that after the years of irruption, it would also breed in the nearby lowland. However, this has still not occurred in the region, even if singing males have been heard in two different summers.

The trend of an increasing number of observations in my data is reflected also in Hungarian ringing data (BirdLife Hungary 2023). Even though many European populations of the species are decreasing (Knaus 2020), it appears to be increasing in Hungary, especially in the northern parts of the Great Hungarian Plain (Gyurácz 2021). Perhaps, the trend of an increase in my data could be due to this growth in population size. Nevertheless, the most probable place of origin of Coal Tits in my study area is the Apuseni Mountains.

The dynamics of the migration in my study differ from those of the birds migrating through western Hungary. The migration peaks in the area in mid-September and ends in mid-October (Gyurácz *et al.* 2017). In my study area, the migration peaks later, in October. The start of the autumn migration is also later in the study area. The reason for the differences between the two areas probably depend on the different distances travelled by the arriving migrants birds. Tömörd is much closer to the Alps than my study area in south-eastern Hungary is to the species' breeding grounds in the Apuseni Mountains or the northern Great Hungarian Plain.

By comparing the data of the two bird observatories of northern Europe with my own data, it can be concluded that there was no correlation between the movements of birds migrating through the Great Hungarian Plain and northern Europe. Since even the northern populations of the species are at most short-term migrants (Gosler & Clement 2020), and the direction of long-distance movements is almost always south-westerly (Spina *et al.* 2022), it is not surprising that the individuals of northern populations do not reach the Carpathian Basin. This is confirmed by the fact that only two foreign recaptures from Slovenia and Slovakia can be found in the Hungarian bird ringing database but not a single one from northern Europe (BirdLife Hungary 2023).

It is important to note, however, that in 2018, the species was widely ringed both in northern Europe and in south-eastern Hungary. It is possible that some northern birds may have reached the Carpathian Basin at that time. Some birds may show longer-term movements in certain periods. According to Sellers (1984), only 16.8% of Coal Tits ringed as nestlings or as migrants and later recaptured in Great Britain were found at a distance of more than 5 km from the place of ringing. Sellers (1984) found that the movement was driven by the decreasing amount of food. Brotons (1997) found a correlation between the depth of the snow cover and the birds' diet in the Pyrenees. In the case of a thicker snow cover, the birds need to expend more energy to forage for the required amount of food. This also to an advantage in leaving the breeding grounds in case of unfavourable weather. In some cases, long-term migration has also been demonstrated. Based on ringing data from the Curonian Spit in the south-eastern Baltic Sea from 1958 to 2000, Sokolov *et al.* (2003) concluded that there was a significant correlation between the number of birds and the winter weather in different parts of Eurasia. After a mild winter, due to the higher survival rate of old birds, breeding success will be higher, which contributes to invasion movements away from this region the following autumn. It was also established that a

significant part of the birds caught there during the irruptive years did not come from the Baltic region, but from the European parts of Russia, possibly the Trans-Urals.

Most likely, during these invasions Coal Tits do not reach the Carpathian Basin in high numbers, because these mountains act as significant ecological barriers. The movements in Hungary are therefore probably intra-Carpathian, and the higher numbers of birds in a region depend on the weather and breeding success of the nearest nesting populations.

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Svensk sammanfattning

Under speciella omständigheter kan vissa fågelarter uppvisa invasionsliknande flyttningsmönster, så kallad irruptiv flyttning eller invasionsflyttning (engelska: irruptive migration), vilket innebär att individer rör sig oregelbundet och ansamlas i stora antal på platser och i områden där de vanligen inte återfinns i samma utsträckning. Dessa rörelser inträffar oftast under år med god häckningsframgång tillsammans med en efterföljande låg tillgång på föda. Svartmesen *Periparus ater*, som vanligen är en stannfågel, är ett exempel på en sådan art.

I denna studie analyserar jag mina observationer av svartmes, under 2 480 fältdagar fördelade över åren 2005–2023, i byarna Kevermes och Lőkösháza (figur 1) på det ungerska slättlandet i sydöstra delarna av Ungern (Alföld), för att identifiera potentiella invasionsliknande flyttningsmönster. I Ungern har svartmes tidigare främst häckat i tallskogsområden på hög höjd, men numera häckar de även till viss del i tall- och blandskog på lägre höjd.

Svartmes observerades totalt under 258 av dessa 2 480 dagar. Antalet observerade individer varierade kraftigt över åren, men ökade generellt under studiens gång. Vissa år observerades inga svartmesar alls medan andelen observationer per fältdag vissa år uppnådde cirka 20% (figur 2). Observationen med flest antal individer vid ett enskilt tillfälle inträffade i oktober 2017 då en flock om cirka 15 individer noterades (figur 3). Baserat på det totala antalet observerade individer är säsongen 2017/2018 den enda som skulle kunna anses innehålla någon form av invasionsartad flyttning (figur 4). Trots vissa år med relativt många observationer och sjungande hannar under två häckningsperioder (2014 och 2022) har inga häckningar i närliggande slättområde observerats.

Vid en jämförelse med ringmärkningsdata från Gedser och Falsterbo under åren 2007–2022 gick det inte att finna någon korrelation mellan antalet ringmärkta individer på dessa platser och mina observationer av svartmes. Det är dock värt att notera att antalet ringmärkta svartmesar 2018 var högt, både i Gedser och Falsterbo. Trots det är det sannolikt så att invasionsartade flyttningar av svartmes från norra Europa inte når Donaubäckenet och det ungerska slättlandet på grund av de ekologiska barriärerna som Karpaterna och Alperna utgör. Således är antalet svartmesar sannolikt främst en effekt av väderförhållanden och häckningsframgång i de närliggande häckningsområdena, vilket för nordvästra Ungern är Alperna och för mitt studieområde i sydöstra Ungern de norra delarna av slättlandet eller Apusenibergen.

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