

SHORT COMMUNICATION

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The influence of climate change on brood size and breeding time in three tit species in Sweden, 1962–2019

Klimatförändringarnas påverkan på kullstorlek och häckningstid hos tre mesarter i Sverige 1962–2019

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CLIMATE change is expected to affect many biological systems, including the timing of seasonal events such as breeding in birds. In this study, I investigated how brood size and timing of reproduction (measured as median date for ringing of broods) changed for three tit species in Sweden 1962–2019 using data reported to the Swedish Bird Ringing Centre. The brood size for the Coal Tit *Pariparus ater* increased from 7.74 between 1962–2001 to 7.98 young between 2002–2019, while no change was detected for Crested Tit *Lophophanes cristatus* or Willow Tit *Poecile montanus*. The largest biological effects were seen for timing of reproduction, with Coal Tits and the Crested Tits initiating breeding about seven days earlier at the end of the study period compared to the 1960s. The Willow Tit data also suggested earlier breeding, but only by about two days across the study period.

Keywords: Paridae | ringing | Coal Tit *Pariparus ater* | Crested Tit *Lophophanes cristatus* | Willow Tit *Poecile montanus*

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Introduction

The Intergovernmental Panel on Climate Change (IPCC) predicts increasing global warming during the next 100 years (IPCC 2021). The rate of increase is higher in the Northern hemisphere, dependent on the larger land mass and smaller ice cover (IPCC 2021). An increased average temperature induces many changes in biological systems and have profound effects on both plants and animals over large areas. Important changes in Europe include different timing of seasonal events, such as an advancement of spring and changed phenological timing of adult insects and larvae (Visser et al. 1998). Birds relying on such food sources need to adjust to changed timing of their prey or risk a phenological mismatch, leading to reduced breeding output (Miller-Rushing et al. 2010, Saalfeld et al. 2019).

In an earlier study using ringing data on four tit species (Paridae) in Sweden, Ryttman & Karlsson (2010) found that Coal Tits *Pariparus ater*, Crested Tits *Lophophanes cristatus*, and Marsh Tits *Poecile palustris* had advanced their breeding over a 40-year period (1962–2001), while Willow Tits *Poecile montanus* had not. As another two decades have passed since that study, I wanted to return to this subject and investigate whether the pattern with earlier breeding continues and—if so—how rapid this change is for the Coal Tit, Crested Tit, and Willow Tit, breeding in the same habitat.

Material and methods

The underlying data for both the previous and this study are ringing data of broods reported to the Bird Ringing Centre at the Swedish Museum of Natural History in Stockholm. The centre oversees all ringing conducted in Sweden, and brood data can be separated from other types of bird ringing data with the use of

specific codes in the database. In total there were 4,967 broods available, of which 3,884 were from Coal Tits, 644 from Willow Tit, and 455 from Crested Tit across the years 1969–2019 (Table 1).

Reproductive timing was measured by estimating the median date for when broods were ringed for each year from 1962 to 2019, except for Crested Tit, where no brood was ringed in 2019. When no specific date could be determined I used a mean between the two dates for the median, or the most likely date (the date when most broods were ringed).

In addition, the mean number of ringed young was estimated for the three species and a comparison between the two periods (1962–2001 vs 2002–2019) was made.

As a measure of climate, the mean April temperatures for Stockholm, Sweden, was used (accessible at <https://miljobarometern.stockholm.se/klimat/klimat-och-vaderstatistik/manadsmedeltemperatur/table/>).

Results

BROOD SIZE

The number of young per brood increased for Coal Tit, from a mean of 7.74 during the years 1962–2001 to 7.98 in the period 2002–2019 ($t=2.92$, $n=3,882$, $p=0.003$). There were no statistical differences in brood size for Crested Tit (4.32 in 1962–2001 vs 4.10 in 2002–2018; $t=1.03$, $n=453$, $p=0.303$) and Willow Tit (6.68 in 1962–2001 vs 6.76 in 2002–2018; $t=0.34$, $n=642$, $p=0.738$). On a general note, the numbers of ringed Coal Tit, Crested Tit, and Willow Tit broods decreased over the study period (Figure 1). At least for Crested Tits, this may be due to a specific research project in the 1970s that ringed a large number of broods.

TABLE 1. Difference in average brood size and number of ringed broods, with standard error (SE), for the three parid study species during 1962–2001 and 2002–2019.

— Skillnad i genomsnittlig kullstorlek och antal kullar och antal ringmärkta kullar, med standardfel (SE), antal märkta kullar under 1962–2001 och 2002–2019 och p-värde.

Species	Art		Average brood size <i>Genomsnittlig kullstorlek</i>		Significance (p-value) <i>Signifikans (p-värde)</i>
			1962–2001	2002–2019	
Coal Tit	<i>Pariparus ater</i>	Svartmes	7.74 (SE=0.032, n=3,279)	7.98 (SE=0.076, n=589)	<0.0001
Crested Tit	<i>Lophophanes cristatus</i>	Tofmes	4.32 (SE=0.055, n=425)	4.10 (SE=0.210, n=30)	0.303
Willow Tit	<i>Poecile montanus</i>	Talltita	6.68 (SE=0.078, n=570)	6.76 (SE=0.224, n=74)	0.738

TIME OF BREEDING

All species advanced their breeding, measured as the time for ringing young—which is done at nearly the same development stadium of the young, during the study period. Regression analyses of median date over year all resulted in negative slopes (b-values), corresponding to an earlier breeding time by six to seven days today compared to the early 1960s for Coal Tit ($r=0.418$, $t=28.6$, $n=58$, $p<0.001$; **Figure 2a**) and Crested Tit ($r=0.285$, $t=6.33$, $n=57$, $p<0.001$; **Figure 2b**). The Willow Tit advanced its breeding by only about two days, but this estimate is also significant ($r=0.117$, $t=2.99$, $n=58$, $p=0.003$; **Figure 2c**).

The mean temperature during 1962–2019 in April in Stockholm increased by over 3 °C since the 1960s (**Figure 3**).

Discussion

The data presented here show a clear pattern in all three tit species that timing of breeding has advanced significantly over the 57–58 years of the study. Furthermore, the rates of advancement are fairly constant across the time series, albeit with some interannual variation. It is important to note that brood ringing occurs at specific development stage of the nestlings and is therefore not a variable that has varied over time. Thus, a likely explanation for a progressively earlier ringing of broods is climate change-driven warmer temperatures in Sweden, resulting in an increasing advancement of spring and corresponding selection for earlier breeding among the tits.

In a long-term nest-box study on Coal Tits from Örebro in south central Sweden in 1949–2012, **Schölin &**

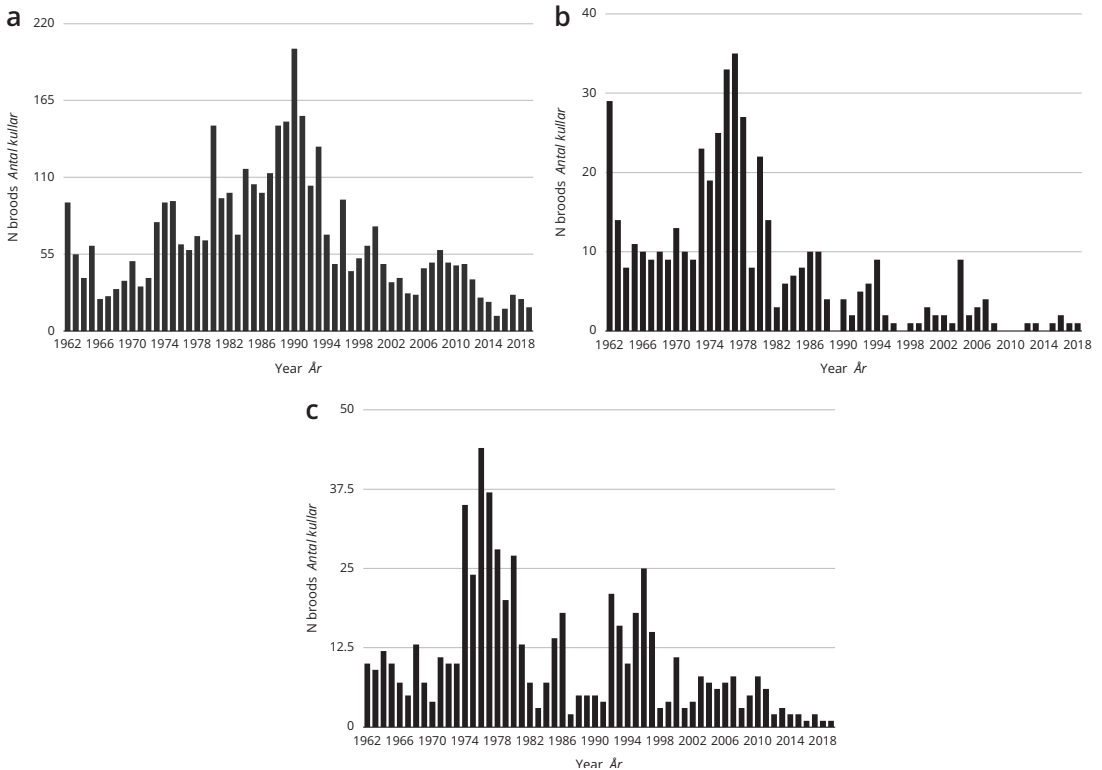


FIGURE 1. The number of ringed broods of (a) Coal Tits *Parus ater*, (b) Crested Tits *Lophophanes cristatus*, and (c) Willow Tits *Poecile montanus* in Sweden 1962–2019.

— Antal ringmärkta kullar av (a) svartmes *Parus ater*, (b) tofsmes *Lophophanes cristatus* och (c) talltita *Poecile montanus* i Sverige 1962–2019.

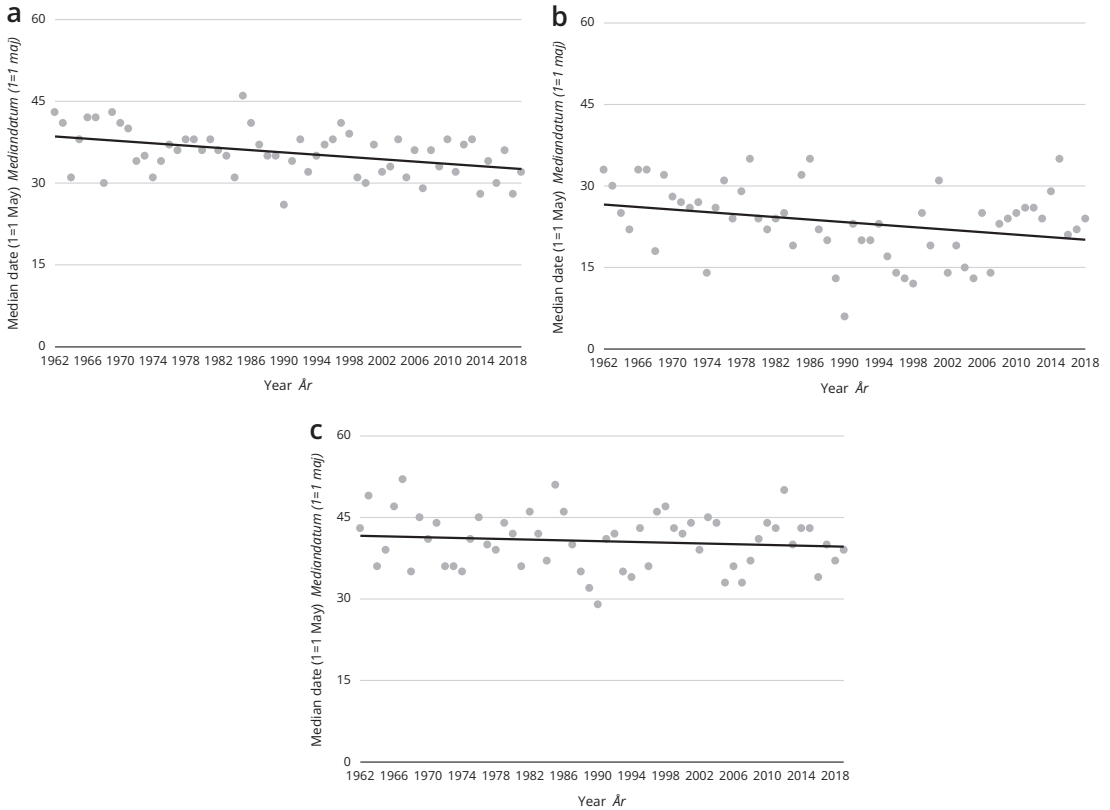


FIGURE 2. Median date (day from 1 May) of ringed clutches, reflecting timing of breeding, over time for **(a)** Coal Tits *Periparus ater* (start value 1962=38.7, i.e. 7 June, $b=-0.106$, $r^2=0.175$), **(b)** Crested Tits *Lophophanes cristatus* (start value=26.7, $b=-0.115$, $r^2=0.082$), and **(c)** Willow Tits *Poecile montanus* (start value=41.7, $b=-0.035$, $r^2=0.014$) in Sweden 1962–2019. The regression lines represent significant advances in breeding time for all species.

— Mediandatum för kullmärkning (dag från 1 maj), vilket reflekterar häckningstid, för **(a)** svartmesar *Periparus ater* (startvärde 1962=38.7, dvs. 7 juni, $b=-0.106$, $r^2=0.175$), **(b)** tofsmesar *Lophophanes cristatus* (startvärde=26.7, $b=-0.115$, $r^2=0.082$) och **(c)** talltitor *Poecile montanus* (startvärde=41.7, $b=-0.035$, $r^2=0.014$) i Sverige 1962–2019. Regressionslinjerna motsvarar signifikanta tidigareläggningar av häckningen för alla arter.

Källander (2013) found that there were no trends in laying date in the first 27 years, but an increasing advancement in the second 28-year period; this advancement correlated with increasing temperature in April. The same study also found a similar correlation between advanced laying date and increased temperature over time in Blue Tits *Cyanistes caeruleus*, where mean temperature in April increased by 3 °C in their study region (Schölin & Källander 2012).

An interesting result is the increasing number of young per brood observed for the Coal Tit (Table 1; Rytman & Hall-Karlsson 2010). Schölin & Källander (2013) reported an average of 7.78 ringed young Coal Tits per brood from a mean of 8.55 eggs per

clutch ($n=105$) during 1949–2012, which is comparable to clutch sizes reported here. The reason for the increased brood size of Coal Tits is difficult to explain. The two other tit species do not show the same pattern, despite breeding in similar habitats and showing advanced breeding times. Potential artefacts could be differences resulting from sampling different geographic regions of Sweden, which was not investigated here, or that nest-box placement affects breeding output. I have previously shown increased brood sizes in another nest-boxing species, the Eurasian Wryneck *Jynx torquilla* between 1962 and 2012 (Rytman 2003, 2014), where I considered nest-boxes being placed in more suitable areas in the 1990s, when many new

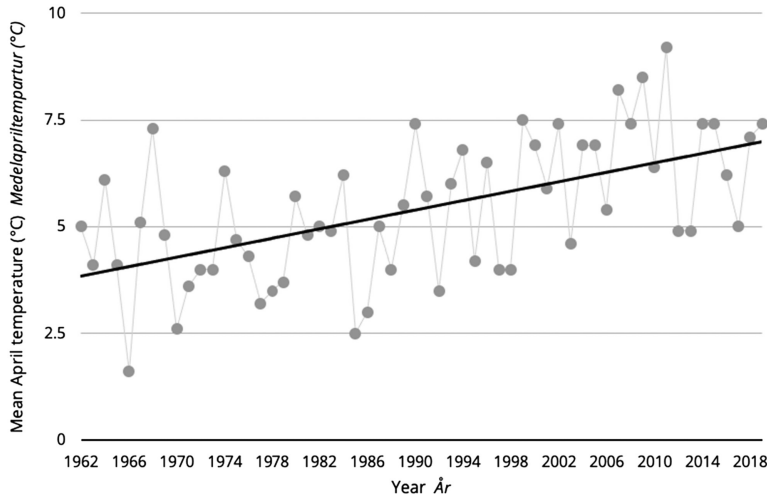


FIGURE 3. Mean temperature (°C) for April in Stockholm 1962–2019. Over the study period, the mean temperature rose significantly by on average 0.055 °C per year from 3.8 to 6.9 °C ($b=0.055$, $r^2=0.319$).
 — Stockholms medeltemperatur (°C) för april 1962–2019. Över studieperioden steg medeltemperaturen signifikant med i snitt 0.055 °C per år från 3.8 °C till 6.9 °C ($b=0.055$, $r^2=0.319$).

ringers started projects for studying the breeding of Eurasian Wrynecks.

The Swedish Bird Monitoring (www.fageltaxering.lu.se) shows different results in the different types of areas where monitoring is carried out. In point counts, which represent survey sites that are selected freely by the observers, all tits have decreased ($p < 0.01$; Green et al. 2019). Across the standard routes, which represent surveys in predetermined areas representative of the overall habitat composition, Green et al. (2019) show that the Coal Tit has a stable population while the Crested Tit increases ($p < 0.001$) and the Willow Tit decreases ($p < 0.05$). The Coal Tit and Crested Tit have larger populations in southern Sweden while the Willow Tit has a distribution which is more northerly. The less pronounced reaction to the changing climate in Willow Tit could potentially affect its decreasing population, perhaps depending on the disadvantage of missing the most suitable time for feeding their young (cf. Visser et al. 1998). However, such a disadvantage of mistiming should be detectable as fewer chicks alive at the time of ringing, and this was not the case. Fewer decomposing birch *Betula* spp. trees in forests may pose a constraint to finding

suitable nesting sites, but that should equally affect the Crested Tit.

References

- Green M, Haas F & Lindström Å. 2019. Monitoring population changes of birds in Sweden. Annual report for 2018. Report, Department of Biology, Lund University. 92 pp.
- IPCC. 2021. Summary for Policymakers. In: *Climate change 2021: the physical science basis. Contribution of working group I to the sixth assessment report of the intergovernmental panel on climate change* (Masson-Delmotte V, Zhai P, Pirani A, Connors SL, Péan C, Berger S, Caud N, Chen Y, Goldfarb L, Gomis MI, Huang M, Leitzell K, Lonnoy E, Matthews JBR, Maycock T, Waterfield TK, Yelekçi O, Yu R & Zhou B, eds). Cambridge University Press. https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Full_Report.pdf
- Miller-Rushing AJ, Høye TT, Inouye D & Post E. 2010. The effects of phenological mismatches on demography. *Philosophical Transactions of the Royal Society B* 365: 3177–3186. <https://doi.org/10.1098/rstb.2010.0148>
- Ryttman H. 2003. Breeding success of Wryneck *Jynx torquilla* during the last 40 years in Sweden. *Ornis Svecica* 13: 25–28. <https://doi.org/10.34080/os.v13.22817>
- Ryttman H. 2014. Göktytan på frammarsch i Sverige. *Fauna och Flora* 109: 26–28.
- Ryttman H & Hall-Karlsson S. 2010. Brood size of four titmice (Paridae) during 1962–2001. *Ornis Svecica* 20: 57–62. <https://doi.org/10.34080/os.v20.22639>
- Saalfeld ST, McEwen DC, Kesler DC, Butler MG, Cunningham JA, Doll AC, English WB, Gerik DE, Grond K, Herzog P, Hill BL,

Lagassé BJ & Lanctot RB. 2019. Phenological mismatch in Arctic-breeding shorebirds: impact of snowmelt and unpredictable weather conditions on food availability and chick growth. *Ecology and Evolution* 9: 6693–6707. <https://doi.org/10.1002/ece3.5248>

Schölin KG & Källander H. 2012. A Blue Tit *Cyanistes caeruleus* population: its recent increase and breeding data. *Ornis Svecica* 22: 19–24. <https://doi.org/10.34080/os.v21.22597>

Schölin KG & Källander H. 2013. The breeding biology of the Coal Tit *Pariparus ater* in South Central Sweden. *Ornis Svecica* 23: 151–158. <https://doi.org/10.34080/os.v23.22567>

Visser ME, van Noordwijk AJ, Tinbergen JM & Lessels CM. 1998. Warmer springs lead to mistimed reproduction in great tits (*Parus major*). *Proceedings of the Royal Society London B* 265: 1867–1870. <https://doi.org/10.1098/rspb.1998.0514>

Sammanfattning

The Intergovernmental Panel on Climate Change (IPCC) förutser en ökande global uppvärmning under kommande decennier. Den hastigaste uppvärmningen sker på det norra halvklotet beroende på större landmassa och mindre förekomst av is. Den högre temperaturen leder till en mängd förändringar i biologiska förlopp hos växter och djur, där vissa arter gynnas medan andra arter inte förmår anpassa sig till de nya förhållandena och därför missgynnas. Hos arter med tämligen korta generationstider ses detta tydligast, inte minst hos fåglar.

I uppsatsen studeras kullstorlek och datum för ringmärkningen av tre skogsmesar—svartmes, tofsmes och talltita—under åren 1962–2019. För svartmesen har kullstorleken ökat från 7,74 ungar per kull vid ringmärkningstillfället till 7,98 ungar per kull vilket är en statistiskt signifikant ökning. För tofsmes och talltita

är kullstorleken konstant under den undersökta tiden. Häckningstiden börjar ca sju dagar tidigare under 2000-talet i jämförelser med 1960-talet för svartmes och tofsmes medan talltitan endast börjar ca två dagar tidigare, men den förändringen är statistiskt signifikant. Då födotillgången är av avgörande betydelse för uppfödandet av fågelungar är fåglars anpassning till insekternas larvstadiutveckling väsentlig. Det är troligt att insekter, med sin kortare generationsväxling, snabbare anpassar sig till klimatförändringarna, vilket kräver att fåglarna anpassar häckningen till insekternas tidigare uppträdande. I fallet med de tre undersökta mesarna tycks svartmes och tofsmes ha förflyttat sig i rätt riktning medan talltitan har gjort det mer tveksamt. Möjligen kan den svaga ändringen i häckningstid för talltitan var en tänkbar orsak till talltitans minskande numerärer i Sverige.



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