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Breeding biology of the Cyprus Coal Tit (*Periparus ater cypriotes*) in the coniferous Paphos Forest, Cyprus, over a 9-year period

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We studied the breeding biology of the endemic Cyprus Coal Tit (*Periparus ater cypriotes*) using artificial nest boxes in a coniferous forest from March through May 2010 to 2018. In total, 202 breeding pairs utilized the nest boxes, with a mean number of 22.2 pairs per year. The highest number of nests was observed in 2017, with 38 occupied nest boxes, reflecting a significant fivefold increase compared to 8 occupied nest boxes in 2011. Breeding attempts were not affected by temperature or precipitation prior to and during the breeding period. Average clutch size was 6.2 ± 1.2 eggs and average brood size 6.1 ± 1.2 young. Additionally, 51 pairs of Great Tit (*Parus major aphrodite*) bred in the nest boxes with a mean number of 5.7 ± 1.66 pairs per year. Nest composition of the two species was similar, although Cyprus Coal Tits built heavier nests, composed of double the percentage of wool and feathers (60%) compared to Great Tits (33%).

Keywords: Great Tit; nest boxes; nest composition; clutch size; brood size

Introduction

The Cyprus Coal Tit (*Periparus ater cypriotes*) is endemic to Cyprus and one of the 21 subspecies of Coal Tit (*Periparus ater*) found in the Palearctic (Johansson et al., 2013). Its population is estimated at 43,000–79,000 pairs (Birds Directive, 2018). The only other species of Paridae nesting in Cyprus is the Great Tit, *Parus major aphrodite* (Flint & Stewart, 1992). Research on the nominate species of Coal Tit has shown they may utilize similar habitats and diets and are potential competitors (e.g. Atiénzar et al., 2015).

The Cyprus Coal Tit is widespread in the mountains and common in almost all natural pine forests in Cyprus during the breeding season (Zogaris & Poirazidis, 2011). The highest population densities occur in Paphos and Troodos Forests, above altitudes of 200 m (Flint & Stewart, 1992). Nests are usually relatively close to the ground, in tree cavities, holes in stone walls or slopes (Zogaris & Poirazidis, 2011). Studies on breeding biology are not available.

Materials and Methods

Study area. Paphos Forest is situated in the northwest part of the Troodos Mountain range (Figure 1). It is a mainly coniferous forest of 600 km² and constitutes the most extensive and continuous forest ecosystem in Cyprus, ranging from 200 m up to the peak of Tripylos at 1352 m. The predominant vegetation is the Calabrian Pine (*Pinus brutia*). The area also includes a unique endemic Cyprus Cedar (*Cedrus brevifolia*) forest and important scrub and low forest vegetation, including

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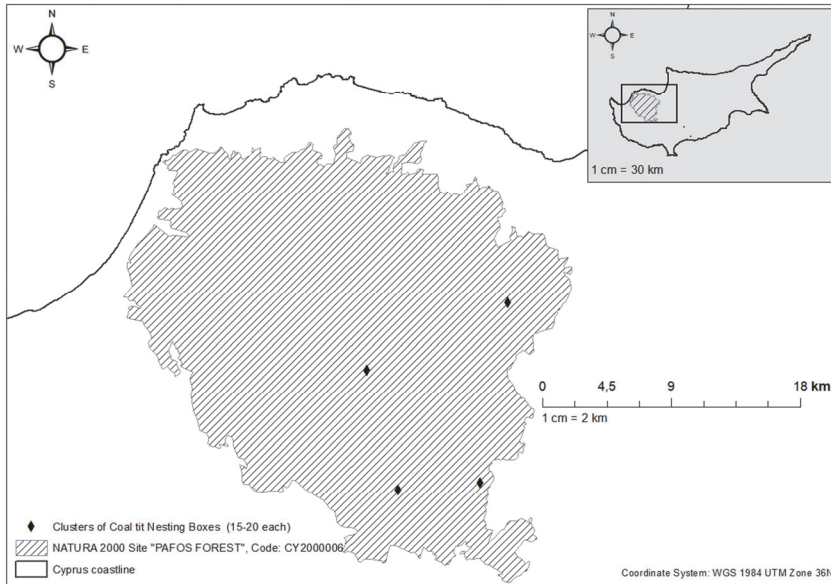


Figure 1. Location of Paphos Forest in Cyprus (inset map), boundaries of Paphos Forest Natura 2000 site and location of Cyprus Coal Tit nest box clusters.

the endemic Golden Oak (*Quercus alnifolia*). Riparian vegetation encountered at all elevations includes broadleaves such as the Oriental Plane (*Platanus orientalis*), Oriental Alder (*Alnus orientalis*), Bay Laurel (*Laurus nobilis*), and Common Myrtle (*Myrtus communis*). Paphos Forest has been declared a Special Protection Area (SPA) according to the Birds Directive (79/409/EEC) due to its high value for avifauna (Game and Fauna Service, 2016).

Data collection. Wooden nest boxes were provided by the Game and Fauna Service (200 mm height, 120 mm deep, 35 mm diameter hole, and 144 cm² internal floor area) following specifications for *Parus* spp. (Everett, 1991) and placed on pine trees at four locations in Paphos Forest (Figure 1). The locations were chosen to have a wide representation of the forest and established populations of the Cyprus Coal Tit. The nest boxes were mounted on tree trunks at a height of approximately 2 m from the ground. In total, 72 nest boxes were used. From 2010 to 2018, they were visited once a year during the nesting season between March and May, therefore, predominantly first clutches were studied.

Observers noted whether the nest boxes were occupied, the bird species using them, clutch size (number of eggs per nest) and brood size (number of young per nest). Average clutch size (number of eggs per nest/total number of nests) was calculated from nests where the female had finished incubation, and average brood size (number of young per nest/total number of nests) from nests that contained only chicks and no eggs. Ten nests of Cyprus Coal Tits and ten nests of Great Tits were collected to determine composition of nesting material and nest structure. The nests were weighed and then left to dry for 48 hours. Once dried, they were separated into different components (moss, grass-pine needles, wool-feathers, others) that were also weighed. Due to the complex nature of the nests, a fixed time of 10 minutes of manipulation was set.

Statistical analyses. The total number of nest boxes used by the Cyprus Coal Tit and the Great Tit each year (2010-2018) was analysed using General Linear Models (GLM) in R version 3.6.3 via RStudio, to investigate whether they increased or decreased over time. In addition, the number of nest boxes used by the Cyprus Coal Tit was compared with weather data from every year (provided by the Department of Meteorology), using linear models. The number of occupied nest boxes was set as a response variable and the mean temperature and mean precipitation for each of the months before and during the breeding period (February, March, April) was a fixed effect.

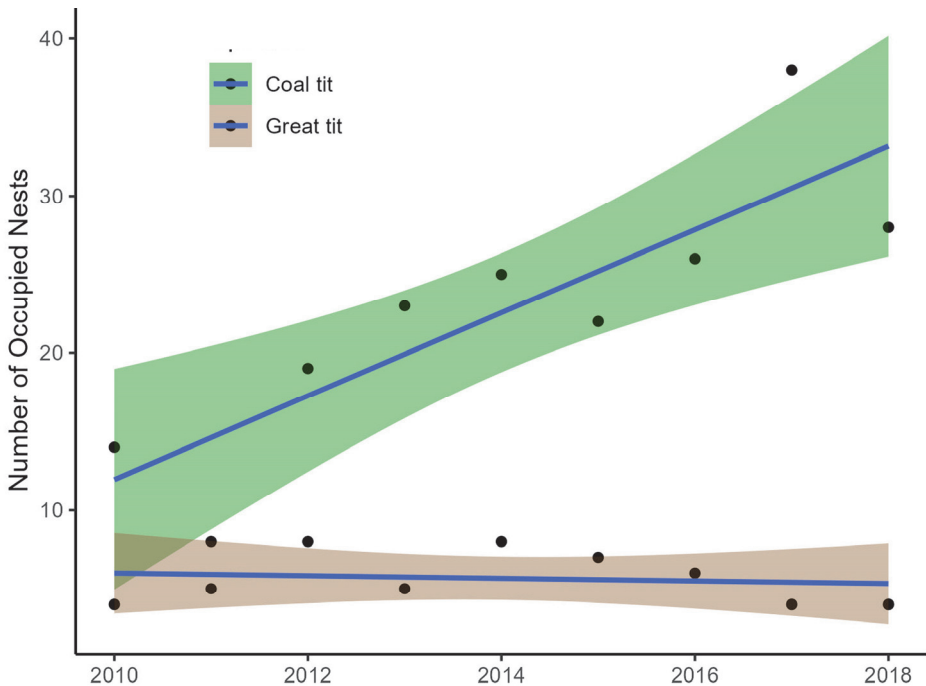


Figure 2. Number of nest boxes used by the Cyprus Coal Tit (Green) and the Great Tit (Brown) in Paphos Forest from 2010 to 2018. The Green and Brown areas include the error bars (black circles) showing the 95% confidence intervals of the regression lines.

Results

During our study, Cyprus Coal Tit and Great Tit bred in the artificial nest boxes over the nine-year period. A total of 253 pairs of tits bred in the nest boxes out of which, 202 were Cyprus Coal Tit, with a mean number of 22.2 breeding pairs per year. A total of 51 Great Tit pairs bred in the nest boxes with a mean number of 5.7 breeding pairs per year.

The number of nest boxes occupied by the Cyprus Coal Tit increased over time indicating a significant positive trend (Estimate = 0.12 occupied nest boxes per year; $p < 0.01$; Figure 2). The highest number of nests was observed in 2017, with 38 occupied nest boxes, reflecting a fivefold increase compared to 8 occupied nest boxes in 2011. Mean temperatures and mean precipitation in February, March and April of each year did not influence occupancy of the nest boxes ($p = 0.07-0.73$). Clutch size was $(6.2 \pm 1.2 [5-9]$ eggs; $N=27$) and brood size $(6.1 \pm 1.2 [3-8]$ young; $N=25$). The number of nest boxes used by Great Tits (4 to 8) remained stable throughout the study period (Estimate = -0.01 occupied nest boxes per year, $p = 0.79$; Figure 2).

Nest composition of the two species was similar although the Cyprus Coal Tits built nearly twice as heavier nests, composed of double the percentage of wool and feathers (60%) compared to Great Tits (33%) (Table 1). Most of the moss and pine needles-grass were used on the outer layer of the nests as structural materials, and the wool and feathers were used to build a nest cup approximately 2 cm thick.

Table 1. Composition and weight of the nesting material in 10 nests of the Cyprus Coal Tit and 10 nests of Great Tit collected from nest boxes in Paphos Forest in 2020.

	Cyprus Coal Tit (<i>Periparus ater cypriones</i>)	Great Tit (<i>Parus major aphrodite</i>)
Moss (average, %)	20	22
Wool-feathers (average, %)	60	33
Pine needles-grass (average, %)	5	7
Other materials (average, %)	15	38
Total weight (g, \pm SD)	38.0 \pm 4	21.0 \pm 6

Discussion

In our study, Cyprus Coal Tits had the highest number of breeding pairs, while use of the nest boxes by the Great Tit remained low. Whereas the Great Tit is common in Cyprus, it prefers to breed in broadleaved wooded areas and urban gardens, especially on low ground and the lower hills, and is less common in montane pine forest (Flint & Stewart, 1992). Therefore, Paphos Forest is not its preferred breeding habitat. Similarly, in Europe the Great Tit is mostly found in open deciduous and mixed forests, edges and clearings in dense forest, urban habitats, cultivations, and orchards (Gosler et al., 2013).

The onset of the breeding season of the Cyprus Coal Tit (last week March to second week April) falls within the range described for the Coal Tit in Europe where the breeding season is from the end of March to late July (del Hoyo et al., 2007). The clutch size of the Cyprus Coal Tit (5-9 eggs) also falls within the range of clutch sizes described for the Coal Tit in Europe (5-13 eggs) (del Hoyo et al., 2007). The average clutch size of the Cyprus Coal Tit (6.2) was low compared to other European localities, e.g., 7.8 eggs in Spain (Sanz et al., 1993), 8.2 in mainland France (Blondel, 1985), 8.6 in Finland (von Haartman, 1969) and 9.3 in Germany (Winkel, 1975), and similar to Corsica (5.8-5.9) (Isenmann, 1982; Blondel, 1985) and Turkey (6.0) (Kiziroğlu, 1982). The brood size of the Cyprus Coal Tit (3-8 young) most closely represents hatching rather than fledging success in other studies (e.g., Blondel, 1985) since the numbers of young per nest were only counted once during the breeding season. Differences among Coal Tit populations in relation to onset of laying, clutch and brood sizes, are known to be influenced by a variety of factors, e.g., mainland vs. island populations (Blondel, 1985), different habitats, altitudes (Blondel et al., 1987; Fidalgo, 1990) and number of clutches (Sanz et al., 1993).

According to del Hoyo et al. (2007), the Coal Tit makes its nest almost entirely of moss, with some animal hair, wool, and feathers while the Great Tit nest consists mostly of plant fibres, grasses, moss, animal hair, wool, and feathers. In our study, both species utilized the same nesting materials but in different proportions. Blue Tits (*Cyanistes caeruleus*), another cavity-nesting species, also use similar nesting material (Tomas et al., 2006). In our study, Cyprus Coal Tit nests consisted mainly of wool and feathers (60% of nest material) with 'other materials' representing 15%, while Great Tit nests were mostly made of other materials (38%) with less wool and feathers (33%). The smaller size of the Cyprus Coal Tit may require a nest with more thermoregulating function, hence the utilization of more wool and feathers (Suarez et al., 2013). Furthermore, the Cyprus Coal Tit built larger nests than the Great Tit, in agreement with Lambrechts et al. (2016).

In conclusion, this is the first systematic study on the breeding biology of the Cyprus Coal Tit. Although the genus *Parus* is well studied, species in southern parts of their distribution tend to be less studied compared to more northern species (Kiziroğlu, 1982). We found no evidence that the species is affected by increasing average temperatures on the island (Department of Meteorology, 2018), although Flint (2019) suggests that its population may be increasing as a result of climate change.

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Disclosure Statement

No potential conflict of interest was reported by the authors.

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