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Research Article

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Parental Care and Nest Properties in the European Roller, *Coracias garrulus*, in a Novel Nesting Site

Gökkuzgunların, *Coracias garrulus*, Alışılmamış Tipteki bir Yuvalama Alanındaki Ebeveyn Bakımı ve Yuva Özellikleri

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ABSTRACT

I investigated parental behavior and nest site occupancy of the European Roller, *Coracias garrulus* in a novel breeding site, 10 cm diameter pipes in retaining walls in 2020–22 in Corum, Turkey. They occupied 6 holes for 12 nesting attempts across three years. Nest height from the ground was 4.7±0.3 m (n = 12). I video-recorded the nest holes during the incubation and nestling periods for 22.9 and 25 hours in total, respectively. Males and females shared incubation and nestling provisioning tasks. Nest attentiveness was 97.9%±0.79. Average feeding rate of nestlings was 10.86±2.15 trips h^{-1}. Feeding rates increased from early (5.94±1.09 h^{-1}) to late (15.8±2.04 h^{-1}) nestling ages, significantly. A literature review of species in the order showed that most species were relatively similar in development times but that little data is available on parental behavior. More studies of parental behavior in this order are needed.

Key Words

Nest attentiveness, feeding rate, nest site, European Roller.

ÖZ

2020-22 yıllarında Çorum'da yürütülen çalışmada, bir istinat duvarında yer alan deliklerde üreyen gökkuzgunların *Coracias garrulus* ebeveyn davranışı ile yuva yeri kullanımı araştırılmıştır. Gökkuzgunlar 6 delikte toplamda 12 kez yuvalanmışlardır. Yuvaların yerden yüksekliği 4.7±0.3 m olarak bulunmuştur. Yuvalar kuluçka döneminde 22.9, yavru döneminde 25 saat kameralar ile izlenmiştir. Dişi ve erkeğin kuluçka ve yavru bakımını birlikte yürüttükleri ve kuluçka döneminde ebeveynlerden birinin zamanın %97.9±0.79'ini yuvada geçirdiği belirlenmiştir. Ortalama yavru besleme oranı 10.86±2.15 sa^{-1} olup, geç üreme sezonunda (15.8±2.04 sa^{-1}) erken üreme sezonuna (5.94±1.09 sa^{-1}) göre artış göstermiştir. Literatür taraması ile bu gruptaki türlerin çoğunun benzer gelişme süresine sahip oldukları ancak ebeveyn davranışları konusunda çok az datanın bulunduğu ve gelecek araştırmalara ihtiyaç olduğu ortaya konulmuştur.

Anahtar Kelimeler

Kuluçka bakımı oranı, yavru besleme oranı, yuva yeri, gökkuzgun.

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INTRODUCTION

Parental care is a type of parental investment which is closely associated with fitness and survival and varies broadly across bird species [1,2,3]. Parental behavior data for species that vary phylogenetically are necessary to provide a better understanding of how parental care behavior has evolved to differ among species. Nest attentiveness (percent time spend incubating) and provisioning rate are two pivotal parental care forms that influence offspring production and to provide quantitative data on them is important for comparative studies [4,5]. At the same time, understanding the kinds of nest sites that can be successfully used is critical for maintaining populations.

European Roller, *Coracias garrulus*, a member of the family Coraciidae, order Coraciiformes, is a secondary cavity-nester. European Rollers use abandoned woodpecker nests and holes on roadside banks [6,7]. They also nest in cavities in adobe and concrete buildings [8,9]. Study of other novel nest sites are lacking, but needed. To have knowledge about how consistently and successfully they can use human-made structures as nest sites might be important to decisions of future management plans.

The use of human-made nest sites might suggest nest sites are limited and rollers would readily use nest-boxes in such areas. Most studies on rollers have been based on nest boxes, since that is an active conservation measure applied in Europe [10,11,12]. Given that European Roller has been subject to long-term nest box programs, it is surprising that parental behavior data for it are scarce [13]. Data on their behavior are needed not only to eventually allow comparisons with other species but also to allow comparisons among populations in different geographic regions. Beside the scientific value of parental behavior data, it might provide a key for finding nesting sites of cryptic bird species, such as cavity-nesters whose nests are not usually accessible.

Here, I describe a novel breeding area and nest site properties of the European Roller using 3-years of field data to contribute to the evaluation of its status. I provide nest attentiveness and feeding rates. Gaining information about how often the nest is visited by the adults in nesting stages might facilitate location of active nest holes [14]. I also reviewed parental behaviors, incubation and nestling period lengths in members of the order Coraciiformes.

MATERIALS and METHODS

Study area and field study

The study area is located near a busy highway in an industrial area where some grasslands and wheat fields exist in Corum, northern Turkey (40° 29’ N - 34° 53’ E). I visited the study area 3 times between early June and early July in 2020, and 11 and 13 times starting late April through early July and late July in 2021 and 2022, res-

Figure 1. Nesting site of the European Rollers in the study area.

pectively. A building with two retaining walls that were built in 2013 using large concrete blocks existed in the study area. The walls were c. 1m wide, 168 and 98 m long, 7.5 m tall at the corner and declining to 1 m to the north and declining to 4 m at the west end. They had c.700 embedded 10 cm diameter plastic pipes which were 1.5 m apart that served as nest sites for rollers. They were oriented west and north (Figure 1).

I considered the pipes that were entered by an individual frequently for at least two observation days during the breeding season to be active nest holes. During the incubation and nestling period two nests were video recorded in 2022. I put the cameras with tripods 20 m away from the nest site in the early morning (5:30-6:00 a.m.) and recorded the nest entrances for about 3 hours ranging 2.7–3.4 h. I watched the videos and noted the time of every nest visit and any switching or feeding behavior.

Statistics

I present mean values with standard error and sample sizes. Nest attentiveness (percent time incubating) was calculated by taking the time than one mate spent inside the nest hole divided by the duration of video-recording and multiplied by 100. Feeding rate, the number of the nest visits per hour, was calculated for early and late nestling periods. I assumed early nestling period if the parents brooded (stayed in the nest to warm young), otherwise it was considered the late nestling period. I tested if feeding rate differed between early and late nestling periods using a Mann-Whitney U test. I considered $P < 0.05$ to be statistically significant. All the analyses were conducted in R [15].

Literature data

I searched the literature to gather incubation behavior data for 68 species from 5 families of the order Coraciiformes that included the European Roller [16]. Kingfishers, (Alcenidae) were not included because of their far different foraging ecology from rollers and other members of the order. I searched online for scientific and common names of the species using the Web of Science database (https://clarivate.com), Birds of the World (https://birdsoftheworld.org) and Google Scholar (https://scholar.google.com). I summarize incubation periods, sex or sexes responsible for incubation duty. I also report nestling periods of the species. I did not include data gathered in captivity conditions.

Figure 2. A European Roller nestling in the nest hole just before it fledged.

RESULTS

The pairs showed up in the breeding site in late April and early May. I located 5, 4 and 3 active nests in 2020, 2021 and 2022, respectively. Two nest holes were occupied for three years while one nest was occupied two consecutive years and one was used two years with a year break. Nests were at an average height of 4.7±0.3 m (range = 3–6.15, n =12 total nesting attempts) from the ground. The average distance between the two closest nests in each breeding season was 14.4±1.6 m (range = 11.2–16 m, n = 3 years). The nest holes were usually protected from conspecifics and some other species such as Eurasian Magpie, *Pica pica* and Little Owl, *Athene noctua* aggressively by the pairs. However, parents sometimes did not defend nests from conspecifics. Moreover, in the late breeding season (early July), 4–6 individuals were seen perching on power lines next to each other several times.

In 2022, an individual was observed carrying food to its mate that was in a nest hole, but they did not stay in this nest hole more than 5 min after that day. They apparently failed in the early breeding season. Although they did not have a replacement brood, the nest hole and some other neighboring holes were checked regularly during the entire breeding season by a pair assumed to be the same ones that failed. In the same year, I observed a nestling fledged from the second nest on August 1 (Figure 2). I did not visit the breeding site within probable fledging time for the third nest but it was active for a minimum of 15 days in the nestling stage. In the other two years I did not monitor the nests long enough to see the fates of the nests.

I recorded parental behavior at two nests for 22.9 hours during the incubation period. Both parents incubated: I recorded 6 confirmed incubation duty switches between parents. In these cases, one of the mates switched with the other one at the entrance of the nest holes and stayed in the hole for a minimum of 22 minutes. Average recorded time in which an individual stayed in the nest following a duty switch was 51.3±14.7 min (n = 3). I did not have the exact end of the time that an individual stayed in the nest following a duty switch in the other three video recordings because the video ended before they switched. Based on these recordings they stayed in the hole at least 28, 50 and 60 minutes. Beyond these verified duty exchanges, pairs might have switched inside the hole: one parent visited the nest 9 times while the other one was incubating.

Nest attentiveness was 97.9±0.79% (n = 7 video recordings with an average duration of 3.27±0.1 h). Feeding rates were 5.94±1.09 h^{-1} (n = 4 video recordings with an average duration of 3.19±0.2 h) and 15.8±2.04 h^{-1} (n = 4 video recordings with an average duration of 3.06±0.03 h) during early and late nestling periods, respectively (Figure 3). These feeding rates differed between early and late nestling stages (Mann Whitney U Test, W = 0, P = 0.03). Average feeding rate was 10.86±2.15 h^{-1}(n = 8 video recordings with the average duration of 3.12±0.1 h).

Most species from Coraciiformes had around 3 weeks (17 – 24 d) for the incubation period, although a couple of species had longer periods. In addition, most species in the order had 25–30 days for the nestling period. European Rollers were similar to the other members of the order. Both sexes participated in incubation duty in most species but only females incubated in three of five Ground Roller species for which data existed (Table 1). Attentiveness data was available for only one species in its natural breeding habitat, the Short-legged Ground-Roller and attentiveness was lower (81%) than in the case of rollers at my site [17].

DISCUSSION

Turkey hosts a considerable part of the decreasing world population of the European Rollers [18]. This species usually nests in sandstone burrows solitarily and in small groups across the country [19,9,20,21]. However, the following spring after the retaining walls had been constructed, one European Roller pair was reported in my study site suggesting that potential nesting sites were noticed by rollers very quickly [9]. Moreover, I observed one pair in my study area in 2022 that nested in a hole in an abandoned White Stork, *Ciconia ciconia* nest, which has also been reported from Spain [22]. Another unusual nest site, old magpie nests have been documented in Corum [9]. Novel nest sites and newly existing cavities were occupied across years despite some possible disturbance (the name of the building was written using huge solid letters on the wall and two lights were placed to illuminate them at night before the 2021 breeding season). The use of these nest sites despite disturbance might reflect a shortage of available nest sites in their nearby traditional breeding area [11,9]. Further researches on reproductive success in “recently appeared” nesting sites and human made structures are necessary to contribute to the existing

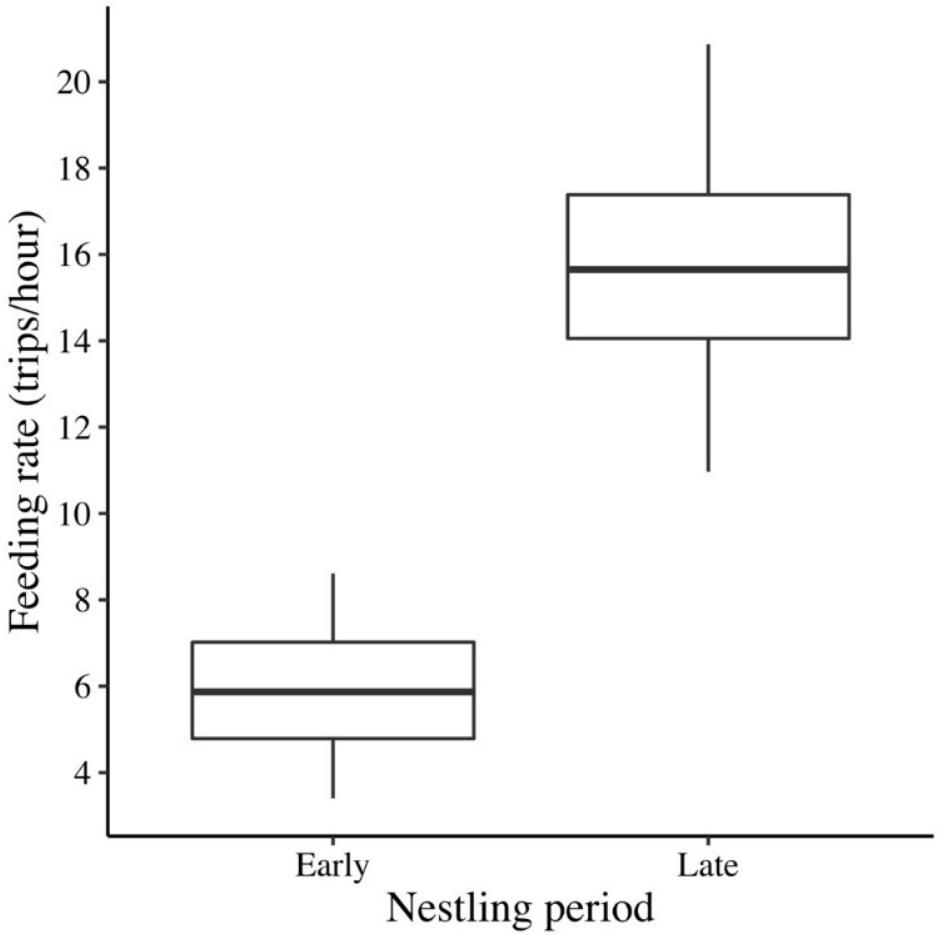

Figure 3. Feeding rates in early and late nestling stage in the European Roller.

knowledge of the population status of the European Roller in this region.

Average nest height was similar to some natural breeding habitats where abandoned Green Woodpecker, *Picus viridis* nests were occupied by rollers [23,24]. Nest height above the ground affects nest site selection in nest box and natural populations [24,11] in the European Rollers. Bouvier et al. (2014) argued that they prefer to nest in holes lower than 6 m height. In my study, eleven of twelve nesting sites were in the upper line of holes on the walls suggesting that they preferred to breed in higher available holes. However, they sometimes use cavities higher than 10 m [9]. Their fidelity to their breeding grounds and reuse of nest holes [25, this study] may indicate high quality sites with good reproductive success [26,27].

Incubation duty was shared by both parents. It has been suggested that incubation is carried out mainly by females [28]. However, I did not have any signs that one mate took a greater part of the incubation duty during day hours. Further studies are needed to understand the role of mates in parental behavior in the European Rollers.

Variation in nest attentiveness across species is explained by numerous factors such as nest site, nest insulation capacity, latitude, nest predation risk, adult survival probability and body mass [29,30,5,31,32]. It is highest in species in which both males and females share incubation [33,30,31]. Nonetheless, nest attentiveness in the European Roller was higher in comparison to most other bird species with altricial young, even when considering species that share incubation [29,34,31,32]. Higher attentiveness might be associated with its lar-

ger size and shared incubation by males and females. As a small example, attentiveness was higher than the related Short-legged Ground-Roller, *Brachypteracias leptosomus* that has female-only incubation [17]. Still, the reasons for the extremely high nest attentiveness deserve more attention.

Both parents fed the nestlings, as is common in many species with altricial young [35]. Average feeding rate was similar to the provisioning rate for c. one-week-old nestlings in a nest-box population [13]. Furthermore, I showed that feeding rate was higher in the late than early nestling period (Figure 3). Feeding rate usually increases with nestling age [36,37,38 but see 39,40] due to increasing energy needs of developing young and rollers exhibit this common trend with nestling age.

Parental behavior and development time of the eggs and nestlings in Coraciiformes have not been well-documented. Incubation and nestling periods were provided in ranges rather than mean values in the literature (Table 1). Eggs are usually laid in two days intervals and nestlings in a brood hatch and fledge on different days [41,42,14]. Such asynchronous hatching is often associated with some loss of the latest hatched young [43]. The paucity of accurate developmental time might be due to the difficulty of daily nest checks that is necessary to detect exact hatching and fledging days. Complex breeding system with helpers in Bee-eaters might lead to further difficulty of collecting robust life history data [42]. Ultimately, however, much more study is needed of parental behavior associated with development and associated development time as possible influences on fledgling quality and survival [44,45].

In conclusion, the European Rollers show high nest attentiveness in the incubation period and increase provisioning rate over nestling period. They discover and use recently appeared holes and cavities for nesting, which suggests that nest box installation in this region might be an efficient part of an action plan to facilitate population in the future.

Table 1. Development periods and incubation behavior data for species from Coraciiformes.

		Incubation period (day)	Nestling period (day)	Incubation Duty	Reference
Rollers	Coraciidae				
European Roller	*Coracias garrulus*	17-19	Mostly 26–27 (25–30)	Both sexes	[46]
Indian Roller	*Coracias benghalensis*	17–20	No data	Both sexes (Mainly female)	[47]
Lilac-breasted roller	*Coracias caudatus*	22–24	35	Both sexes	[48]
Ground Rollers	Brachypteraciidae				
Short-legged Ground-Roller	*Brachypteracias leptosomus*	22–26	No data	Female	[17]
Scaly Ground-Roller	*Geobiastes squamiger*	18	24	Female	[49]
Pitta-like Ground-Roller	*Atelornis pittoides*	No data	No data	Female	[50]
Todies	Todidae				
Cuban Tody	*Todus multicolor*	No data	No data	Both sexes	[51]
Motmots	Momotidae				
Blue-throated Motmot	*Aspatha gularis*	21–22	29–31	Both sexes	[52]
Russet-crowned Motmot	*Momotus mexicanus*	20	33.7	No data	[53]

Table 1. Development periods and incubation behavior data for species from Coraciiformes. Continue

		Incubation period (day)	Nestling period (day)	Incubation Duty	Reference
Blue-capped Motmot	*Momotus lessonii*	c. 3 weeks	29–32	Both sexes	[54]
Rufous Motmot	*Baryphthengus martii*	No data	No data	Both sexes	[55]
Broad-billed Motmot	*Electron platyrhynchum*	No data	24–25	Both sexes	[55]
Turquoise-browed Motmot	*Eumomota superciliosa*	18–20	27.16	No data	[56]
Bee-eaters	Meropidae				
Red-bearded Bee-eater	*Nyctyornis amictus*	31–34	No data	Both sexes	[57]
Black-headed Bee-eater	*Merops breweri*	No data	No data	Female	[58]
Little Bee-eater	*Merops pusillus*	18–20	23–24	Both sexes (Mainly female)	[59]
Cinnamon-chested Bee-eater	*Merops oreobates*	No data	25 or more	Both sexes (Mainly female)	[60]
Red-throated Bee-eater	*Merops bulocki*	19–21	c. 28	Pairs and helpers (Mainly female)	[61]
African Green Bee-eater	*Merops viridissimus*	No data	No data	Both sexes (Mainly female)	[62]
Asian Green Bea-eater	*Merops orientalis*	14.4±1.01	26–28	Both sexes	[63]
Blue-cheeked Bee-eater	*Merops persicus*	23–26	c. 30	Both sexes	[64]
Blue-tailed Bee-eater	*Merops philippinus*	19–21 65	29–33 66	Both sexes 66	[65,66]
Rainbow Bee-eater	*Merops ornatus*	24.4±2.2 (22–31)	28.8±3.3 (24–36)	Pairs and helpers	[67]
Blue-throated Bee-eater	*Merops viridis*	22.5 (13–26)	mostly 30–31 (26–40)	Both sexes	[68]
Chestnut-breasted Bee-eater	*Merops leschenaulti*	c. 30	No data	Both sexes	[69]
European Bee-eater	*Merops apiaster*	19-22	30-33	Both sexes	[70]

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References

1. D. Lack, The significance of clutch-size. Ibis, 89 (1947) 302-352.
2. R.L. Trivers, Parent-offspring conflict. American Zoologist, 14 (1974) 249-264.
3. P.T. Smiseth, M. Kölliker, N.J. Royle, What is parental care? In: Royle NJ, Smiseth T, Kölliker M, editors. The Evolution of Parental Care. Oxford University Press Oxford, UK, 1-17, 2012.
4. T.E. Martin, Age-related mortality explains life history strategies of tropical and temperate songbirds. Science, 349 (2015) 966-970.
5. T.E. Martin, J.C. Oteyza, A.J. Boyce, P. Lloyd, R. Ton, Adult mortality probability and nest predation rates explain parental effort in warming eggs with consequences for embryonic development time. The Am. Nat.,186 (2015) 223-236.
6. L.P. Sack, M. Tiefenbach, W. Ilzer, J. Preiler, B. Wieser, Monitoring the Austrian relict population of European Roller *Coracias garrulus* – A review of preliminary data and conservation implications. Acrocephalus, 25 (2004) 51-57.
7. D. Pomeroy, F. Walsh, C. Richardson, Documenting status of the European roller *Coracias garrulus* in western Cyprus. Sandgrouse, 35 (2013): 2024.
8. I. Catry, P. S. Silva, A. Cardoso, A. Martins, A. Deldago, A. R. Sanches, A. Santos, B. Estanque, C. M. Cruz, C. Pacheco et al., Distribution and population trends of the European Roller in pseudo-steppe areas of Portugal : results from a census in sixteen SPAs and IBAs. Airo, 21 (2011) 3-14.
9. N. Şahin Arslan, G. Arslan Akveran, Habitat and nest site selection of the European Rollers in the northern Anatolia. KSU. J. Agric. Nat., 22 (2019) 794-798.
10. J.M. Avilés, J.M. Sánchez, A. Sánchez, D. Parejo, Breeding biology of the Roller *Coracias garrulus* in farming areas of the southwest Iberian Peninsula. Bird Study, 46 (1999) 217-223.
11. O. Kiss, B. Tokody, T. Ludnai, C. Moskát, The effectiveness of nest-box supplementation for the conservation of European Rollers (*Coracias garrulus).*Acta Zool. Acad. Sci. Hung., 63 (2017) 123-135.
12. F. Monti, L. Nelli, C. Catoni, G. Dell'Omo, Nest box selection and reproduction of European Rollers in central Italy: a 7-year study. Avian Research, 10 (2019) 13.
13. J. M. Avilés, D. Parejo, J. Rodríguez, Parental favouritism strategies in the asynchronously hatching European Roller (*Coracias garrulus*). Behav. Ecol. Sociobiol., 65 (2011): 1549-1557.
14. T.E. Martin, G.R. Geupel, Nest-monitoring plots: methods for locating nests and monitoring success. J. Field Ornithol., 64 (1993) 507-519.
15. R Core Team R, A language and environment for statistical computing, R Foundation for Statistical Computing, Vienna, Austria, 2022. https://www.r-project.org/.
16. F. Gill, D. Donsker, P. Rasmussen (editors), IOC World Bird List, Version 13.1, 2023.
17. R. Thorstrom, J. Lind, First nest description, breeding, ranging and foraging behaviour of the Short-legged Ground-Roller *Brachypteracias leptosomus* in Madagascar. Ibis, 141 (1999) 569-576.
18. BirdLife International), Species factsheet: *Coracias garrulus* [online], http://www.birdlife.org [accessed 23 April 2023].
19. G. Kirwan, B. Demirci, H. Welch, K. Boyla, M. Özen et al., The Birds of Turkey, 1st ed. Christopher Helm Publishers, London, UK, 2008.
20. K.A. Boyla, L. Sınav, D.E. Dizdaroğlu, Türkiye Üreyen Kuş Atlası, WWF-Türkiye, Istanbul, 2019.
21. H. Karaardıç, E. Kızılkaya, Sand banks in pseudo-steppe areas provide suitable nesting sites: High breeding numbers of the European Roller (*Coracias garrulus* L. 1758) in southwest Turkey. Acta Biologica Turcica, 34 (2021) 205-210.
22. J.M. Avilés, E. Costillo, A roller (*Coracias garrulus*) presumably nesting in a White Stork (*Ciconia ciconia*) nest. Butll. GCA., 14 (1997) 47-49.
23. S.J. Butler, Nest-site selection by the European Roller (*Coracias garrulus*) in southern France, MSc Thesis, University of York, York, UK, 2001.
24. J.C. Bouvier, I. Muller, M. Génard, F. Lescourret, C. Lavigne, Nest-site and landscape characteristics affect the distribution of breeding pairs of European Rollers *Coracias garullus* in an agricultural area of southeastern France. Acta Ornithol., 49 (2014) 23-32.
25. R. Václav, F. Valera, T. Martínez, Social information in nest colonisation and occupancy in a long-lived, solitary breeding bird. Oecologia, 165 (2011) 617-627.
26. K. Aitken, K. Wiebe, A. Martin, Nest-site reuse patterns for a cavity-nesting bird community in interior British Columbia. The Auk, 119 (2002) 391-402.
27. T. Wesołowski, Nest-site re-use: Marsh Tit *Poecile palustris* decisions in a primeval forest. Bird Study, 53 (2006) 199-204.
28. H. Fry, E. de Juana, P.F.D. Boesman, Red-bearded Bee-eater (*Nyctyornis amictus*), In: del Hoyo J, Elliott A, Sargatal J, Christie DA, de Juana E, editors. Birds of the World, Version 1.0., Cornell Lab of Ornithology, New York, USA, 2020.
29. A.D Chalfoun, T.E. Martin, Latitudinal variation in avian incubation attentiveness and a test of the food limitation hypothesis. Anim. Behav., 73 (2007) 579-585.
30. T.E. Martin, S.K. Auer, R.D. Bassar, A.M. Niklison, P. Lloyd, Geographic variation in avian incubation periods and parental influences on embryonic temperature. Evolution, 61 (2007) 2558-2569.
31. B. Matysiokova, V. Remeš, The importance of having a partner: male help releases females from time limitation during incubation in birds. Front. Zool., 11 (2014) 24.
32. D.C. Deeming, L.A. Gray, Incubation attentiveness and nest insulatory values correlate in songbirds. Avian Biol. Res., 9 (2016) 32-36.
33. D.C. Deeming (editor), Avian Incubation : Behaviour, Environment, and Evolution, 1st ed., Oxford University Press, Oxford, UK, 2002.
34. S.K. Auer, R.D. Bassar, J.J. Fontaine, T.E. Martin, Breeding biology of passerines in a subtropical montane forest in Northwestern Argentina. The Condor, 109 (2007) 321-333.
35. A.P. Møller, Male parental care, female reproductive success, and extrapair paternity. Behav. Ecol., 11 (2000) 161-168.
36. D. Muñoz, T.E. Martin, Breeding biology of the Spotted Barbtail (*Premnoplex brunnescens*). Wilson J. Ornithol., 126 (2014): 717-727.

37. A.E. Mitchell, F. Tuh, T.E. Martin, Breeding biology of an endemic Bornean turdid (*Chlamydochaera jefferyi*), and life history comparisons with turdid species of the world. Wilson J. Ornithol., 129 (2007) 36-45.
38. N. Şahin Arslan, T.E. Martin, Reproductive biology of Grey-breasted Wood-Wren (*Henicorhina leucophrys*): a comparative study of tropical and temperate wrens. Wilson J. Ornithol., 131(2019) 1-11.
39. E.C. Zarri, T.E. Martin, A comparison of the breeding biology of the Bornean Whistling-Thrush (*Myophonus borneensis*) and White-crowned Forktail (*Enicurus leschenaulti borneensis*). J. Field Ornithol., 93 (2022) 3.
40. N. Şahin Arslan, D. Muñoz, T.E. Martin, Reproductive biology of the Whitehead's Broadbill (*Calyptomena whiteheadi*). Emu, 123 (2023) 152-160.
41. D.W. Winkler, S.M. Billerman, I.J. Lovette, Rollers (Coraciidae), In: Billerman SM, Keeney BK, Rodewald PG, Schulenberg TS, editors. Birds of the World, Version 1.0, Cornell Lab of Ornithology, New York, USA, 2020.
42. D.W. Winkler, S.M. Billerman, I.J. Lovette, Bee-eaters (Meropidae), Billerman SM, Keeney BK, Rodewald PG, Schulenberg TS, editors. Birds of the World, Version 1.0, Cornell Lab of Ornithology, New York, USA, 2020.
43. R. Ostreiher, Food division in the Arabian Babbler nest: adult choice or nestling competition? Behav. Ecol., 8 (1997) 233-238.
44. T.E. Martin, A.J. Boyce, K. Fierro-Calderón, A.E. Mitchell, C.E. Armstad et al., Enclosed nests may provide greater thermal than nest predation benefits compared with open nests across latitudes. Funct. Ecol., 31 (2017) 1231-1240.
45. D Sol, S. Olkowicz, F. Sayol, M. Kocourek, Y. Zhang et al., Neuron numbers link innovativeness with both absolute and relative brain size in birds. Nat. Ecol. Evol., 6 (2022) 1381-1389.
46. H. Fry, P.F.D. Boesman, G.M. Kirwan, C.J. Sharpe, European Roller (*Coracias garrulus*), In: del Hoyo J, Elliott A, Sargatal J, Christie DA, de Juana E, editors. Birds of the World, Version 1.0, Cornell Lab of Ornithology, New York, USA, 2020.
47. S. Asokan, A. Mohamed Samsoor Ali, . Manikannan, Preliminary Investigations on diet and breeding biology of the Indian Roller *Coracias benghalensis* in a portion of Cauvery Delta, Tamil Nadu, India. WJZ, 4 (2009) 263-269.
48. H. Fry, G.M. Kirwan, P.F.D. Boesman, Lilac-breasted Roller (*Coracias caudatus*), In: del Hoyo J, Elliott A, Sargatal J, Christie DA, de Juana E, editors. Birds of the World, Version 1.1, Cornell Lab of Ornithology, New York, USA, 2021.
49. J.E. Rakotoarisoa, B. Be, Breeding and foraging behaviour and habitat characteristics of the Scaly Ground-roller Geobiastes squamigerus in Madagascar. Ostrich, 75 (2004) 25-31.
50. O. Langrand, G.M. Kirwan, Pitta-like Ground-Roller (*Atelornis pittoides*), In: del Hoyo J, Elliott A, Sargatal J, Christie DA, de Juana E, editors. Birds of the World, Version 1.0, Cornell Lab of Ornithology, New York, USA, 2020.
51. A. Farnsworth, Cuban Tody (*Todus multicolor*). In: Schulenberg TS, editor. Birds of the World, Version 1.0, Cornell Lab of Ornithology, New York, USA, 2020.
52. A.F. Skutch, Life history of the Blue-throated Green Motmot. The Auk, 62 (1945) 489-517.
53. T.G. Murphy, V.G. Rohwer, E. Scholes, Breeding biology and longevity of Russet-crowned Motmots in central Mexico. J. Field Ornithol., 81 (2010) 13-16.
54. A.F. Skutch, Life history of Blue-diademed Motmot *Momotus momota*. Ibis, 106 (1964) 321-332.
55. A.F. Skutch, Life history of the Broad-billed Motmot, with notes on the Rufous Motmot. The Wilson Bulletin, 83 (1971) 74-94.
56. P.E. Scott, R.F. Martin, Reproduction of the Turquoise-browed Motmot at archaeological ruins in Yucatan. Biotropica 15 (1983) 8-14.
57. H. Fry, E. de Juana, P. F. D. Boesman, Red-bearded Bee-eater (*Nyctyornis amictus*), In: del Hoyo J, Elliott A, Sargatal J, Christie DA, de Juana E, editors. Birds of the World, Version 1.0, Cornell Lab of Ornithology, New York, USA, 2020.
58. H. Fry, G.M. Kirwan, Black-headed Bee-eater (*Merops breweri*), In: del Hoyo J, Elliott A, Sargatal J, Christie DA, de Juana E, editors. Birds of the World, Version 1.0, Cornell Lab of Ornithology, New York, USA, 2020.
59. H. Fry, P.F.D. Boesman, Little Bee-eater (*Merops pusillus*), In: del Hoyo J, Elliott A, Sargatal J, Christie DA, de Juana E, editors. Birds of the World, Version 1.1, Cornell Lab of Ornithology, New York, USA, 2021.
60. H. Fry, P.F.D. Boesman, Cinnamon-chested Bee-eater (*Merops oreobates*), In: del Hoyo J, Elliott A, Sargatal J, Christie DA, de Juana E, editors. Birds of the World, Version 1.0, Cornell Lab of Ornithology, New York, USA, 2020.
61. H. Fry, P.F.D. Boesman, Red-throated Bee-eater (*Merops bulocki*), In: del Hoyo J, Elliott A, Sargatal J, Christie DA, de Juana E, editors. Birds of the World, Version 1.0, Cornell Lab of Ornithology, New York, USA, 2020.
62. G.M. Kirwan, H. Fry, P.F.D. Boesman, African Green Bee-eater (*Merops viridissimus*), In: Kirwan GM, editor. Birds of the World, Version 1.0, Cornell Lab of Ornithology, New York, USA, 2022.
63. S. Asokan, A. Mohamed Samsoor Ali, R. Manikannan, Breeding biology of the Small Bee-eater *Merops orientalis* (Latham, 1801) in Nagapattinam District, Tamil Nadu, India. J. Threat. Taxa, 2 (2010) 797-804.
64. G.M. Kirwan, H. Fry, P.F.D. Boesman, Blue-cheeked Bee-eater (*Merops persicus*), In: del Hoyo J, Elliott A, Sargatal J, Christie DA, de Juana E, editors. Birds of the World, Version 1.0, Cornell Lab of Ornithology, New York, USA, 2020.
65. D.B. Burt, Social and breeding biology of Bee-eaters in Thailand. The Wilson Bulletin, 114 (2002) 275-279.
66. Z. Wu, L. Han, Z. Kuang, Breeding behaviors of Blue Tailed Bee-eater of Nujiang Valley. Zool. Res., 30 (2009) 429-432 (in Chinese with an abstract in English).
67. C.R.J. Boland, Breeding biology of Rainbow Bee-eaters (*Merops ornatus*): a migratory, colonial, cooperative bird. The Auk, 121 (2004) 811-823.
68. L.D. Stader, Breeding behaviour of a tropical bird: a study of the Blue-throated Bee-eater (*Merops viridis*) using a relational database and DNA fingerprinting. PhD Thesis, University of Stirling, Stirling, UK, 1994.
69. N.K.M. Huda, Some observations on the nesting activities of Chestnut-headed *Merops leschenaulti* and Green Bee-eaters *M. orientalis* in Chittagong, Bangladesh. Forktail, 12 (1997) 155-156.
70. H.V. Bastian, A. Bastian, European Bee-eater (*Merops apiaster*), In: Billerman SM, Keeney BK, editors. Birds of the World, Version 2.0, Cornell Lab of Ornithology, New York, USA, 2022.