

ROCKY NESTS ARE BETTER NESTING SITES THAN WOODPECKER CAVITIES FOR THE EASTERN ROCK NUTHATCH *SITTA TEPHRONOTA*

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The reproductive success of birds depends on many factors, including nest construction and placement. In the mountainous regions of southwestern Iran, broods of Eastern Rock Nuthatch *Sitta tephronota* were surveyed in 2016 and 2017. During the study, 11 broods in rocky cavities and 16 in abandoned Syrian woodpeckers' *Dendrocopos syriacus* tree cavities were compared in terms of breeding performance (phenology, clutch size, hatching success, number of fledglings, breeding success). The Eastern Rock Nuthatch began egg-laying on March 24 and continued until April 15. The number of eggs in the clutch ranged from 3 and 7 (mean 5.6 ± 1.19 , median 6, $N = 27$). The two types of clutches compared usually contained 6 eggs, and the number of nestlings was statistically lower in tree cavities than in rocky nests. Hatching success was almost 30% higher in rocky nests than in tree cavities. In broods located in trees, 4 nestlings hatched most often (42%, $N = 12$), and in rock nests, 5 nestlings hatched (50%, $N = 10$). Rocky nests were also statistically greater (by over 40%) for breeding success. For all analysed broods and broods with success, roughly two extra fledglings left the rocky nests compared with tree cavities. 5 fledglings (50%, $N = 10$) most often left rocky nests, whereas, in general, 4 fledglings (50%, $N = 10$) left tree nests. Research results did not confirm that woodpecker cavities are safe nest sites for cavity dwellers.

Key words: brood size, reproductive success, secondary cavity nesters, mountains, rocky habitats, natural forests.

INTRODUCTION

Many factors influence bird reproductive parameters (MONAGHAN & NAGER 1997, MAINWARING & HARTLEY 2013). One of the main factors influencing breeding success is food availability during the nestling feeding period (LACK 1950), which determines, among other things, brood size as well as the start of the breeding season (GARCÍA-NAVAS & SANZ 2011, WESOŁOWSKI *et al.* 2019, 2021, WAWRZYŃIAK *et al.* 2020). Bird reproduction parameters may also depend on the habitat type in breeding places (WAWRZYŃIAK *et al.* 2020). Nest parameters can also significantly affect the reproductive success (MARTIN & LI 1992, WESOŁOWSKI & TOMIAŁOJCZAK 2005). The location of the nest should also protect the broods against rainfall, and excessive humidity, which may weak-

en the nestlings' condition (WIEBE 2001, KULASZEWICZ & JAKUBAS 2018, SCHÖLL & HILLE 2020), or even if the nest is filled with water (WESOŁOWSKI & STAWARCZYK 1991, WESOŁOWSKI & ROWIŃSKI 2004).

Proper nest camouflage may also reduce the degree of brood losses by predators (EGGERS *et al.* 2006, ZIELIŃSKI 2011). Tree cavities provide relatively secure protection for broods (MARTIN & LI 1992, WESOŁOWSKI & TOMIAŁOJC 2005). Many species use naturally formed cavities in trees (WESOŁOWSKI & ROWIŃSKI 2004, MAZIARZ *et al.* 2016), but birds can also excavate the nests, e.g., by primary cavity nesters, such as woodpeckers Picidae (WINKLER *et al.* 1995, WINKLER & CHRISTIE 2002). Woodpeckers' cavities can be adopted for breeding by secondary cavity nesters; i.e., those that do not excavate cavities but use only the resources available in the environment (WESOŁOWSKI 1989, WESOŁOWSKI & ROWIŃSKI 2004, MAZIARZ *et al.* 2015). Woodpeckers' cavities are also a fundamental nest placement for Nuthatches Sittidae (HARRAP 1996, MATTHYSEN 1998, CRAMP & SNOW 2000, PASQUED *et al.* 2014). Over 20 species, mainly in Eurasia and North America, commonly use a wide variety of tree cavities (PRAVOSUDOV 1993, WESOŁOWSKI 1989, WESOŁOWSKI & STAWARCZYK 1991, HARRAP 1996, MATTHYSEN 1998, CRAMP & SNOW 2000, WESOŁOWSKI & ROWIŃSKI 2004), in addition, nest boxes or are able to excavate cavities by themselves (LÖHRL 1987, MATTHYSEN 1998, ALBAYRAK & ERDOĞAN 2005, MAÍCAS *et al.* 2012). Some species, such as the Western Rock Nuthatch *Sitta neumayer* and Eastern Rock Nuthatch *Sitta tephronota*, also build nests in rock gaps and cliffs (HARRAP 1996, MATTHYSEN 1998, CRAMP & SNOW 2000, SHAFAEIPOUR *et al.* 2020).

However, conclusions about the biology and ecology of individual cavity nester species, drawn from the studies carried out in nest boxes, can be misleading (e.g., ROBERTSON & RENDELL 1990, MØLLER *et al.* 2014). Therefore, it is important to distinguish the factors determining the birds' reproduction in natural habitats with differing nesting sites and various nest parameters. This allows for a better understanding of the birds' nesting strategies.

The aims of this study are 1) to compare breeding performance between two types of nests (i.e. rocky vs. tree nests), 2) to compare breeding performance between different years in pooled nests and 3) to reveal breeding performance in total in pooled nests. During the study, the reproductive biology of the breeding pairs in abandoned Syrian woodpecker *Dendrocopos syriacus* cavities and old nests located on rocky shelves was assessed. It was assumed that the tree cavities adopted by the Eastern Rock Nuthatch for nesting could negatively influence the reproductive bird parameters in comparison to broods located in nests constructed by the birds themselves (e.g., ROBERTSON & RENDELL 1990, MØLLER *et al.* 2014). This could be due to certain constructional limitations, e.g., the dimension of the nesting chamber. Unfortunately, there is no accurate data regarding the breeding of this species in Iran, and

the results of this study could help to unravel the ambiguous aspects of the breeding ecology of this bird. Such knowledge is crucial for guiding habitat management and conservation efforts.

MATERIAL AND METHODS

Target species

The Eastern Rock Nuthatch occurs mostly in the mountainous regions of Iran and in wider regions such as southwestern Asia e.g., Afghanistan, Turkmenistan, Turkey and Pakistan (SCOTT *et al.* 1975, CRAMP & SNOW 2000). This species situates its nests below the rocks, rarely into the gap of rocks and sporadically in walls of bridges or buildings located in human settlements (SHAFAEIPOUR *et al.* 2020). The semi-ball-shaped nest of the Eastern Rock Nuthatch is constructed from soil mixed with mud, and the apex reveals a vertical circular entrance. In the semi-open forest habitats, the Eastern Rock Nuthatch takes over old disused holes of woodpeckers. When adopting this type of nest site, the birds reduce the cavity entrance size with mud (e.g., see SHAFAEIPOUR *et al.* 2020).

Study area

The study area (400 hectares) is situated at c.a. 2200 m above sea level, south of the city of Yasuj in Southwestern Iran (31° 31' N, 51° 09' E) (SHAFAEIPOUR *et al.* 2020). The climate in this region is cold, with an average annual temperature of 14 °C (with minimum temperature noted in December -7.4 °C and maximum temperature noted in August 36.4 °C), and the average annual rainfall is 817 mm (I.R. of Iran Meteorological organisation). It is a rocky region devoid of dense built-up areas, with poor vegetation and is generally represented as a natural cold-forest mountain habitat. The open forests and shrubs include various tree species such as Narrow-leaved Ash *Fraxinus angustifolia*, Mount Honeysuckle *Lonicera nummularifolia*, Wild Pears *Pyrus glabra*, Mount Atlas Mastic Tree *Pistacia atlantica*, and Dotted Hawthorn *Crataegus punctata*. Although rarely, at lower elevations, the Persian Oak has also been noted *Quercus brantii* var. *persica* (SHAFAEIPOUR *et al.* 2020).

Nest searching method

The research was conducted from late March and the end of May in 2016 and 2017, respectively. Nest searching in the study area was repeated (at least 8 times per season) by 2–4 people on foot using parallel transects (length and width of transects was 40–50 m per 2–2.5 km).

Many appropriate nesting sites (e.g., rock shelves and gaps, or old woodpecker cavities located in trees) were investigated during the field works. New nests were searched by direct observation of birds carrying nest material. On numerous occasions, we found that birds in the visited nests contained broods. Due to impassable cliff faces in the study area, it was impossible to get direct access to three nests located in rocks. For this reason, these nests were inspected using ladders and tripods. In addition, nests located in woodpeckers' cavities excavated in trees were examined in the study. All tree nests were old nests of the Syrian Woodpecker (SHAFAEIPOUR *et al.* 2020).

Assessment of breeding parameters

The nest contents were checked using a Borescope (Extech BR300) every 2–3 days. The survey of the breeding performance included the following details: date of first and last eggs laid, clutch size, hatching date, hatching success, number of hatched nestlings in successful nests, number of hatched nestlings in all searched nests, number of fledglings in successful nests, number of fledglings in failed broods, date of flight of the first nestling in brood, and the nesting success of each nest. The duration of specific breeding stages was compared with the number of days from March 1 to the day on which the next breeding stage began (egg laying or fledging). One day was added during 2016, as it was a leap year (see Table 1). Dates of specific breeding stages were set relative to the medians calculated for the breeding stages in a particular breeding season. Based on direct observations of nests and traces and remnants of birds or eggs left in or near the nest cavity, the degree of nest loss (because of, e.g., nest predation by snakes), was assessed. Nesting success was calculated as the ratio of the number of nests with at least one fledged young to the number of nests in which eggs were found. Hatching success was calculated as the percentage share of all monitored eggs from which nestlings hatched, and breeding success was considered to be the percentage of all monitored eggs that resulted in fledged young. After the nestlings had fledged, the nests were examined to detect whether they contained any eggs or dead chicks. In addition, one brood (in which egg-laying began on May 3, 2016) was excluded from the analysis because it was probably a repeated brood after the loss of the nest.

Data handling and statistical analysis

The first aim was to determine whether there are differences in brood parameters between the breeding seasons. To this end, depending on the location, all Eastern Rock Nuthatch broods were divided into two groups. The first group comprised broods located in abandoned Syrian Woodpecker cavities excavated in trees (hereafter called tree broods – TB). The woodpeckers' old cavities were adopted by the Eastern Rock Nuthatch. For this purpose, cavity entrances were fortified by Eastern Rock Nuthatches with soil mixed with mud and plant material. The second group comprised muddy old nests built by Eastern Rock Nuthatches themselves or other Eastern Rock Nuthatches in previous years in rock gaps and other rocky sites located in cliffs and rocky shelves (hereafter called rocky broods – RB). These nests have a semi-ball shape and are built by birds the same way – from soil mixed with mud, but at the apex they include a vertical circular entrance (SHAFAEIPOUR *et al.* 2020). Finally, these two separated groups (16 TBs and 11 RBs) were compared at the next phase of the study. For this purpose, the Mann-Whitney U test was used. The relationships between qualitative variables were analysed using the chi-square test. The relationships between variables were analysed using Spearman rank correlations. Statistical calculations were performed using the TIBCO Statistica 13.3 PL software. Differences were assumed to be significant at the level of $P < 0.05$.

RESULTS

No statistical differences were found in the breeding parameters of the Eastern Rock Nuthatch between 2016 and 2017 (Table 1). Egg-laying began on March 24 and continued until April 15, except in 2016, when one brood began

Table 1. The breeding phenology and parameters of the Eastern Rock Nuthatch broods in 2016 and 2017. Denotations: Z = Mann-Whitney U test; χ^2 = Chi squared test; * = 1=1 April, in 2016 leap-year one day added.

Breeding parameters		2016	2017	Total	Statistical test
Laying date*	mean±SD	35±5	33±5	34±5	
	range	29–47	24–39	24–47	Z = 0.53
	[date]	[29.III–15.IV]	[24.III–8.IV]	[24.III–15.IV]	P = 0.593
	n (median)	13 (33)	14 (33)	27 (33)	
Fledglings date*	mean±SD	80±3	78±4	79±4	
	range	76–87	73–86	73–87	Z = 1.31
	[date]	[15.V–26.V]	[12.V–25.V]	[12.V–26.V]	P = 0.189
	n (median)	9 (79)	12 (78)	21 (78)	
Duration of breeding season	date	29.III–26.V	24.III–25.V	24.III–26.V	
	(n days)	(59)	(63)	(59–63)	–
Clutch size	mean±SD	5.5±1.51	5.6±0.84	5.6±1.19	
	range	3–7	4–7	3–7	Z = 0.16
	n (median)	13 (6.0)	14 (6.0)	27 (6.0)	P = 0.884
Number of hatched nestlings with failure broods	mean±SD	3.9±2.15	4.4±1.38	4.2±1.79	
	range	0–7	2–6	0–7	Z = –0.40
	n (median)	14 (4.5)	12 (4.5)	26 (4.5)	P = 0.686
Number of hatched nestlings in successful nest	mean±SD	4.7±1.25	4.4±1.38	4.6±1.30	
	range	3–7	2–6	2–7	Z = 0.26
	n (median)	10 (5.0)	12 (4.5)	22 (5.0)	P = 0.792
Number of fledglings with failure broods	mean±SD	2.8±2.42	3.6±1.95	3.2±2.17	
	range	0–7	0–6	0–7	Z = –0.90
	n (median)	12 (3.0)	14 (4.0)	26 (4.0)	P = 0.368
Number of fledglings in successful nest	mean±SD	4.1±1.64	4.2±1.34	4.2±1.42	
	range	2–7	2–6	2–7	Z = –0.12
	n (median)	8 (4.0)	12 (4.0)	20 (4.0)	P = 0.908
Hatching success	%	72.3	79.1	75.8	
	n eggs	65	67	132	χ^2 = 0.83
	(n broods)	12	12	24	P = 0.362
Breeding success	%	50.8	63.3	57.6	
	n eggs	65	79	144	χ^2 = 2.29
	(n broods)	12	14	26	P = 0.130
Nesting success	%	83.3	100	91.7	
	(n broods)	12	12	24	–

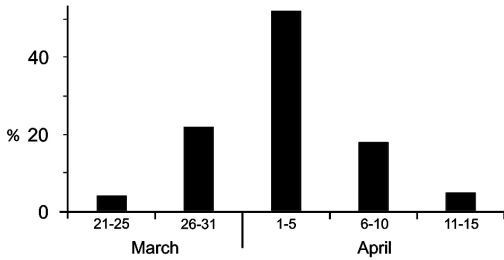


Fig. 1. *Sitta tephronota* egg laying phenology for specific 5-day periods during the breeding season (N broods = 27)

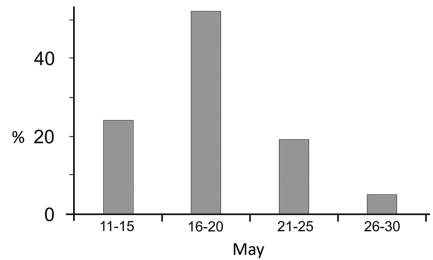


Fig. 3. *Sitta tephronota* fledglings' phenology for specific 5-day periods during the breeding season (N broods = 21)

on May 3 (most likely a replacement brood located in a newly constructed nest). In more than 52% of the nests, the egg-laying date was between April 1 and 5. Six broods began between March 26 and 31 (22%), and in five cases, the birds started egg-laying between April 6 and 10 (18%, $n = 27$, Fig. 1). The clutch size ranged from 3 (observed for two clutches) to 7 eggs (22% broods), and most nests included 6 eggs (41%, $n = 27$, Fig. 2). The relative laying date shows that the clutch size did not decrease at the end of the breeding season ($r_s = -0.272$, $P = 0.170$, $n = 27$). In the Eastern Rock Nuthatch broods, most often, 6 nestlings hatched (36%), and 7 or 5 nestlings less frequently (23 and 18%, $n = 22$). There were also 2 broods with 2 young and 3 broods with 3 young (Fig. 2). Fledglings were found in over 90% of nests (Table 1). Broods with nest success contained most frequently four fledglings (35%) and rarely two and five young (25% and 20%, $n = 20$). From two single broods fledged 7 and 3 nestlings and only from one nest, 2 young left (Fig. 2). Half the broods were active between May 16–20, rarely five days earlier or after this pentad and sporadically active at the end of May (respectively 25, 20 and 5%, $n = 20$, Fig. 3). There was no correlation between relative fledging date and the number of fledged nestlings ($r_s = 0.0004$, $P = 0.999$, $n = 20$). Broods that contained bigger clutches produced more hatchlings ($r_s = 0.590$, $P = 0.004$, $n = 22$, Fig. 4), but

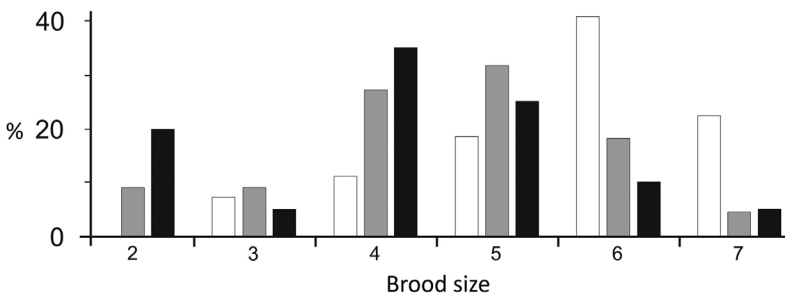


Fig. 2. Distribution of the Eastern Rock Nuthatch brood sizes. White – size of clutch (N = 27), gray – number of hatched nestlings (N = 22), black – number of fledglings (N = 20)

such dependencies were not confirmed between the number of eggs in broods and the number of fledglings ($r_s = -0.005$, $P = 0.842$, $n = 20$).

The breeding phenology of Eastern Rock Nuthatch was similar in TBs and RBs (Table 2). In both types of nests, similar brood size was found, amounting

Table 2. The breeding phenology and parameters of the Eastern Rock Nuthatch broods located in rocky and tree nest sites. Denotations are the same as in Table 1.

Breeding parameters		Tree nests	Rocky nests	Statistical test
Laying date*	mean±SD	33±5	33±5	
	range	29–47	24–39	Z = 0.20
	[date]	[29.III–15.IV]	[24.III–8.IV]	P < 0.980
	n (median)	16 (33)	11 (34)	
Fledglings date *	mean±SD	79±4	79±4	
	range	76–87	73–86	Z = 0.35
	[date]	[15.V–26.V]	[12.V–25.V]	P = 0.725
	n (median)	11 (78)	10 (78)	
Clutch size	mean±SD	5.4±1.41	5.9±0.70	
	range	3–7	5–7	Z = 0.72
	n (median)	16 (6.0)	11 (6.0)	P = 0.474
Number of hatched nestlings with failure broods	mean±SD	3.3±1.77	5.4±0.84	
	range	0–6	4–7	Z = -3.07
	n (median)	14 (4.0)	10 (5.0)	P = 0.002
Number of hatched nestlings in successful nest	mean±SD	3.8±1.19	5.4±0.84	
	range	2–6	4–7	Z = -2.80
	n (median)	12 (4.0)	10 (5.0)	P = 0.005
Number of fledglings with failure broods	mean±SD	2.1±1.71	4.7±1.79	
	range	0–4	0–7	Z = -3.35
	n (median)	15 (2.0)	11 (5.0)	P = 0.008
Number of fledglings in successful nest	mean±SD	3.1±0.99	5.2±0.92	
	range	2–4	4–7	Z = -3.36
	n (median)	10 (3.5)	10 (5.0)	P = 0.001
Hatching success	%	53.5	83.1	
	n eggs	86	65	$\chi^2 = 14.49$
	(n broods)	14	10	P = 0.001
Breeding success	%	36	80	
	n eggs	86	55	$\chi^2 = 17.16$
	(n broods)	15	11	P = 0.001
Nesting success	%	70.6	92.9	
	(n broods)	16	11	$\chi^2 = 1.22$ P = 0.269

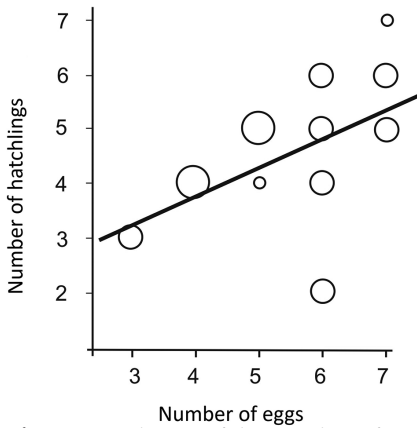


Fig. 4. Correlation of the number of eggs in clutch in relation to the number of hatched nestlings in successful nest recorded in *Sitta tephronota* broods (N broods = 22). The size of the circles corresponds to the number of cases from 1 to 3

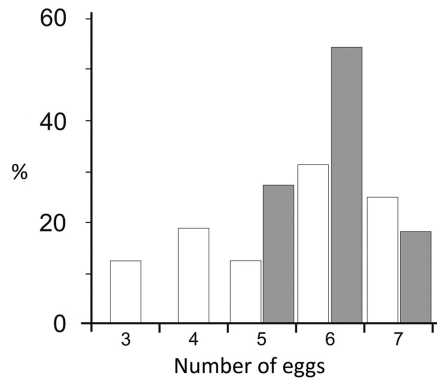


Fig. 5. Distribution of clutch sizes noted in the *Sitta tephronota* broods located in tree nests (white, N = 16) and rocky nests (gray, N = 11)

to more than 5 eggs. The two types of broods compared usually contained 6 eggs (respectively 31%, n = 16 and 45%, n = 11, Table 2, Fig. 5). However, the number of nestlings (assessed with success and loss cases) was statistically lower in TBs than in RBs. In both types of broods analysed, the differences were almost two chicks (Table 2). The hatching success was almost 30% higher in the RBs compared to TBs (Table 2). In the broods located in trees, 4 nestlings most often hatched (42%, n = 12), and in the rock nests, 5 nestlings hatched (50%, n = 10, Fig. 6). The RBs also recorded statistically greater (by over 40%)

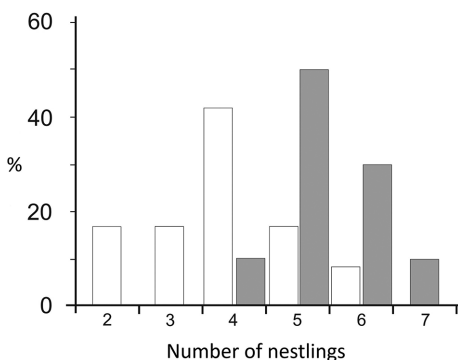


Fig. 6. Distribution of number of hatched nestlings noted in the *Sitta tephronota* successful broods located in tree nests (white, N = 12) and rocky nests (gray, N = 10)

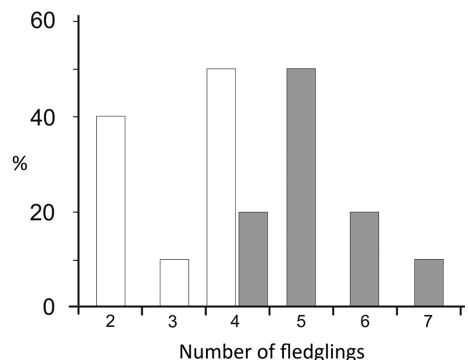


Fig. 7. Distribution of number of fledglings noted in *Sitta tephronota* successful broods located in tree nests (white, N = 10) and rocky nests (gray, N = 10)

breeding success (Table 2). For all the analysed broods and broods with success, about two more fledglings left the RNs compared to TNs (Table 2). The RBs most often had 5 fledglings leave (50%, $n = 10$), and the TNs generally had 4 fledglings leave (50%, $n = 10$, Fig. 7). Although the nest success was also over 20% higher in RBs, these differences were not significant in comparison to TBs (Table 2). Full brood failures were noted only in 2016. In this season, two TBs were lost in the incubation stage because the cavities were destroyed (probably by a weasel, marten or rat), and one TB was probably plundered by a snake in the nestling stage.

DISCUSSION

The Eastern Rock Nuthatches' breeding season, which began at the turn of March and April in Yasuj region, and continued for about one month, was similar to the season of broods noted in Pakistan and Turkmenistan (TICEHURST 1926, RUSTAMOV 1958). The Eastern Rock Nuthatch lives mainly in the mountainous regions of Central and South-West Asia, and their nests are located between 1000 and 3000 m above sea level (CRAMP & SNOW 2000). The broods of this species may also start at the turn of February and March, which was recorded e.g., in Tadzhikistan (SARUDNY & HÄRMS 1923, IVANOV 1969, CRAMP & SNOW 2000). During the research carried out in 2016, a very late brood was also found: the Eastern Rock Nuthatch started on May 3. However, the Eastern Rock Nuthatch's breeding attempts were also recorded in early June (RUSTAMOV 1958). Such late observations may refer to broods repeated after the loss of the first, or they could be the second broods, occasionally noted in the Nuthatch Sittidae family (RUSTAMOV 1958, MATTHYSEN 1989, SCHMIDT *et al.* 1992).

The research findings showed that the Eastern Rock Nuthatch clutch size did not vary in terms of seasons and nest sites. Birds nesting in the two compared types of nests invested at a similar level in broods. Nuthatches used old nests on rock shelves, where the birds most often improved only the nest entrance. The birds also adopted abandoned Syrian woodpecker cavities for breeding and only modified the cavity entrance with soil and mud (SHAFAEIPOUR *et al.* 2020). The use of old nests by Eastern Rock Nuthatches probably reduces the costs of breeding investment that the birds bear for the construction of new nests, which ultimately should have a positive influence on this specie's brood size (e.g., WIEBE 2001). However, the brood size of the Eastern Rock Nuthatch was slightly smaller compared to the results recorded for this species in other parts of Central Asia, where they ranged from 4 to 9 eggs (CRAMP & SNOW 2000). In Turkmeniya, broods of Eastern Rock Nuthatch included 4–8 eggs (RUSTAMOV 1958). Very similar brood size was also noted in

Pakistan (5–8 eggs, TICEHURST 1926) and in Kazakhstan (4–9 eggs, DOLGUSHIN *et al.* 1970). The study also revealed a smaller number of fledglings leaving the nest (about 4 nestlings) compared with the value of 5 nestlings recorded in Turkmeniya (RUSTAMOV 1958). As research has shown, this is associated with the lower number of eggs laid by females in a clutch. Similar relationships were also found for other cavity nesters (e.g., MICHALCZUK & MICHALCZUK 2016).

However, Eastern Rock Nuthatch broods in tree cavities showed far lower reproductive parameters than nests in rocks. The number of hatchlings in the woodpeckers' cavities was less. This could be due to the lower probability of egg hatchability noted in such nests. These performances may be the result of less thermal parameters of woodpecker cavities compared to rock nests. In the case of cavities located in trees, the quality of the substrate in which the tree-hole is excavated may be the most important factor providing stability of thermal conditions inside the nest (WIEBE 2001). Compared with cavities excavated in hard wood (in good condition), hollows located in rotten sites may be characterised by diminished thermal conditions, e.g., greater amplitude of temperatures inside the cavity chamber during the day (WIEBE 2001). Hot or cold temperatures could negatively influence broods located in such nests. Consequently, thermal stress can also negatively affect the condition and survival of nestlings (e.g., SHIAO *et al.* 2015, RODRÍGUEZ & BARBA 2016, RODRÍGUEZ *et al.* 2016). It can be assumed that for the same reason, the number of departing young from Eastern Rock Nuthatch broods was also lower in tree nests compared with rocky nests. Even though no direct studies of the thermal conditions of Eastern Rock Nuthatch nests were conducted, it has been suggested that rocky nests have a more stable microclimate in comparison to woodpecker cavities, which are probably subjected to greater insulation (WIEBE 2001, BUTLER *et al.* 2009). Other factors should also be considered, such as limitations in the cavity construction e.g., the thin wood walls in cavity nests can also negatively influence microclimatic stability in the nests (WIEBE 2001, MAZIARZ 2019).

Research has shown that brood failures recorded for the two types of Eastern Rock Nuthatch nests analysed resulted from their different susceptibilities to destruction and predation. Two breeding tree cavities were destroyed because they were located in inferior wood, and thus the construction weaknesses were easily penetrated by predators (probably a marten or rat). Such cases of brood failures are recorded in cavity nesters (e.g., WESOŁOWSKI 2017). However, the case of brood robbery noted for this species in tree cavities, probably achieved by snakes, also proves that predation may be a cause of Eastern Rock Nuthatch brood failures at the nestling stage. In the mountainous habitats of Central Asia, snakes pose a threat to Nuthatches (KORSH 2012, YADOLLAHVAND *et al.* 2018). Research into the Eastern Rock Nuthatch suggests

that such predators can especially devastate broods located in tree cavities. Similar tendencies were also noted in other studies e.g., for the Brown-headed nuthatch *Sitta pusilla*, in which tree nests were plundered by Texas Ratsnake *Pantherophis obsoletus* (WITHGOTT & AMLANER 1996). It can be assumed that in order to avoid predators, the cavities selected by the Eastern Rock Nuthatch for breeding were located much higher above the ground level than nests built in rock gaps (SHAFAEIPUR *et al.* 2020). As shown by other studies, a high nest site should limit brood failures because such a location can prevent nest access by predators (FISHER & WIEBE 2006, MAZIARZ *et al.* 2016, but see also WESOŁOWSKI & ROWIŃSKI 2004).

Even though the Eastern Rock Nuthatch's rock nests are built lower to the ground than the tree nests located in the woodpeckers' cavities (SHAFAEIPUR *et al.* 2020), the level of failures in the rock broods was clearly lower. Based on these observations, it can be assumed that rocky shelves may effectively limit access to Nuthatch nests by predators (e.g., snakes). Better reproductive parameters recorded for this type of nest may also result from their different construction. Compared with woodpecker cavities, Rocky nests include smaller dimensions of the nest entrance (SHAFAEIPUR *et al.* 2020). The smaller entrance noted in rocky nests limits the possibility of penetration to the nest interior by predators and thus increases the safety of the brood (e.g., WESOŁOWSKI & ROWIŃSKI 2004, WESOŁOWSKI 2017, MAZIARZ *et al.* 2016).

The study results showed that despite similar brood investments, the Eastern Rock Nuthatches nesting in cavities adopted after the Syrian Woodpecker achieved worse reproductive parameters than pairs that used rocky nests. These studies indicate that contrary to other results proving the high reproductive success of cavity nesters (e.g., MARTIN & LI 1992, WESOŁOWSKI & TOMIAŁOJCZAK 2005), for some species, such as the Eastern Rock Nuthatch, woodpecker cavities may not be safe breeding sites.

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