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The nesting ecology of song thrush (*Turdus philomelos*) in Stepanakert City of Nagorno-Karabakh and its adjoining areas

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Abstract. Urbanization and intensive anthropogenic transformation of natural habitats significantly influence avian breeding ecology, particularly in rapidly changing urban environments. Understanding species-specific reproductive responses to these pressures is essential for effective conservation planning. This study presents the first comprehensive analysis of the nesting ecology and breeding success of the Song Thrush (*Turdus philomelos*) in the Republic of Nagorno-Karabakh, focusing on Stepanakert city and its surrounding urban, suburban, and peri-urban habitats. Field studies were conducted during the breeding seasons from 2017 to 2023 across a range of habitat types, including parks, gardens, orchards, bushes, cemeteries, and suburban forests. Nest placement, nesting substrates, nest dimensions, egg characteristics, and breeding phenology were recorded using standard ornithological and biometric methods. Breeding success and fledging success were assessed across habitat categories. The results revealed clear habitat-related differences in nesting success. Breeding success ranged from 78.5% in urban parks to 94.4% in suburban forests. Fledging success was lowest in bush habitats (52.2%) and highest in urban forests (78.2%). Overall, 73.1% of chicks reached fledging age, and approximately 64% of the 1,277 recorded eggs resulted in mature juveniles. Breeding activity occurred in two main periods, with hatching primarily observed from early June onward. The findings demonstrate that song thrush exhibits considerable ecological plasticity, with higher reproductive success in less disturbed semi-urban habitats. These results highlight the importance of habitat structure and anthropogenic pressure in shaping breeding success and provide essential baseline data for the conservation and management of urban bird populations in the region. This study is particularly relevant as it provides the first quantitative evidence of how habitat type and anthropogenic pressure shape the breeding success and population ecology of song thrush in urban, suburban and peri-urban landscapes of Nagorno-Karabakh.

Keywords: urban ecology, breeding success, nesting ecology, *Turdus philomelos*, anthropogenic impact, habitat selection.

1. Introduction

Within the intricate network of anthropogenic ecosystem modifications, avian species increasingly adapt to human-altered and urban environments, developing a range of ecological adaptations (Kashkarov 2001, Rakhimov 2002). Understanding the mechanisms underlying animals—especially birds' capacity to adjust to evolving habitats stands as a pivotal juncture in the intricate interplay between humanity and the natural world (Vakhrushev 1988). Delving into the adaptation of avian fauna to life within anthropogenically influenced landscapes is a paramount concern within the realm of general biology (Georgievsky 1974, Vakhrushev 1988, Kashkarov 2001, Rakhimov 2002).

Within urbanized landscapes, ecological groups or closely related species with akin environmental requisites undergo continual selection (Fridman & Yeryomkin 2009). Among these, the song thrush is a particularly intriguing subject for investigating the mechanisms of adaptation and survival among native species in urbanized environments (Morozov 2009).

The nesting period is very significant within the avian life cycle, with detailed investigations proving pivotal for comprehending population dynamics, demographic structures, fauna conservation, and the patterns governing resource utilization (Zhao *et al.* 2019, Jiménez-Franco *et al.* 2018). Despite its paramount importance, the study of avian breeding characteristics is fraught with complexities, compounded by the scarcity of comprehensive data across varying geographical and ecological contexts. Despite its importance, comprehensive ornithological studies in the region have remained limited, and full-fledged ornithological inquiries have languished for years (Adamian & Klem 1997). The breeding behaviors of birds, notably those of the song thrush, remain largely unexplored within the avifauna of Nagorno-Karabakh, marking this endeavor as a pioneering effort within the scope of the present discourse.

These birds demonstrate remarkable mobility, utilizing both ground and arboreal habitats throughout their lives. Their activity spans the entirety of daylight hours, although the extent of activity is influenced by climatic conditions and seasonal variations. Similar to other avian species, female activity experiences interruption solely during the mating period (Aydinyan 2022).

Song thrushes construct their nests using a variety of materials. They start with thin branches, rocks, fallen tree barks, and dry leaves for the framework. Wet loam mixed with grass or moss forms the middle layer, reinforced with mortar. The inner layer consists of moss, dry grass, and leaves, again reinforced with clay mortar. After letting the nests dry for 1-2 days, they line the inside with soft leaves, grass, and sometimes bits of wool or feathers (Simkin 1990).

This study aims to investigate the nesting ecology of the song thrush in Stepanakert and surrounding areas, focusing on nest site selection, nest height, and breeding success across urban, suburban, and peri-urban habitats, with the hypothesis that habitat type and anthropogenic pressure influence nesting and reproductive outcomes.

The song thrush (*Turdus philomelos*) is used in this study as a model species to understand avian urban adaptation. This work represents the first comprehensive study of nesting ecology in the Nagorno-Karabakh region (Stepanakert city and its surroundings), filling a significant geographical gap in the ornithology of the South Caucasus.

2.Study Area

The studies were conducted across all urban, suburban and peri-urban habitats within the administrative territory of Stepanakert city, including parks, promenades, green spaces, residential districts, streets, and construction and industrial zones. Stepanakert is situated in the southeastern part of the Armenian Highlands, on a small plain at the foothills of the Nagorno-Karabakh mountain range, along the left bank of the Vararakn River, a tributary of the Karkar River, at coordinates 39°49'04"N, 46°45'03"E, and an elevation of 650–1100 meters above sea level. The city has mild climatic conditions (Figure 1).

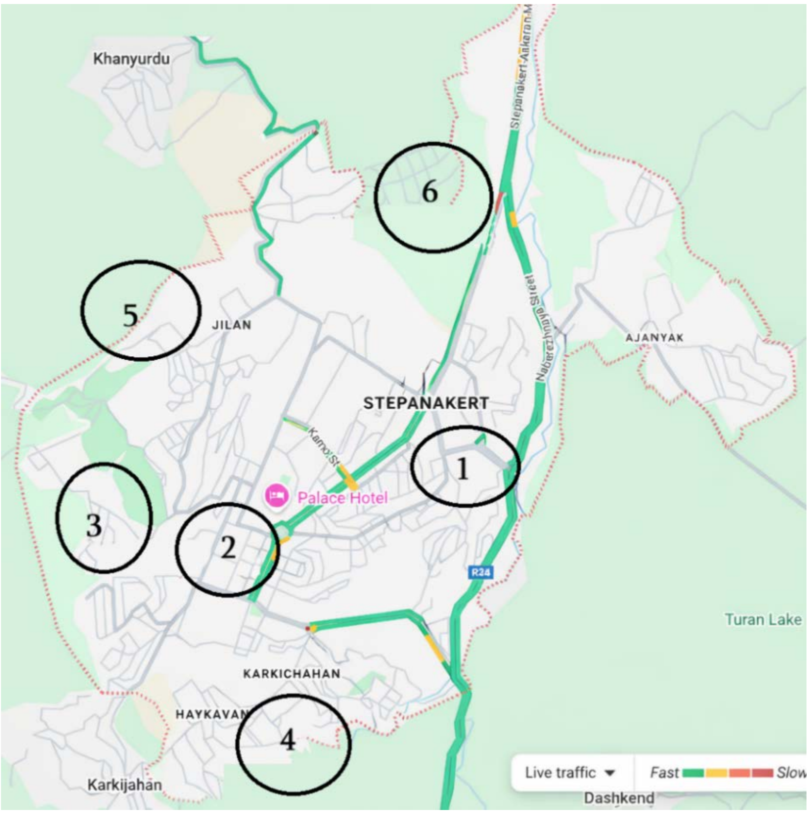

Figure 1. Map of stationary monitoring stations

1. Grove, 2. Park, 3. Cemeteries, 4. Orchard, 5. Bushes, 6. Urban Forest

Urban 1. Grove, 2. Park,

Sub-urban 3. Cemeteries, 4. Orchard

Peri-urban 5. Bushes, 6. Urban Forest

The total study area spans approximately 114.36 km², comprising Stepanakert itself (29.12 km²), adjacent areas (22.15 km²), and suburban areas (63.09 km²). Tree-covered areas constitute 14.3% of the total area in Stepanakert, with shrubs covering 5.2%. In adjacent areas, trees cover 29.6%, and shrubs cover 12.5%. In suburban areas, trees cover 36.4%, and shrubs cover 26.3%. Detailed information on tree and shrub types is provided in Table 1.

Habitats were classified as urban (city center with high building density and intensive human activity), suburban (residential outskirts with gardens, parks, and small groves), and peri-urban (countryside with agricultural fields, orchards, larger forest patches, and minimal human disturbance).

The most cultivated areas are heavily influenced by anthropogenic factors, including orchards. The central part of Stepanakert is most affected by urban development, transport, noise, and other anthropogenic impacts, whereas suburban and adjacent areas experience comparatively less human influence (Hayrapetyan & Aydinyan 2022).

3.Material and Methods

The study was conducted between 2017 and 2023 throughout the breeding season, focusing on gathering primary data from groves, parks, orchards, and suburban regions in and around Stepanakert city. Using mapping techniques (Bibby et al. 2000), we surveyed the nesting sites of song thrushes. The ecological observations adhered to classic zoological methodologies (Novikov 1953). The observation of nests started from late March to mid-April and persisted until the second half of June. Upon locating nests, we measured them and determined their elevation using GPSmap62stc electronic navigation equipment. Nest dimensions were measured to the nearest centimeter (cm), including diameter (D), cup diameter (d) (the distance between the inner walls of the nest), height (H), and cup depth (h), were measured with precision up to 5mm using tapes or rulers (Numerov et al. 2010). Egg measurements were conducted using a digital caliper, and recorded with precision up to 0.1 mm. Egg counts started with the laying of the first egg and continued throughout subsequent stages of development, with nests monitored at seven-day intervals. In instances where nests were inaccessible for direct observation, we recorded habitat characteristics, tree or shrub species, and estimated height above ground level (to the nearest millimeter (cm)). Throughout the study, a total of 278 nests were recorded in Stepanakert city and its periphery, housing 1277 eggs within 269 nests. Detailed nest and oological measurements were conducted on 22 nests with 86 eggs. Egg measurements were analyzed using established biometric methods (Lakin 1990). Graphical and statistical data analysis was conducted using MS Excel and SPSS 27 software. The statistical analysis employed the following methods: Paired Student's t-test which was used to determine the average population density of nesting birds across different habitats; One-way Analysis of Variance (ANOVA) which was applied to compare the effects of four plant groups (broad-leaved trees, shrubs, coniferous trees, and shrubs) on the number of nests;

Regression Analysis which was used to calculate the expected relationships between the number of nests and their height above the ground.

Abbreviations

ANOVA – Analysis of Variance
SD – Standard Deviation
Cv – Coefficient of Variation

4.Results and Discusion

4.1 Nest Distribution and Habitat Use

In this study, we focused our research efforts on the song thrush, a species noted for its sedentary behavior. Despite its widespread occurrence, the species has received limited research attention within the Republic of Nagorno-Karabakh. As shown in Table 1, our data illustrates the highest concentration of nests within urban forests, followed by cemeteries and orchards, with comparatively fewer nests observed in bushy areas. This pattern is attributed to the limited availability of suitable tall trees required for nesting in these areas.

Song thrushes exhibit nesting preferences for both broad-leaved and coniferous trees and shrubs, as indicated in Table 1. Analysis of the data reveals that the central parts of the city harbor the fewest proportion of nests, comprising only 25.2% of the total nests studied, with the majority situated within broad-leaved trees and shrubs and coniferous trees, predominantly in groves and parks. Suburban regions of Stepanakert supported an intermediate proportion of nests, accounting for 32.4% of the nests, while the highest proportion of nests, 42.4%, is observed in rural areas.

The observed nests of song thrushes typically contain 3 to 6 eggs each, with the average number of eggs per nest varying across years and locations, ranging from 4 to 5.3 eggs. Across 269 nests surveyed, the average number of eggs per nest stands at 4.7. Our observations indicate that the maximum number of eggs in nests is typically recorded at the onset of the breeding season.

Table 1 shows the number of nests in different habitats, with the average number being higher in urban forests, parks, and gardens at higher nesting sites.

Table 1. Number of observed nests in different habitats

Nesting site	Urban		Suburban		Peri-urban	
	(n = 70)	%	(n = 90)	%	(n = 118)	%
Broad-leaved trees	39	55.7	55	61.1	78	66.1
Coniferous trees	12	17.1	14	15.5	17	14.4
Broad leaved shrub	19	27.2	15	16.7	19	16.1
Coniferous shrub	-	-	6	6.7	4	3.4
Total	70	100	90	100	118	100

Table 2. Number of nests and eggs per nest of Song Thrushes in different years

year	Place of study localities											
	Grove		Park		Orchard		Cemeteries		Urban Forest		Bushes	
	number											
	nest	egg	nest	egg	nest	egg	nest	egg	nest	egg	nest	egg
2017	5	15	4	20	5	25	8	32	9	45	3	9
2018	4	20	3	12	6	30	8	40	14	70	-	-
2019	-	-	6	30	8	32	9	36	12	60	2	8
2020	4	20	-	-	4	16	5	30	10	50	4	16
2021	6	30	7	28	6	30	8	40	13	78	4	16
2022	4	20	6	24	8	32	11	55	14	84	3	15
2023	5	25	4	20	8	32	13	52	12	60	4	16
Total	28	130	30	134	45	197	62	285	84	447	20	80
M±m	4.7±0.33	4.6±0.14	5±0.63	4.5±0.09	6.4±0.09	4.4±0.07	8.8±0.1	4.6±0.08	12±0.05	5.3±0.11	3.3±0.09	4±0.16

SD	0.82	0.77	1.54	0.50	0.58	0.48	0.79	0,66	0.51	0.99	0.41	0.71

Nesting Period and Tree and Shrub Preferences

During the breeding season, our observations revealed that song thrushes exhibit selectivity in their choice of trees. Among the 278 nests found as a result of our studies, 172 nests (61.9%) were found in broad-leaved trees, 43 nests (15.5%) in coniferous, 53 nests (19.1%) in broad-leaved shrubs, and 10 nests (3.4%) in coniferous shrubs. Table 3 summarizes the preferred tree species for nesting by the song thrush. Notably, among broad-leaved trees, oaks (*Quercus iberica*) (22.1%), willows (*Salix alba*) (14.5%), and plane trees (*Platanus orientalis*) (13.9%) were the most frequently used for nesting. Within the conifer category, pines (*Pinus sylvestris*) were the most frequently used with 23 nests (53.5%), followed closely by cypress *(Cupressus sempervirens)* with 20 nests (46.5%). Similarly, when considering shrub habitats, song thrushes exhibit a preference for broad-leaved shrubs, with 84.1% (53 nests) of the 63 nests surveyed found in such habitats, compared to 15.9% (10 nests) in coniferous shrubs. According to data presented in Table 3, nests were most frequently recorded in broad-leaved shrubs, particularly common hazel (*Corylus avellana*), syringa (*Syringa vulgaris*), blackthorn (*Prunus spinosa*), and honeysuckle (*Lonicera periclymenum*). Among coniferous shrubs juniper (*Juniperus communis*) was the most commonly used for nesting (see Table 3).

Table 3. Preferred Trees and Shrubs for Song Thrush Nesting

Tree and Shrub Types	The Number of Nests						Total	
	Urban		Suburban		Peri-urban			
	n	%	n	%	n	%	n	%
trees								
Lindens *(Tilia orientalis)*	7	10	9	10	3	2.5	19	6.8
Oak *(Quercus iberica)*	10	14.2	12	13.4	16	13.6	38	13.7

Maple *(Acer platanoides)*	3	4.3	6	6.7	9	7.7	18	6.5
Plane tree *(Platanus orientalis)*	6	8.6	7	7.8	11	9.3	24	8.6
Willow *(Salix alba)*	5	7.1	8	8.9	13	11	26	9.2
Plum tree *(Prunus domestica)*	1	1.4	2	2.2	3	2.5	6	2.2
Apple tree *(Malus domestica)*	2	2.9	1	1.1	3	2.5	6	2.2
Pear tree *(Pyrus communis)*	1	1.4	-	-	4	3.4	5	1.8
Persimmon *(Diospyros kaki)*	2	2.9	-	-	-	-	2	0.7
Hawthorn *(Crataegus laevigata)*	-	-	6	6.7	9	7.7	15	5.4
Mespilus *(Mespilus germanica)*	2	2.9	4	4.4	7	5.9	13	4.7
Pine tree *(Pinus sylvestris)*	7	10	6	6.7	10	8.6	23	8.3
Cypress (*Cupressus sempervirens)*	5	7.1	8	8.9	7	5.9	20	7.2
Bushes								
Common hazel (*Corylus avellana)*	6	8.6	3	3.3	8	6.8	17	6.1
Honeysuckle (*Lonicera periclymenum)*	2	2.9	2	2.2	3	2.5	7	2.5
Syringa (Syringa vulgaris)	5	7.1	4	4.4	4	3.4	13	4.7

Blackberry *(Rubus fruticosus)*	2	2.9	1	1.1	2	1.7	5	1.8
Blackthorn *(Prunus spinosa)*	4	5.7	3	3.3	1	0.8	8	2.9
Paliurus *(Paliurus spina-christi)*	-	-	2	2.2	1	0.8	3	1.1
Juniper *(Juniperus communis)*	-	-	6	6.7	4	3.4	10	3.6
Total	70		90		118		278	

Song thrushes begin their nesting activity in early spring, selecting nest sites even before complete snow melt. By the second half of March, construction of nests commences and typically lasts for 4-5 days. Within urban settings, song thrushes are primarily solitary, occasionally forming small groups of 4-5 individuals, a behavior coinciding with breeding periods. Throughout the spring breeding season, the melodious songs of these birds resonate at various intervals throughout the day. Singing activity of these birds typically commences between as early as 4:00-4:30 in the morning and persists until 10:00-10:30, ceasing briefly before resuming from 16:30-17:00 until 20:00-21:00. Nighttime sees a cessation of singing, only to resume with the early morning hours. This daily pattern of song activity persists into the second stage of the breeding period, typically occurring from June to July. Nest construction is predominantly carried out by females, while males assume the role of territorial guardians during this critical period of reproductive activity.

During the observations, we found that, in areas with minimal anthropogenic influence, song thrushes exhibit a more open behavior, often using open forest glades. However, in urbanized environments, they tend to adopt a more concealed behavior.

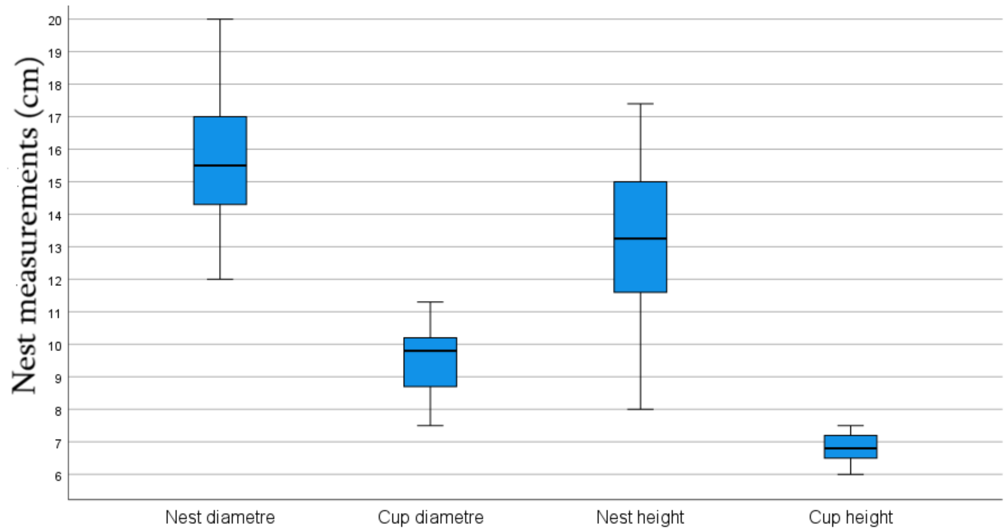

Figure 2. Measurements of Song Thrush nests

Nest Measurements and Height Above Ground

In our research, we did not find any building materials of human origin in both active and abandoned nests of song thrushes, whether in urban areas or natural environments. The examined abandoned nests (n=12) weighed between 168.2g to 188.9g (M=178 ±2,0g). The composition of these nests comprised soil (41.3%), branches of trees and bushes (33.7%), moss (8.4%), leaves (7.9%), and grass (4.6%)

The nests of song thrushes typically have a cup-like shape, although some variations can occur depending on the nesting site (Figure 2). 1). The cup shape may vary, ranging from flattened on one side to boat-shaped or rounded. In terms of size, song thrush nests also show considerable variability, as illustrated in Figure 2. The measurements reveal high variability in the total diameter of the nest (Cv=12.4%), inner diameter of the cup (Cv=13.1%), and total nest height (Cv=16.1%), while nest depth exhibits low variability (Cv=6.7%).

Table 4. The average nest heights of Song Thrush in various habitats within Stepanakert city and its suburb (in meters)

Nesting site	n	min-max	M±m	σ	Cv%
Groves	30	1-7	3.3±0.29	1.7	50.6
Parks	32	1-7	4±0.27	1.5	37.5

Orchards	48	2-3.5	2.7±0.07	0.48	17.8
Cemeteries	47	1-3	1.9±0.08	0.8	30.5
Urban Forests	89	2-7	4.3±0.13	1.2	27.9
Bushes	32	1-2	1.5±0.07	0.4	26.7

Pairs nest independently, often at considerable distances from each other. The nests are constructed at various heights, commonly ranging from 1-5 m above the ground, with occasional nests reaching heights of 6-7m. Our observations indicate varying nest heights across different habitats: 3.3m (Cv=50.6%) in groves, 4m (Cv=37.5%) in parks, 2.7m (Cv=17.8%) in orchards, 1.9m (Cv=30.5%) in cemeteries, 4.3m (Cv=27.9%) in urban forests, and 1.5m (Cv=26.7%) in bushes (Table 4).

In our study of 278 nests, we found that 20.9% were located 1-1.5m from the ground, 26.6% at 2-2.5m, 22.7% at 3-3.5m, 13.3% at 4-4.5m, 7.9% at 5-5.5m, 6.8% at 6-6.5m, and 1.8% at 7m (see Fig. 3). These nests were discovered in Stepanakert and surrounding areas at altitudes ranging from 600-950m. Our observations indicate that the nest height varies depending on both the area and the tree species used. Similar to other thrush species, song thrushes tend to nest higher in urbanized areas - defined here as landscapes modified by human activity, including buildings, roads, and maintained green spaces, likely due to disturbances caused by human activity (Aydinyan et al. 2022). While there are reports of song thrushes nesting near rivers or in foxholes, we did not observe this behavior in our study (Naniknov 2022).

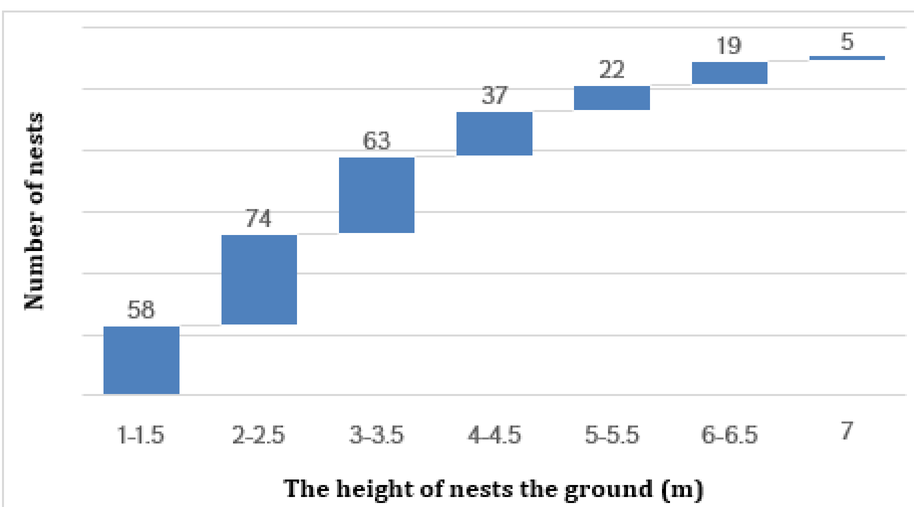

Figure 3. Nest Heights of Song Thrushes

Egg-laying Periods

Our research indicates that song thrush (nests in Stepanakert and its surrounding areas typically contain 3-5 eggs. Egg laying begins within 2-3 days after nest construction. The timing of egg laying varies and is influenced by climatic conditions, typically starting from the second half of March and extending until the end of April, occasionally continuing into the first half of May. For instance, in 2017, the first eggs were observed in 3 nests on March 25 in an urban forest near Stepanakert. In 2018, the first eggs were recorded in 2 of 20 monitored nests on March 30, and in 2019, they were recorded in 5 nests on April 4 (Table 5). The second egg typically follows 1-2 days after the first. Our observations suggest that the timing of spring egg laying correlates with atmospheric temperature, often occurring when temperatures exceed +10°C.

Table 5. Start and end dates of spring egg-laying of Song Thrushes

Year	Number of nests	Start of egg laying	Egg-laying peak	End of egg laying
2017	3	25 March	7-21 April	5 May
2018	2	30 March	11-30 April	15 May
2019	5	4 April	28 April- 10 May	23 May
2020	7	24 April	15 - 22 April	2 May
2021	6	2 April	4-12 May	18 May
2022	8	31 March	15-30 April	16 May
2023	5	3 April	1-9 May	21 May

In Nagorno-Karabakh, the second breeding season of song thrushes typically commences towards the end of May or the beginning of June. Given that the end of the spring breeding season often extends into the first or second week of May, determining the exact onset of the second reproductive stage can be challenging. Egg measurements were primarily conducted in 22 out of 278 nests to minimize disturbance to the birds' normal reproductive activity. Based on our data, morphological analysis of eggs revealed significant variations in egg shape, diameter, and mass (Table 6).

Table 6. Measurements (mm) and Weight (g) of Song Thrush Eggs

Measurements	n	Min-max	M	δ	m	Cv%
Length (mm)	86	18.2-28.9	24.2	2.54	0.27	10.5
Diameter (mm)	86	17.1-26.8	21.8	2.23	0.24	10.2
Weight (g)	86	4.9-7.3	6.3	0.64	0.07	10.2

Based on our direct observations and the natural hatching process of chicks, we have noted that brooding in song thrushes typically begins after the third egg has been laid. Females are primarily responsible for incubation, while males mainly provide food for the females. The incubation period lasts approximately 13-14 days. During the spring breeding season, the first chicks usually appear in nests during the first half of April. For instance, in 2017, in three nests where the first eggs were laid on March 25, one nest contained one chick and three eggs on April 15, another had two chicks and three eggs, and the third one had two chicks and two eggs. Similarly, nests observed on April 4, 2019, had their first chicks between April 21 and 23. In the second stage of the nesting period, the first chicks typically hatch in the first ten days of June, occasionally extending into the second half of the month. The hatching process generally lasts 1-2 days. Newly hatched chicks (n=6) weigh between 5.9-6.8 grams. By the 5th and 6th day of life, their eyes open, and they are covered with natal down, with their weight increasing to 20-25 grams. By the 8th-9th day, the rectrices begin to emerge, and at this stage, the chicks are almost fully feathered. Chicks remain in the nest for approximately 14-15 days, during which both parents contribute to feeding them. The frequency of feeding depends on various factors such as weather conditions, the number of chicks in the nest or food availability. Fledglings typically begin to fly at 19th-20th day of age. Based on our observations, the entire reproductive cycle - from nest site selection to chicks leaving the nest - lasts approximately 43-44 days.

Hatching

Nesting success serves as a critical indicator of population health. However, similar to other bird species, not all song thrush fledglings survive to adulthood, with some perishing even before hatching. Eggs and nestlings of song thrushes face significant predation pressure from various predators, including martens (*Martes* spp.), squirrels (*Sciuridae*), Eurasian Magpie (*Pica pica*), crows (*Corvus* spp.), and other potential nest predators. Moreover, adverse climatic conditions can further reduce the reproductive success in this species.

In our observations conducted in Stepanakert city and its suburbs, we recorded a total of 1277 eggs across 269 nests. Through subsequent monitoring, we found 130 eggs in 28 nests within groves, resulting in 102 chicks after brooding, indicating a reproductive success of 78.5%. Reproductive success in other habitats was 83.6% in parks, 81.2% in orchards, 89.8% in cemeteries, 94.4% in urban forests, and 79.8% in bushes (Table 7). Overall, between 2017-2023, the average breeding success of song thrushes in these areas was 87.6%. However, it is important to note that not all nestlings successfully fledge from the nest or reach maturity. Some succumb during the nesting period due to various factors such as undernourishment, sudden environmental temperature changes, falling from the nests, or becoming prey to predators. For instance, between 2017 and 2023, two out of the 28 nests studied in groves were destroyed by beech martens (*Martes foina*), while nests in parks, orchards, cemeteries, and urban forests faced damage from stray cats and squirrels.

Table 7. Number of Eggs and Hatchlings in Song Thrush nests

Nesting Sites	2017		2018		2019		2020		2021		2022		2023		The total number of eggs	The number of hatchlings	Efficiency %
	The number of eggs in the nests	The number of hatchlings	The number of eggs in the nests	The number of hatchlings	The number of eggs in the nests	The number of hatchlings	The number of eggs in the nests	The number of hatchlings	The number of eggs in the nests	The number of hatchlings	The number of eggs in the nests	The number of hatchlings	The number of eggs in the nests	The number of hatchlings			
Groves	15	12	20	15	-	-	20	16	30	26	20	13	25	20	130	102	78.5
Parks	20	11	12	8	30	24	-	-	28	28	24	22	20	19	134	112	83.6

Orchards	25	20	30	24	32	26	16	16	30	21	32	28	32	25	197	160	81.2
Cemeteries	32	30	40	33	36	32	30	28	40	37	55	49	52	47	285	256	89.8
Urban Forests	45	43	70	68	60	60	50	47	78	69	84	75	60	60	447	422	94.4
Bushes	9	9	-	-	8	6	20	18	16	11	15	10	16	13	84	67	79.8
Total	146	125	172	148	166	148	136	125	222	192	230	197	205	184	1277	1119	87.6

Observations conducted across different years and locations have revealed variations in the number of song thrush fledglings (Table 8). For instance, in parks, 75 (73.5%) of the 102 observed chicks in various years successfully fledged, while this figure in orchards was 71.2%, 74.6% in cemeteries, 78.2% in in urban forests, and 52.2% in in bushes. Out of a total of 1119 observed chicks, approximately 818 individuals, or 73.1% successfully reached the age of flight. Additionally, around 64% of the total 1277 eggs observed successfully produced fledglings.

Table 8. Number of chicks in Song Thrush nests and number of chicks that fledged

Nesting Sites	2017		2018		2019		2020		2021		2022		2023		Total	The total number of the chicks that left the nest	Efficiency %
	The number of chicks in the nests	The number of chicks that left the nests	The number of chicks in the nests	The number of chicks that left the nests	The number of chicks in the nests	The number of chicks that left the nests	The number of chicks in the nests	The number of chicks that left the nests	The number of chicks in the nests	The number of chicks that left the nests	The number of chicks in the nests	The number of chicks that left the nests	The number of chicks in the nests	The number of chicks that left the nests			

Groves	12	8	15	8			16	12	26	20	13	13	20	14	102	75	73.5
Parks	11	6	8	3	24	17			28	18	22	16	19	13	112	73	65.2
Orchards	20	13	24	18	26	19	16	10	21	14	28	22	25	18	160	114	71.2
Cemeteries	30	22	33	25	32	20	28	25	37	30	49	36	47	33	256	191	74.6
Urban Forests	43	34	68	50	60	48	47	43	69	52	75	58	60	45	422	330	78.2
Bushes	9	5			6	2	18	11	11	5	10	7	13	5	67	35	52.2
Total	125	88	148	104	148	106	125	101	192	139	197	152	184	128	1119	818	73.1

Data Analyses

The coefficient of determination (R^2=0.125) indicates that 12.5% of nest placement variability is explained by tree groups. The regression equation Y = 7.319 - 1.198X suggests that the number of nests decreases by 1.198 as the tree group type changes.

To identify deviations in the mean measurements of song thrush nests and their reliability, an analysis of variance (ANOVA) was conducted. Between nest height and nest diameter, the analysis showed $F(5, 272) = 1451.248$, $p < 0.001$, $\eta^2 = 0.98$, and between cup diameter and cup height, it showed $F(20, 257) = 857.048$, $p < 0.001$, $\eta^2 = 0.96$. Post hoc comparisons using the Tukey HSD test indicated the most pronounced deviations between cup diameter and cup height, with significance at $p < 0.001$. Out of the 278 nests studied, the distribution of nest heights was as follows: 20.9% were located at 1–1.5 m above the ground, 26.6% at 2–2.5 m, 22.7% at 3–3.5 m, 13.3% at 4–4.5 m, 7.9% at 5–5.5 m, 6.8% at 6–6.5 m, and 1.8% at 7 m.

To assess mean deviations in nest heights across six landscape types, a one-way ANOVA was conducted, yielding F(5. 272) = 54.117, $p < 0.001$. Multiple comparisons using the Tukey HSD test revealed significant deviations between nest height above ground and nest beds in groves, cemeteries, urban forests, and shrubs ($p < 0.001$), while no significant deviations were found in orchards and parks. Additionally, significant differences in nest heights and numbers were observed between parks, orchards, cemeteries, and bushes ($p < 0.001$), but no significant differences were noted between parks and urban forests. This suggests that nest height and density are influenced by the landscape.

An analysis of variance (ANOVA) was performed to identify deviations in the means of linear measurements of song thrush eggs. The results were as follows: between egg length and diameter: $F(12, 73) = 658.370$, $p < 0.001$, with significant differences confirmed by Tukey's HSD test ($p < 0.001$); between egg length and weight: $F(8. 77) = 237.952$, $p < 0.001$, with Tukey's HSD test ($p < 0.001$); between egg diameter and weight: $F(8. 77) = 217.006$, $p < 0.001$, with Tukey's HSD test ($p < 0.001$). All linear measurements showed significant Pearson correlations at the $p = 0.01$ level. To analyze differences between the number of eggs laid (n=1277, M=212.8±54.8, SD=134.1) and hatched chicks (n=1119, M=181.5±54.1, SD=132.6) across six landscapes (n=269, M=44.8±9.9, SD=24.3), Fisher's exact test revealed $F(5, 1272) = 75.934$, $p < 0.01$. Post hoc Tukey HSD test analyses showed no significant differences between the number of eggs and hatched chicks in parks and orchards (p=0.464), cemeteries and bushes (p=0.640), and forest parks and bushes (p=0.31). Significant differences were found in all other landscapes (p=0.05). To identify differences between the average numbers of chicks in nests and fledged chicks (n=818, M=136.3±44.4, SD=108.7), another ANOVA was performed, yielding $F(5, 1113) = 19.9$, $p < 0.01$. Tukey HSD test results showed no significant differences between parks (p=0.2), orchards (p=1.0), and shrubs (p=0.576), or between cemetery orchards (p=0.178) and shrubs (p=0.376). However, significant differences were observed in all other comparisons (p=0.05).

4.2 Discussion

The nesting ecology of the song thrush in Nagorno-Karabakh exhibits both regional specificities and broader patterns typical of the species across Eurasia. Our findings demonstrate that nest construction follows a complex structural layering, as previously described by Simkin (1990). However, the selection of nesting substrates and heights in our study area appears to be a direct response to local environmental constraints and anthropogenic pressures.

Our findings provide the first detailed insight into the nesting biology of *T. philomelos* in the specific environmental conditions of Stepanakert. As the first comprehensive ornithological assessment in this region, this study establishes a baseline for monitoring how urban transformation affects bird populations in previously unstudied areas of the South Caucasus.

Nest Placement and Adaptive Strategies

We found that nest height varies significantly depending on the landscape type and tree species availability. The observed height range (1–7 m) is consistent with data from the Pskov region (Golovan 2004) and Belarus (Sakhvon & Grichik, 2018), yet we recorded no ground-nesting, which is likely due to the limited availability of dense, protective ground cover in our specific study plots.

Interestingly, song thrushes in Stepanakert showed a tendency to nest higher in urbanized areas. Our observations regarding increased nest height in urban settings align with findings by Møller (2010), who noted that urban birds often modify their nesting strategies to mitigate risks associated with anthropogenic disturbances and different predation pressures in city environments. This behavior aligns with adaptive responses to human-induced disturbances, such as pedestrian traffic and infrastructure development, as noted in other thrush species (Aydinyan et al., 2022). The preference for nesting in natural landscapes—groves, parks, and urban forests—rather than heavily modified urban centers, suggests a limited degree of synanthropization in this population. While previous studies have documented extensive synanthropization across Eurasia (Matsyura & Zimaroyeva, 2016), our results indicate that the Nagorno-Karabakh population maintains a stronger reliance on natural or semi-natural habitats.

Phenology and Environmental Influences

The onset of egg-laying in late March is primarily governed by ambient temperature, with a marked threshold around +10°C. This phenological timing is notably earlier than in the Central Caucasus (Telpova, 2006; Vengerov, 2017) or northeastern Ukraine (Melnikov & Yarys, 2022), where laying typically begins in April. We attribute this early start to the milder spring climatic conditions of the study region. Furthermore, the significant negative correlation between laying date and clutch size (decreasing as the season progresses) is a widespread strategy in avian ecology, aimed at balancing the higher metabolic costs of later broods with decreasing food availability or increasing predation risk.

Behavioral Plasticity and Reproductive Success

Song thrushes in our study exhibited high behavioral plasticity relative to human presence. In contrast to the Common blackbird , song thrushes adopted more concealed behaviors in urbanized settings while remaining more vocal and open in forest glades. This "stealth" strategy in urban environments may be a survival mechanism to reduce nest detection by anthropogenic-associated predators.

Variations observed in egg measurements and clutch sizes can be attributed to several interacting factors: the age structure of the population, physiological state of the females, and the stability of food sources during the pre-laying period. The higher reproductive success in urban forests (94.4%) compared to bushes (79.8%) suggests that the vertical and structural complexity of forest habitats provides superior protection against both adverse weather and nest predation.

Conclusions : In conclusion, our study of the nesting ecology of song thrush in Stepanakert city and its surrounding areas reveals several key patterns:

1. Song thrushes exhibit sedentary behavior in the studied areas, predominantly nesting in urban forests, cemeteries, orchards, and bushes.
2. There is a discernible selectivity among song thrushes for specific 4 types: out of the 278 nests discovered, 172 (61,9%) were on broad-leaved trees, 43 (15,5%) were on coniferous trees, 53 (19,1%) in broad-leaved bushes, 10 (3,5%) in coniferous bushes.
3. The nesting period of song thrushes in the study area is prolonged, with the first stage of reproduction typically commencing in early March and the second stage at the end of May or the beginning of June. Nests are typically situated at an average height of 1.5-3.3 meters above the ground.
4. Variations in egg measurements suggest influences from factors such as population age structure, heterogeneity, nesting conditions, and the physiological state of birds.
5. Our observations indicate deviations in the length (Cv=10.5%), diameter (Cv=10.2%), and weight (Cv=10.2%) of song thrushes' eggs. We attribute these variations to population

differences, age structure, nesting conditions, the physiological state of birds, and the stability of their diet.

6. The relatively low fledging success rate of 52.2% in the existing bushes is likely attributed to their low height, which makes eggs and chicks more vulnerable to predation.

7. Out of 1,277 eggs observed in 269 nests across the study area, 1,119 chicks successfully hatched, representing 87.6% of the total number. However, only 818 chicks, or 73.1%, survived to the age of flight.

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Conflict of interest

The authors declare no conflict of interest.

Author contributions

V.H. and L.A. designed the study; fieldwork was conducted by all authors; L.A. performed statistical analyses; all authors contributed to writing and approved the final manuscript.

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