Journal of Animal & Plant Sciences, 35(5): 2025, Page: 1431-1445
ISSN (print): 1018-7081; ISSN (online): 2309-8694
https://doi.org/10.36899/JAPS.2025.5.0123

BREEDING ECOLOGY OF AVIAN SPECIES IN DHAP CHAPAK RIVERINE FOREST, DERA ISMAIL KHAN, PAKISTAN

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ABSTRACT

The breeding ecology is a vital aspect of the reproduction of avian species, enabling them to increase their populations. Nest site selection by bird species offers insights into habitat suitability, food resource availability and distribution, and the appropriateness of breeding grounds. In the Dhap Chapak riverine forest, this study investigated the breeding ecology of eight important avian species: common mynas (*Acridotheres tristis*), Asian paradise-flycatchers (*Terpsiphone paradisi*), great egrets (*Ardea alba*), Indian robins (*Saxicoloides fulicatus*), laughing doves (*Spilopelia senegalensis*), little cormorants (*Phalacro niger*), black drongos (*Dicrurus macrocercus*), and black kites (*Milvus migrans*) between February 2022 and August 2023. A total of 62 bird nests were identified across the eight species at four sampling sites in Dhap Chapak Riverine Forest. The nesting habitats and site selection patterns were species-specific, with nests differing in shape, size, height, and material composition. Among the observed species, the laughing dove (*Spilopelia senegalensis*) was the most numerous (15 nests), while the Indian paradise flycatcher (*Terpsiphone paradisi*) was the least common (only two nests). Notably, the frequency of nests varied significantly across species and locations, with Site II exhibiting the highest nest density (21 nests). Our findings also reveal specific breeding ecology patterns for several species. For instance, the black kite (*Milvus migrans*) demonstrated high egg-hatching and chick-fledging success (100%), whereas the laughing dove had a lower fledging success rate of 66.67%. The nests of each species were often built in distinct tree species, such as *Acacia nilotica* for the black kite and *Eucalyptus camaldulensis* for the common myna (*Acridotheres tristis*), indicating preferences for particular tree types. Average egg dimensions and incubation periods significantly varied between species, contributing to the understanding of their breeding behaviors. Based on these findings, it was concluded that the Dhap Chapak Riverine Forest is an ideal habitat and breeding ground for many bird species.

Key Words: Breeding, Clutch size, Ecology, Vegetation, Riverine Forest, Fledging

Published first online August 23, 2025 Published final September 30, 2025

INTRODUCTION

Birds construct nests primarily to support reproduction and ensure the survival of their offspring, wherein the nests perform essential functions in various stages of their life, including reproduction, protection, environmental measures, and survival (Mahmood *et al.,* 2018). Nesting is essential for bird reproduction and for laying eggs and raising chicks (Steenhof and Newton, 2007). Among the significant factors that drive birds to build their nest is their relationship with vegetation structure and composition (Dial, 2003). Usually, birds select trees, shrubs, and grasses that provide shelter from predators and harsh weather conditions. In many instances, nest predation is the leading cause of nest failure and negatively affects recruitment (Conner *et al*., 2010; Ellis-Felege *et al*., 2013; Rader *et al*., 2007; Staller *et al.*, 2005). The best nesting sites are near food sources, offer camouflage from predators, and provide insulation from severe weather. These locations are often

challenging for potential predators to access, thus minimizing the risk of nest and chick predation (Hartman and Oring, 2003). Additionally, they help reduce the chances of embryo mortality.

Breeding ecology plays an important role in bird reproduction, as it increases the number of individuals. Consequently, it affects survival and population parameters for avian species in particular habitats (Wu *et al.*, 2014). Bird species build nests from various materials, such as feathers, twigs and sticks of plants, grass material, hair, mud, and inside soil through tunnel digging and secretions (Nores and Nores, 1994). Consequently, nest location, height, size, shape, and type varied from species to species depending on the size, foraging guild, diversity of food resources, and microclimate conditions (Dalley *et al.,* 2009; Rangel-Salazar *et al.*, 2008). A bird's nest is often built in different places, including houses, rocks, towers, trees, shrubs, grasses, soil, and tunnels (Perez et al., 2023). Therefore, bird nest site selection is a critical decision based on its ecology, resource availability, and protection (Cody, 1981). In addition to identifying and conserving nesting areas, understanding the breeding behaviors of avian species provides essential insights for bird population conservation. Nest site selection is vital for successful reproduction, as birds build nests to lay and incubate their eggs following a thorough investigation. Afterward, chicks hatch from the eggs, and recruitment begins.

To quantify the breeding ecology of avian species, clutch size, hatchling success, parental care, and successful fledglings are essential parameters. Avian breeding behavior varies from species to species. Breeding ability and available resources at the current location significantly determine clutch size ranges within species. Clutch size varies from 2-9 eggs in birds, particularly in passerine species. Birds carefully select nesting sites that meet their basic needs, such as an abundant food supply, safety from predators, and suitable foraging areas. After satisfaction, birds start nest building, followed by egg laying. Even though sometimes they laid the first egg, if they found it unsuitable, they left it and opted for another suitable site because predation causes the mortality of eggs and chicks (Pratt and Winkler, 1985; Rana, 1986 Bestman and Bikker-Ouwejan, 2020; Prochniak *et al.*, 2025).

Different factors significantly impact the nest site selection of avian species, including adverse effects caused by climate change. A variety of predators (carnivorous birds, wild carnivorous reptiles (such as snakes and lizards), domestic predators (such as cats and dogs), and the availability of resources all contribute to predation pressure. The bird selects an appropriate site that offers safety to avoid this situation and to ensure the safety of eggs and chicks. It has been observed (Dunn et al., 2010) that birds living at high altitudes have larger clutch sizes, as food is abundant. As a result of geographical location, Great Egrets tend to hatch larger clutches at higher latitudes (Henny and Bethers, 1971; Pettifor *et al.,* 1988). The size of the egg and the time it takes to incubate are directly proportional in birds. Birds with long incubation periods don't have an advantage regarding fitness. However, higher temperatures and the need to develop the offspring may lead to an extended incubation period (Boersma, 1982; Ricklefs, 1993). Depending on the incubation period, hatching broods may be synchronous or asynchronous. It has also been shown that hatching synchronously or asynchronously affects hatch development and survival rates (Clark and Wilson, 1981). avian breeding ecology has been studied globally, little is known about species-specific behaviors in the Dhap Chapak Riverine Forest. This study aimed to investigate the breeding behavior of eight significant avian species within the Dhap Chapak Riverine Forest.

MATERIALS AND METHODS

***Study area*:** This study was conducted at the Dhap Chapak riverine forest, located between 31° 44' 15" N and 70.9° 41' 12" E along the Indus River in District Dera Ismail Khan, Pakistan (Figure 1). The selected sites represent key variations in habitat types, ranging from water-rich riverine forests to agricultural lands, providing a comprehensive overview of breeding ecology. The area's topography is undulating, and the vegetation includes a variety of trees: Indian siris (*Albizia lebbeck*), Chinaberry (*Melia azedarach*), Gum Arabic tree *(Acacia nilotica)*, Black poplar (*Populus alba*), neem tree (*Azadirachta indica*), and Shisham (*Dalbergia sissoo*), along with shrubs such as Ghaz (*Tamarix dioica*), Peelu (*Salvadora oleoides*), Karira (*Capparis decidua*), Wild sugarcane (*Saccharum munja*), Assyrian plum (*Cordia myxa*), and Narrowleaf cattail (*Typha angustifolia*). Study sites 1 and 2 were riverine forests predominantly composed of *A. nilotica, S. verticillata, S. spontaneum*, and *T. angustifolia*. Sites 3 and 4 were agricultural lands, featuring plantings of *A. lebbeck*, *M. azedarach*, *A. nilotica*, and bordered by *P. alba,* bermudagrass (*Cynodon dactylon*), green amaranth (*Amaranthus viridis*), finger grass (*Digitaria ciliaris*), tall fleabane (*Conyza sumatrensis*), prickly chaff flower (*Achyranthes aspera*), camelthorn (*Alhagi maurorum*), coco grass (*Cyperus rotundus*), *along with T. angustifolia* grasses and herbs (Table 1). In the Dhap Chapak forest, 13933 bird individuals from 43 species belonging to 21 families were recorded by (Nisa *et al.,* 2021). The species list included 21 terrestrial species and 22 waterbird species.

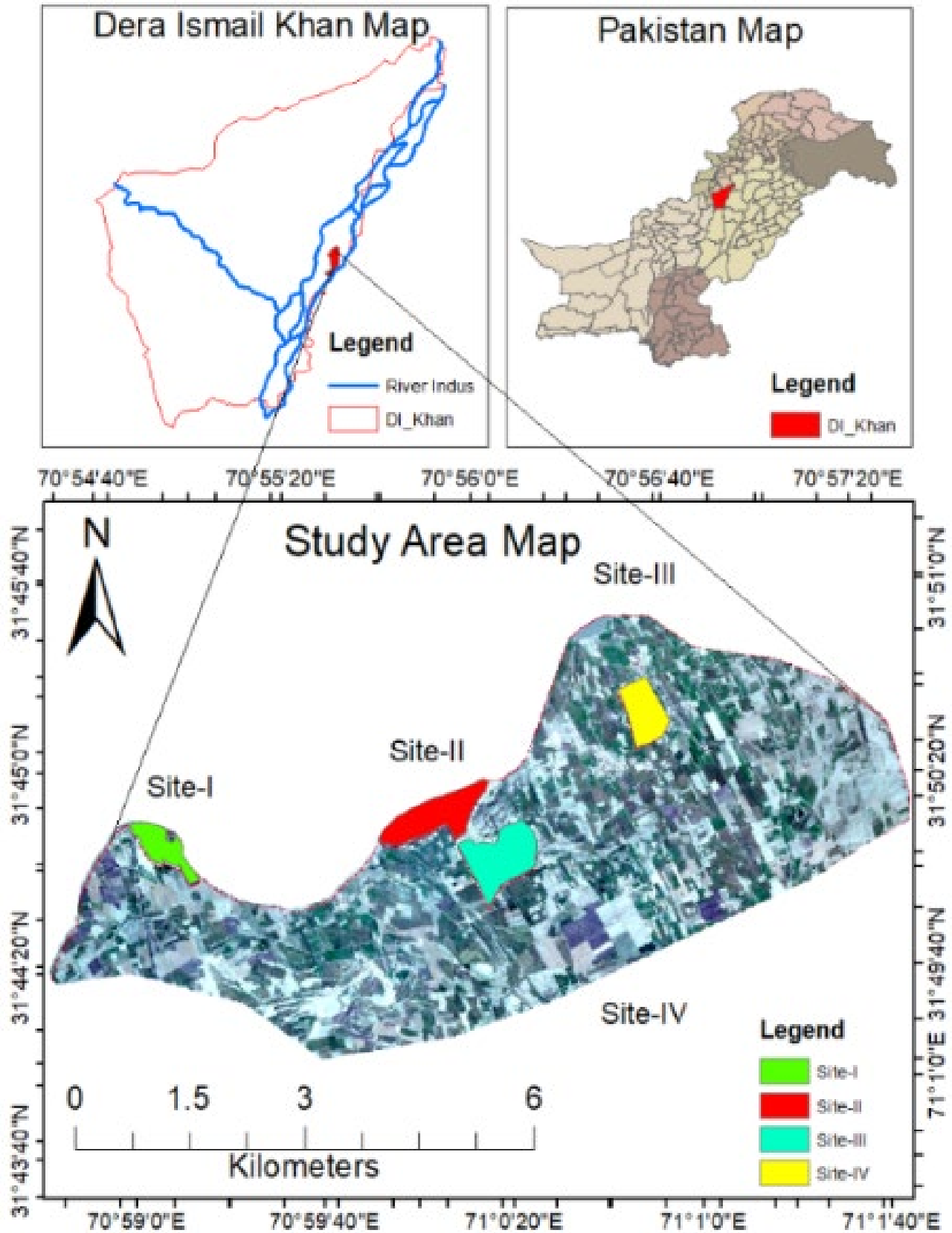


Fig.1. A GIS-based map showing the location of Conducted study sites at Dhap Chapak forest, District Dera Ismail Khan, Pakistan.

Table 1: Details about four selected sampling sites at the Dhap Chapak forest, D.I.Khan, Pakistan

Site No	Geographical Coordinates	Type of site
I	31º 75′ 90' 71″ N , 70º 94′ 81′ 07″ E	Riverine forest with sufficient water
II	31º 78′ 82' 03″ N , 70º 96′ 12′ 03″ E	Terrestrial riverine forest
III	31º 79′ 14' 27″ N , 70º 97′ 31′ 72″ E	Agricultural land adjacent to riverine forest
IV	31º 81′ 42' 51″ N , 70º 96′ 42′ 48″ E	Agricultural land along the river is devoid of forest

***Determining Breeding Ecology of Bird Species in Study Area*:** From February to August 2022 and 2023, data were collected on the nest site selection and breeding ecology of avian species in the Dhap Chapak Riverine Forest. In the study area, we selected four potential sites, which include (i) riverine forest with sufficient water, (ii) terrestrial riverine forest, (iii) agricultural fields adjacent to the riverine forest, and (iv) agricultural fields along the river that lack forest cover (Table 1). Various avian species breed in riverine forest vegetation for safety and to find nearby food sources, which led to the selection of these four sites. The tree canopy provides shelter from harsh weather and protection from predators. It may also be because some bird species, such as the Great White Egret and the Little Cormorant, have easy access to food resources and avoid traveling long distances to catch them. Additionally, some species frequently nest in the dry land of agricultural fields adjacent to riverine forests with scattered trees, such as Black Kites, Laughing Doves, Asian Paradise-Flycatchers, and Black drongos. Invertebrates, especially insects, are a major advantage at this site as they serve as the main source of nutrition for the chicks.

Furthermore, some species prefer to build their nests in areas without vegetation. Nests were constructed in grasses that offered shelter from predators and had abundant food resources. These were major reasons for selecting the four sites to determine the breeding ecology of avian species in the Dhap Chapak riverine forest in Dera Ismail Khan, Pakistan.

Field surveys were conducted weekly or four times a month, totaling 56 surveys over 14 months. The sampling sites were selected based on accessibility. An observer camouflages himself next to the nesting site to avoid disturbing the birds, as disturbances negatively affect the breeding ecology of avian species. Observations took place when birds left their nests to forage. To gain a closer view, binoculars (10 x 50), a digital DSLR camera (Nikon D7200), and a Sigma lens with a focal length of 150-600mm were utilized. Plants, including trees, shrubs, and grasses, were identified as the locations where nests were constructed. Additionally, nest height, size, shape, distance from foraging sites, presence of food resources, and camouflage were assessed. The height of the tree and nest was measured using a clinometer.

Nests were examined regularly for data collection on various aspects of breeding ecology. In addition, trapping cameras were installed carefully above the nest to document the breeding ecology of avian species, i.e., egg laying duration, egg fecundity, incubation period, hatching success, and chick fledging time, egg and chick predation, respectively. The egg length and width were also determined. A Vernier caliper and a digital weighing scale determined the egg weight. We also recorded nest construction materials, clutch sizes, the fecundity of eggs, incubation periods, hatching success, chick fledging, egg predation, and chick predation by trapping cameras were installed carefully above the nest to document the breeding ecology of avian species. The height of the tree and nest was recorded using a Clinometer. Nests were examined regularly for data collection on various aspects of breeding ecology. In addition, trapping cameras were installed carefully above the nest to document the breeding ecology of avian species, i.e., egg laying duration, egg fecundity, incubation period, hatching success, and chick pledging time, egg and chick predation, respectively. The egg length and width were also determined. A Vernier caliper and a digital weighing scale were used to determine the egg weight. The egg volume was measured by employing the formula (Hoyt, 1979): $V = 0.509 \times L \times B2 / 1000$, where L denotes the Length of the egg, and B denotes the Width / Breadth of the egg. The methodology was followed as described (Bi *et al.,* 2020*;* Fuenzalida *et al.,* 2023*;* Sadam *et al.*, 2022).

***Statistical Analysis*:** Data were entered into an Excel sheet, and the mean ± standard error was calculated for various parameters, including tree height, nest height, nest diameter, egg size, egg weight, egg volume, nesting period, incubation period, and clutch size using SPSS Version 27.0 (IBM Corp, 2020; George and Mallery, 2021)

RESULTS

Bird Nest Occupancy and Site Selection: Sixty-two bird nests from eight species were spotted and identified at four sampling sites along the Dhap Chapak Riverine Forest. Nests were constructed from varied materials and came in diverse shapes, heights, and sizes. The nests of each species exhibited differences in size (length, width, depth), height, shape, and nesting materials. The findings clearly indicated that bird nests and breeding environments differed among species. Some species

utilize old nests, but they renovate the damaged sites before use, while others construct new nests for breeding. After successful chick fledging, these nests are not reused. Results showed that laughing doves bred most abundantly in the study area, with fifteen nests. In contrast, the Indian paradise flycatcher was the least common, building only two nests. However, nest frequencies varied among species in the study area (Table 2).

Table 2: Nest occupancy and site selection by avian species among four potential sites of Dhap Chapak Riverine Forest, Dera Ismail Khan, Pakistan

Common Name	Scientific Name	Sampling sites				Total nests
		I	II	III	IV	
Common myna	*Acridotheres tristis*	0	4	3	1	8
Asian Paradise flycatcher	*Terpsiphone paradisi*	0	2	0	0	2
Great egret	*Ardea alba*	6	0	0	0	6
Indian robin	*Saxicoloides fulicatus*	0	2	4	2	8
Laughing dove	*Spilopelia senegalensis*	2	3	8	2	15
Black drongo	*Dicrurus macrocercus*	0	4	3	1	8
Little cormorant	*Microcarbo niger*	9	0	0	0	9
Black kite	*Milvus migrans*	0	6	0	0	6
Total		**17**	**21**	**18**	**6**	**62**

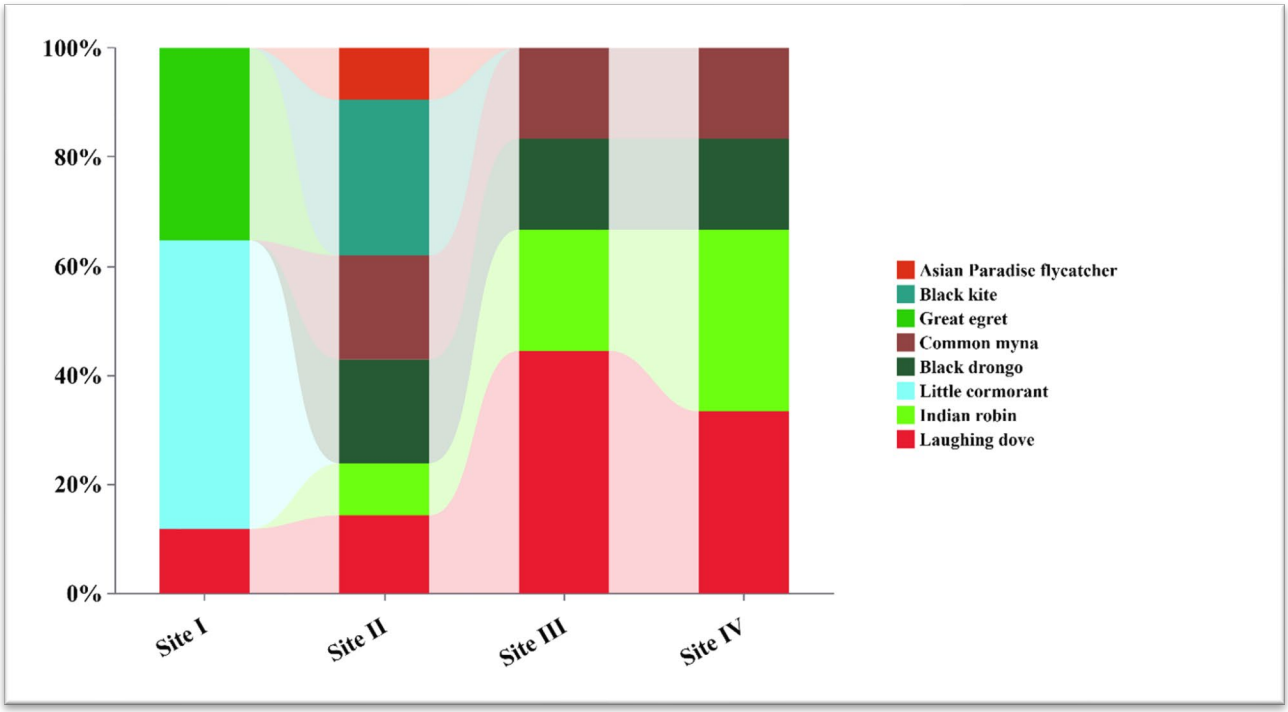


Fig 2: Showing the nest presence at different sites

Four sampling sites in the study area detected 62 nests of eight bird species (Figures 1, 2; Table 2). We recorded four species from the order Passeriformes, including the Asian *paradise* flycatcher (*Terpsiphone paradise*), the Indian robin (*Saxicoloides fulicatus*), the black drongo (*Dicrurus macrocercus*), and the common myna (*Acridotheres tristis*). In contrast, one species from order Pelecaniformes: the great egret (*Ardea alba*) and one species from Suliformes the little cormorant (Phalacrocoracidae). Additionally, the laughing dove (*Spilopelia senegalensis*) is classified under the Columbiformes, while the black kite falls under the Accipitriformes. A total of 21 nests were detected at Site II, which is higher than at the other sites. It was observed that laughing dove nests were the most numerous (15), followed by the little cormorant with 9 nests. However, only two nests of the Indian paradise flycatcher were found at Site II (Table 2).

Breeding Ecology

Black Drongo: A total of eight Black Drongo (*Dicrurus macrocercus*) nests were recorded at sites II, III, and IV (Table 2). Of these nests, n = 5 were found in *Acacia nilotica* and n = 3 in *Azadirachta indica*. The average tree height was 7.28 ± 0.13 m, while the nest height was 6.34 ± 0.14 m above the ground. The mean diameter of a nest was 20.60 ± 0.15 cm (Table 3). On average, an egg weighed 5.30 ± 0.07 grams, measured 24.50 ± 0.18 millimeters in length, and had a width of 17.98 ± 0.11 millimeters. A clutch size of 3.50 ± 0.27 was observed, with an egg volume of 4.04 ± 0.07 $cm^{3,}$ The incubation period lasted 13.63 ± 0.18 days, and the nestling period was 15.88 ± 0.30 days. The hatching success rate for the eggs was 81.25 ± 6.25%, and the fledging success rate was 15.88 ± 0.30%. A Black Drongo nest is round and cup-shaped with rough edges (Fig. 3D). It is constructed using dry branches, leaves, and grasses (with a thin layer of sticks and twigs), and the eggs are pale, cream, or red in color, respectively.

Table 3: Mean comparison for the height of the tree, nest height, and nest diameter regarding different species.

Species	n	Height of Tree	Height of Nest	Nest Diameter
Black drongo	8	7.28 ± 0.13c	6.34 ± 0.14cd	20.60 ± 0.15e
Black kite	6	9.67 ± 0.06a	9.47 ± 0.08a	26.93 ± 0.09a
Common myna	8	9.38 ± 0.06a	7.86 ± 0.05b	24.10 ± 0.19c
Little cormorant	9	9.62 ± 0.09a	7.88 ± 0.12b	24.69 ± 0.15b
Great egret	6	9.43 ± 0.13a	8.16 ± 0.09b	21.18 ± 0.21d
Asian paradise flycatcher	2	9.23 ± 0.00a	7.98 ± 0.00b	20.30 ± 0.70ef
Indian robin	8	7.69 ± 0.11b	6.06 ± 0.11d	21.02 ± 0.10d
Laughing dove	15	9.26 ± 0.07a	6.62 ± 0.12c	20.13 ± 0.07f
P-value		0.000**	0.000**	0.000**

This means sharing similar letters in a column is statistically non-significant (P>0.05).
NS = Non-significant (P>0.05); * = Significant (P<0.05); ** = highly significant (P<0.01)

***Black Kite*:** The Black kite (*Milvus migrans*) constructed its nests at three of four sites, namely II, III, and IV (Table 2). All nests were located in *Acacia nilotica* trees with an average height of 9.67 ± 0.06 meters. Compared to other tree species, the Arabian gum tree was preferred by black kites for nesting. The nests were positioned at 9.47 ± 0.08 meters above ground level. The average nest diameter was 26.93 ± 0.09 cm (Table 3). Each egg weighed, on average, 40.53 ± 5.32 grams, measured 69.39 ± 6.04 mm in length, 50.76 ± 6.14 mm in width, and was colored white and brown dough. The mean egg volume was 23.17 ± 0.22 $cm^{3,}$ and the egg clutch size averaged 2.00 ± 0.00 (Table 4). Egg incubation lasted 33.67 ± 0.56 days, while the nestling period extended to 45.67 ± 0.76 days. The egg hatching and chick fledging success rate was 100.00 ± 0.00% (Table 5). Black kites constructed their nests using rough edges, dry branches, bulky sticks, and feathers.

***Common Myna*:** During the study period, eight common myna nests (*Acridotheres tristis*) were located in *Eucalyptus camaldulensis* and *Acacia nilotica* at three sites within the study area (Table 2). Three nests were discovered on *E. camaldulensis* and five on *A. nilotica,* at a height of 7.86 ± 0.05m. The average nest diameter was 24.10 ± 0.19 cm (Table 3). An average egg weighed 6.19 ± 0.05g, measuring 29.05 ± 0.21mm in length and 18.01 ± 0.14mm in width. The mean egg volume was 4.81 ± 0.10$cm^{3,}$ and the average clutch size was 3.63 ± 0.26 (Table 4). Furthermore, the incubation period lasted 18.63 ± 0.32 days, while the nestling period lasted 23.00 ± 0.78 days. The hatching success rate for eggs was 96.88%, and the chick fledging success rate was 95.83% (Table 5). The nests of the common myna were circular and made of dry grass leaves, and the eggs were turquoise in color.

***Little Cormorant*:** In total, nine nests of little cormorants (*Phalacro niger*) were recorded on *Acacia nilotica* trees, which have an average height of 99.62 ± 0.09 m. No nests were spotted in the other three sites of the study area (Table 2). Tree branches and sticks were used to construct the nests above the ground at an average height of 7.88 ± 0.12 m. The nest diameter measured 24.69 ± 0.15 cm (Table 3). The average egg weight was 46.17 grams, with a length of 57.48 mm and a width of 33.45 mm. The average egg volume and clutch size were 32.69 ± 0.24 cm^3 and 4.44 ± 0.24, respectively (Table 4). The mean incubation period for little cormorant eggs was 23.33 ± 0.33 days, while the nestling period lasted 26.22 ± 0.22 days. The hatching success rate for the eggs was 100.00%, and the fledging success rate for the chicks was 81.67% (Table 5). Nests were constructed using tree branches and sticks, forming a plate-shaped structure. The eggs were unmarked blue and green.

Table 4: Mean comparison for weight of egg (gm), length of egg (mm), width of egg (mm), volume of egg (cm²) and clutch size (eggs) regarding different species.

Species	n	Weight of Egg (gm)	Length of Egg (mm)	Width of Egg (mm)	Volume of Egg (cm²)	Clutch Size (eggs)
Black Drongo	28	5.30 ± 0.07	24.50 ± 0.18	17.98 ± 0.11	4.04 ± 0.07	3.50 ± 0.27
Black Kite	12	40.53 ± 5.32	69.39 ± 6.04	50.76 ± 6.14	23.17 ± 0.22	2.00 ± 0.00
Common Myna	29	6.19 ± 0.05	29.05 ± 0.21	18.01 ± 0.14	4.81 ± 0.10	3.63 ± 0.26
Little cormorant	41	46.17 ± 0.25	57.48 ± 0.36	33.45 ± 0.17	32.69 ± 0.24	4.44 ± 0.2
Great White Egret	25	21.50 ± 0.34	40.51 ± 0.33	27.68 ± 0.23	15.89 ± 0.36	4.17 ± 0.17
Asian Paradise Flycatcher	6	5.05 ± 0.06	19.02 ± 0.06	15.30 ± 0.24	2.27 ± 0.08	2.50 ± 0.50
Indian Robin	24	5.19 ± 0.05	19.62 ± 0.21	15.17 ± 0.17	2.31 ± 0.07	3.00 ± 0.19
Laughing dove	30	5.46 ± 0.03	24.32 ± 0.08	18.81 ± 0.07	4.37 ± 0.04	2.00 ± 0.00

***Great Egret*:** Six nests of the Great Egret (*Ardea alba)* were recorded at Site I, while no nests were detected at the other three sites, namely Site II, Site III, and Site IV (Table 2). The Great Egret nested in *Acacia nilotica* trees with an average height of 9.43 ± 0.13 meters. However, the Great Egret built its nest 8.16 ± 0.09 meters above the ground, indicating a preference for nesting in the crowns of trees. The mean nest diameter was 21.18 ± 0.21 cm (Table 3). The mean weight of the egg was 21.50 ± 0.34 grams, with an egg length of 40.51 ± 0.33 millimeters and a width of 27.68 ± 0.23 millimeters. The average volume of the egg was 15.89 ± 0.36 cm³, and the clutch size averaged 4.17 ± 0.17 (Table 4). Furthermore, the egg incubation period was 22.17 ± 0.60 days, while the nestling period lasted 25.33 ± 0.61 days. The egg-hatching success rate was 88.33 ± 5.27%, and the chick-fledging success rate was 95.83 ± 4.17% (Table 5). The nest shape of the Great Egret was plate-like (Fig 3B), constructed using tree branches, grasses, long sticks, and twigs. The eggs were colored sea green and pale greenish-blue.

***Asian Paradise-Flycatcher*:** Only two nests of the Indian paradise-flycatcher (*Terpsiphone paradisi)* were recorded at Site III, indicating that this species avoided the other three sites (Table 2). They built their nests in *Eucalyptus camaldulensis* at an average height of 9.23 ± 0.00 meters. The Asian paradise-flycatcher constructed its nest at 7.98 ± 0.00 meters above the ground. The average nest diameter was 20.30 ± 0.70 cm (Table 3). The average egg weight was 5.05 ± 0.0 grams, with an egg length of 19.02 ± 0.06 mm and an egg width of 15.30 ± 0.24 mm. The average egg volume was 2.27 ± 0.08 cm³, and the egg clutch size was 2.50 ± 0.50 (Table 4). The incubation period for the eggs was 14.00 ± 0.00 days, while the nestling period lasted 16.50 ± 0.50 days. The egg-hatching success rate was 100.00 ± 0.00%, and the chick-fledging success rate was also 100.00 ± 0.00% (Table 5). The Asian paradise-flycatcher built a conical-shaped nest (Fig 3A) using grasses, mosses, and plant fibers. The eggs of the Asian paradise-flycatcher were white.

Table 5: Mean comparison for incubation period (days), hatching success, nestling period (days), and fledging success (%) regarding different species.

Species	n (Total nest)	Incubation Period (days)	Egg Hatching Success Rate	Nestling Period (days)	Chick Fledging Success Rate (%)
Black Drongo	8	13.63±0.18	81.25±6.25	15.88±0.30	96.88±3.13
Black Kite	6	33.67±0.56	100.00±0.00	45.67±0.76	100.00±0.00
Common Myna	8	18.63±0.32	96.88±3.13	23.00±0.78	95.83±4.17
Little Cormorant	9	23.33±0.33	100.00±0.00	26.22±0.22	81.67±5.46
Great White Egret	6	22.17±0.60	88.33±5.27	25.33±0.61	95.83±4.17
Asian Paradise-flycatcher	2	14.00±0.00	100.00±0.00	16.50±0.50	100.00±0.00
Indian Robin	8	12.63±0.26	100.00±0.00	14.13±0.40	100.00±0.00
Laughing Dove	15	12.33±0.13	90.00±5.35	14.13±0.19	66.67±10.5
P-value		<0.0001	0.052	<0.0001	0.008

***Indian Robin*:** The Indian robin (*Saxicoloides fulicatus*) is a small passerine bird that constructed eight nests across three sites: II, III, and IV within the study area (Table 2). This bird built three nests in *Acacia nilotica* and five in *Eucalyptus camaldulensis*. The nests were deep, cup-shaped structures made from grasses, leaves, and roots. Females lay sky-blue and blue-green eggs in the nest. The height of the nesting trees averaged 7.69 ± 0.11 meters, while the nests were situated at an average height of 6.06 ± 0.11 meters above the ground. The mean

nest diameter was 21.02 ± 0.10 cm (Table 3). The average egg weight was 5.19 ± 0.05 g; the egg length measured 19.62 ± 0.21 mm, and the width was 15.17 ± 0.17 mm. The mean egg volume was 2.31 ± 0.07 cm³, and the clutch size averaged 3.00 ± 0.19 (Table 4). The egg incubation period was 12.63 ± 0.26 days, and the nestling period lasted 14.13 ± 0.40 days. The egg-hatching success rate for the Indian robin was 100.00 ± 0.00%, and the chick-fledging success rate was also 100.00 ± 0.00% (Table 5).

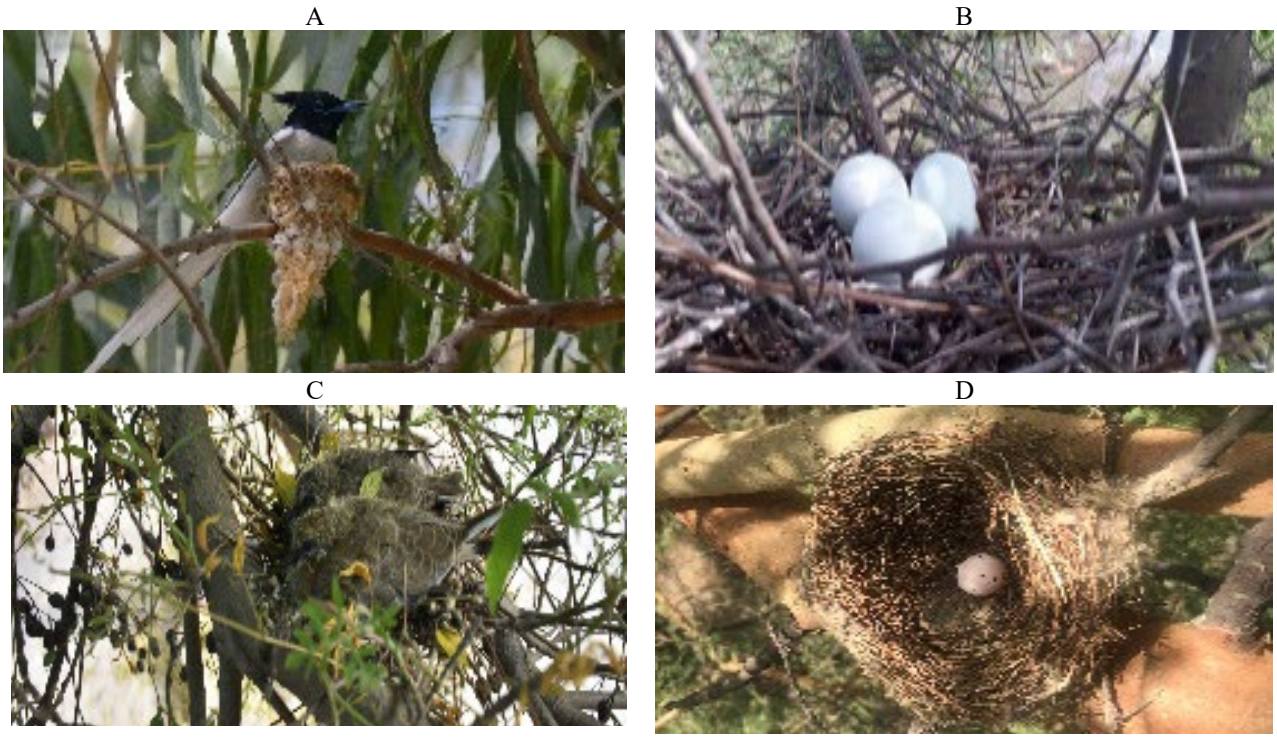


Figure 3: A; conical structure nest of Asian paradise-flycatcher, B; great egret eggs in the nest, C; nest of laughing dove constructed at *Azadirachta indica* tree, and D; nest of black drongo round the rough edges.

***Laughing Dove*:** A total **of** 15 nests of Laughing Doves (*Spilopelia senegalensis*) were recorded across three sites: II, III, and IV. However, no nests were detected in Site I (Tables 2, Fig 3C). The nests of the Laughing Dove were round in shape and made from tree leaves, shrubs, and roots. Out of the 15 nests, 9 were found in *Acacia nilotica* trees and 6 in *Azadirachta indica* trees. The average tree height was 9.26 ± 0.07 meters, with nesting heights of 6.62 ± 0.12 meters above ground level. The nest diameter measured 20.13 ± 0.07 cm (Table 3). The color of the Laughing Dove egg is white. The average egg weight was 5.46 ± 0.03 grams, with an egg length of 24.32 ± 0.08 mm and an egg width of 18.81 ± 0.07 mm. The mean egg volume for the Laughing Dove was 4.37 ± 0.04 cm³, and the clutch size was 2.00 ± 0.00 (Table 4). The average egg incubation period lasted 12.33 ± 0.13 days, while the nesting period lasted 14.13 ± 0.19 days, respectively. The egg-hatching success rate was 90.00 ± 5.35% (Table 5).

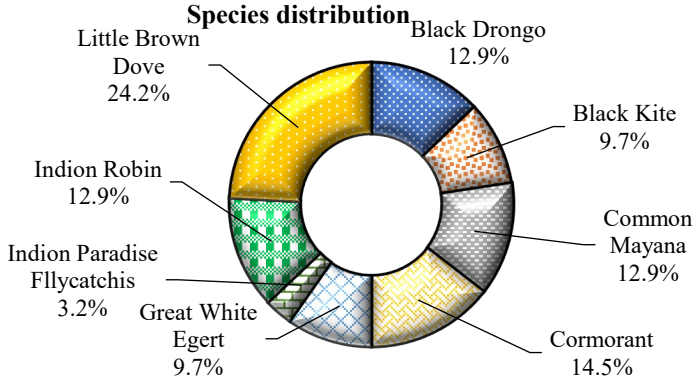


Fig4. Total species distribution (%) at Dhap Chapak forest Dera Ismail Khan.

Table 6: Correlation matrix

	Tree height	Nest height	Nest diameter	Weight of egg	Length of egg	Width of egg	Volume of egg	Clutch size (eggs)	Incubation period	Hatching success	Nestling period	Fledging success
Tree height	1.000											
Nest height	0.735**	1.000										
	0.000											
Nest diameter	0.507**	0.804**	1.000									
	0.000	0.000										
Weight of egg	0.484**	0.635**	0.723**	1.000								
	0.000	0.000	0.000									
Length of egg	0.501**	0.734**	0.796**	0.817**	1.000							
	0.000	0.000	0.000	0.000								
Width of egg	0.442**	0.688**	0.682**	0.636**	0.946**	1.000						
	0.000	0.000	0.000	0.000	0.000							
Volume of egg	0.519**	0.626**	0.712**	0.959**	0.891**	0.734**	1.000					
	0.000	0.000	0.000	0.000	0.000	0.000						
Clutch size (eggs)	-0.030	0.125	0.207	0.330**	0.225	0.017	0.417**	1.000				
	0.815	0.335	0.106	0.009	0.078	0.898	0.001					
Incubation period	0.532**	0.888**	0.876**	0.783**	0.874**	0.805**	0.766**	0.179	1.000			
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.164				
Hatching success	0.110	0.098	0.262*	0.214	0.192	0.138	0.196	0.054	0.190	1.000		
	0.397	0.446	0.039	0.095	0.135	0.283	0.127	0.675	0.140			
Nestling period	0.492**	0.875**	0.869**	0.714**	0.830**	0.796**	0.676**	0.070	0.973**	0.189	1.000	
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.588	0.000	0.141		
Fledging success	-0.175	0.221	0.196	0.032	0.075	0.072	0.002	0.198	0.186	-0.043	0.190	1.000
	0.173	0.085	0.126	0.805	0.564	0.577	0.988	0.123	0.148	0.740	0.139	

Upper values indicated Pearson's correlation coefficient; Lower values indicated a level of significance at 5% probability. * = significant (P<0.05); ** = highly significant (P<0.01)

DISCUSSION

Breeding activities enable bird species to increase their populations and survive on Earth. The breeding ecology of avian species is closely related to their distribution and access to food resources. Each bird species breeds at different sites and times, depending on its behavior. Breeding occurs in areas with abundant food resources or nearby, allowing easy access while remaining safe from disturbances and predators. Such findings have also been reported by (Ferreira *et al*., 2025; Ucero *et al*., 2025). Avian species prefer to breed in locations that provide shelter from harsh weather and predators. For breeding purposes, birds often consider various factors, such as shelter, nesting material, safety, food availability, and suitable foraging sites when selecting their nesting areas. Reproductive success indicates resilience to environmental change, resource acquisition, and chick survival rates among birds. Birds typically breed in optimal sites rich in resources, which allows them to produce more offspring and withstand environmental perturbations successfully. Previously, such findings have been reported by (Foufopoulos *et al*., 2023; Kurucz *et al.*, 2021) noted that avian species nesting in shrub species, such *as Columba livia, Columba palumbus, Turdus merula,* and *Passer domesticus*, were found to be richer in species and more abundant than other birds in Hungary. Due to their year-round fruit production and dense spiny vegetation, these shrub species reduce predator vigilance and help disguise nests from predators. Additionally, in forested areas, birds tend to nest and limit their travel to decrease energy expenditure and minimize predation risks (~~Clair, 2005;~~ Lima, 2009; Mainwaring et al., 2014; van Eerden et al., 2025).

In addition to minimizing predation risk, ensuring visibility for predators and providing sufficient food resources for chicks and adults are among the main objectives of considering these factors. Consequently, these factors contributed to embryonic and chick mortality and failure to reproduce (Lima, 2009; Wang and Hung, 2019). This leads to a decline in the population of avian species. Nesting sites and materials selected by birds differed depending on their behavior, size, and availability (Shane, 2012). Birds built nests in open areas, under tree canopies, on the ground, in tunnels, in grasses, on branches, inside tree boles, inside caves, in water (floating), in creeks, on roofs, on poles, on soil, etc. Nest construction is a joint effort between males (i.e., the laughing dove male collected the nesting material, and the female installed and adjusted the nest as reported (Brunton, 1997).

In contrast, the Asian Paradise-flycatcher female starts nest building, and later on, males join her in collecting nest material (Reza and Hasan, 2022). Sometimes, the nest is constructed by males, and females inspect the nest, while in other cases, the nest is built by only females. Upon satisfaction, paring and breeding activities began. The male and female often protect their nests and chicks from predators; once predators are spotted, they use various tactics to defend them (Hartman and Oring, 2003; Klvanova *et al.*, 2011; Lima, 2009).

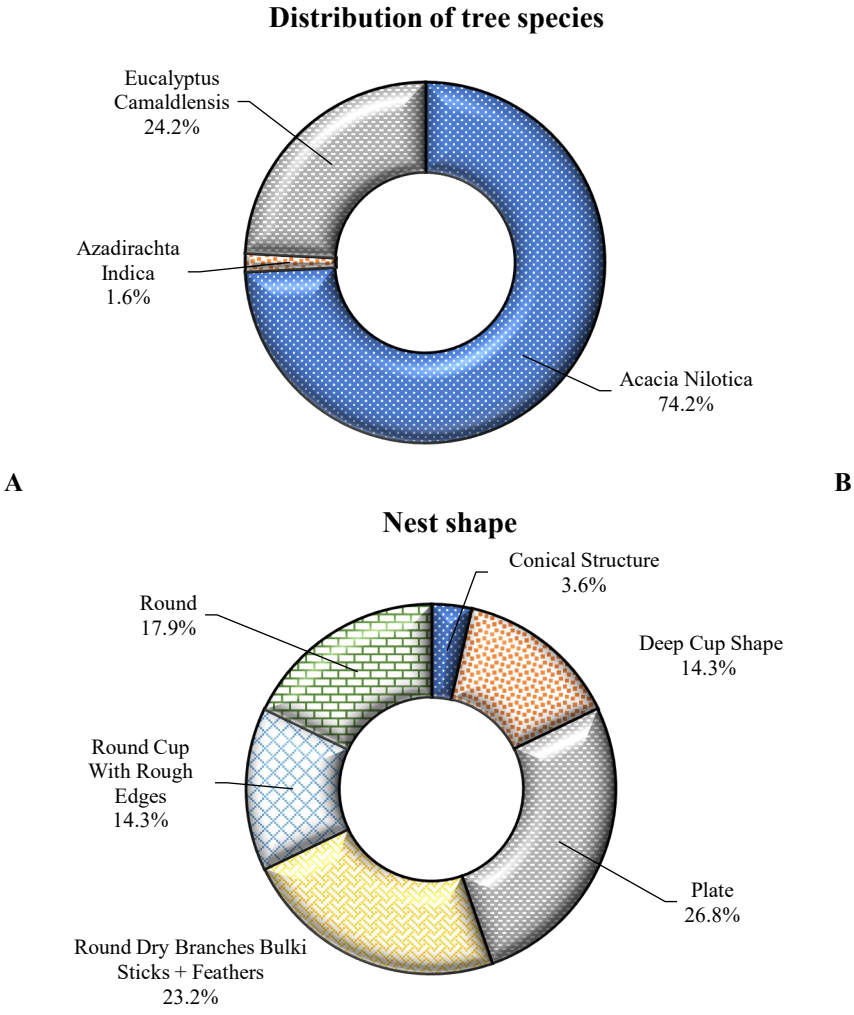
There was a significant variation between species in breeding ecology among avian species studied in this research. Each species has a particular breeding behavior, i.e., nest site selection varies from species to species; for example, some species prefer waterlogged riverine forests to terrestrial riverine forests, and others prefer agricultural fields adjacent to riverine forests and agricultural fields without vegetation along rivers. In addition, birds selected different types of trees to build their nests, such as Indian siris, Chinaberry, Gum Arabic tree, Black poplar, Neem tree, Shisham shrub; Ghaz, Peelu, Karira, Wild sugarcane, Assyrian plum and Narrow-leaf cattails with different heights. Black kites build nests in river red gum trees and gum Arabic trees, common mynas and Indian robins in neem trees and river red gum trees, little cormorants and Great egrets in gum Arabic trees, as well as Asian paradise flycatchers in river red gum trees. Bird species also constructed nests differently, i.e., some built their nests on the ground, others in the middle story, and some at the top (Table 3).

Researchers found that birds use heterogeneous nest materials to construct their nests (Dalley *et al.,* 2009; Rangel-Salazar *et al.,* 2008). Common mynas construct their nests using river red gum trees' leaves, Bermuda grasses (*Cynodon dactylon*), broadleaf hopebushes (*Dodonaea viscosa*), feathers, and other materials. Black drongos also used rootlets from white mulberry and chinaberry trees, river red gum branches, and grasses. Indian robins build their nests using grasses, roots, hair, feathers, and leaves from river red gum trees. Moreover, laughing doves construct fragile nests using sticks, roots, twigs, and grass. In other instances, (Yimer et al., 2024) reported similar findings. The Asian Paradise-flycatcher weaves a cobweb cup-shaped nest out of soft grasses, root and bark fibers, small twigs, mosses, dry leaves, and spider web. The same result has also been reported (Reza and Hasan, 2022). As high as possible, great egrets built their nests with twigs, stems, and sticks near the water of Gum Arabic trees and red gum trees. After renovation, the nest is re-used seasonally. During nest construction, both males and females were involved. In nest construction, one fly takes the stick, and the other weaves (adjusts) the sticks. As soon as the nest is completed, mating and egg-laying begin. Similarly, the little cormorant builds its nest from tree branches and sticks made from Indian siris, Chinese jujube, and Bermuda grass. Previously, it was reported that little cormorants used *Capsicum frutescens, Eucalptus citriodora, Coriandrum sativum, Cynodon datcylon, Enhydra*

fluctuans, Conchorus olitorius, Ziziphus jujube, Mangifera indica, and *Polygonim* species for nesting (Khan and Naher, 2009).

Moreover, results revealed the variation in the height of trees in which birds built their nests. A black kite, for instance, prefers trees having higher height to build its nest, while black drongo prefers trees having lower height. The nest diameters also varied among bird species, i.e., black kites built the most enormous nests, and Asian Paradise-Flycatchers built the most miniature nests. In addition, there was variability in clutch size among avian species, such as little cormorants laying more eggs and laughing doves laying fewer eggs. Little cormorants laid the most giant eggs in size, and Asian paradise-flycatcher laid the most miniature eggs. The egg weight between species also varied among bird species, e.g., heavy eggs were laid by little cormorants and light eggs by Asian Paradise-Flycatcher. The size and length of eggs also differ among species; the most giant egg was found in the nest of black kites, whereas the most miniature eggs were found in the nest of Asian paradise flycatchers. Indian robins laid the narrowest eggs, while black kites laid the widest.

Notably, the incubation period varied from species to species. The highest incubation period (days) was recorded in common myna, and the lowest in Indian robins. Previously, (Wani, 2020) also reported a similar incubation rate in common myna. Comparatively, Khinchi and Yadav (2014) reported an incubation period of approximately 13.7 to 13.10 days. It is evident from this that the incubation rate of common myna varies by region. As a result, the highest mean hatching success rates were recorded in Indian robins, black kites, little cormorants, and Asian paradise flycatchers. A wide range of nestling periods (days) was recorded in various species, e.g., the highest nestling period was recorded in black kites, and the lowest one in Indian robins and laughing doves. Likewise, the chick-fledging success rates varied from species to species, i.e., the highest success rate was recorded in black kite, Asian paradise-flycatcher, and Indian robin. In contrast, the lowest fledgling success rate was detected in the laughing dove.



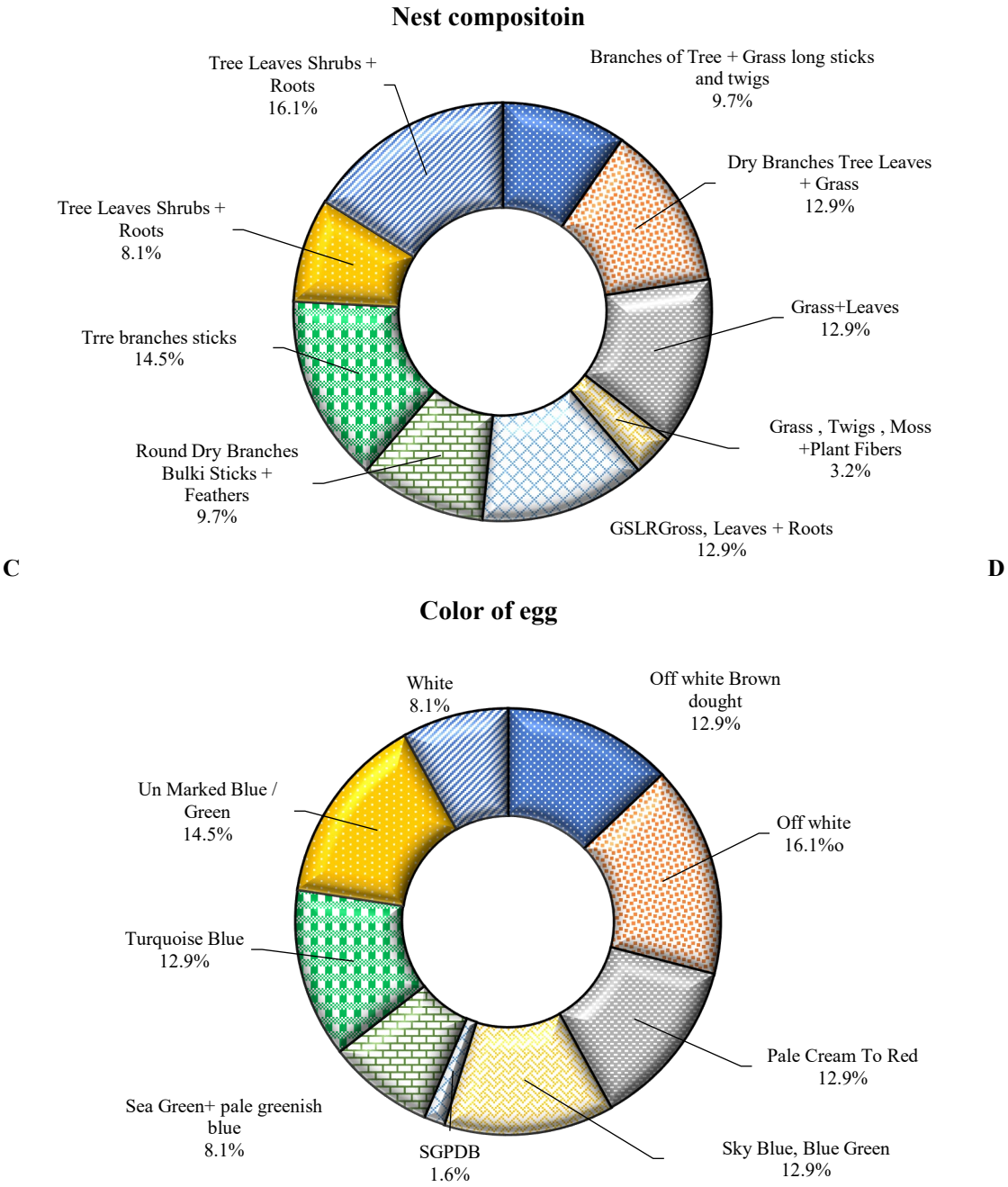


Fig 5. Showing (A)Distributions of tree species, (B) Nest shape, (C) Nest compositions, and (D) colour of the egg.

Conclusion: Our study concludes that Dhap Chapak Riverine Forest is a potential habitat for different bird species to exploit the available resources and use it as breeding grounds to increase their population. Accordingly, we recommend that future studies should focus on various ecological aspects. As a result of the research findings, wildlife ecologists and managers can develop a comprehensive management plan to conserve and protect bird species in this prevalent potential habitat for bird life.

Authors Contributions.

Inam Ullah: Conceived and designed the study, contributed to data collection and analysis, and wrote the manuscript.

Jabbar Khan: Assisted in study design, data collection, interpretation, and manuscript revisions; Muhammad Shuaib Khan: contributed to methodology development, data collection, and manuscript editing.

Muhammad Shoaib Khan. Assisted in manuscript review.

Tauheed Ullah Khan: Participated in data analysis and interpretation, providing technical support and manuscript revisions

Shawana Huma: Assisted in data collection, analysis, and manuscript review

Ramsha Zahra: Contributed to field data collection, data entry, and manuscript preparation.

Abdus Sami: Provided statistical analysis support, contributed to data interpretation, and assisted in manuscript revision; and

Muhammad Nawaz Rajpar: Supervised the study, contributed to manuscript preparation, and provided critical feedback.

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