

Influence of Nesting Habitat and Nest Emplacement

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The black francolin (*Francolinus francolinus*, Phasianidae) is a ground-dwelling bird found across Eurasia, including Pakistan. Understanding its breeding ecology is essential for conservation. This study explores how nesting habitat and site selection affect breeding success in the Totali Game Reserve. Results show that wetlands, particularly bush-covered areas, provide better protection for nests, leading to higher survival rates. These findings help us improve habitat management strategies for the species. Additionally, human activities including bird translocations may influence genetic diversity, highlighting the need for conservation efforts.

eggs

nests

morphometrics

Totali Game Reserve

Limited research exists on the breeding ecology of the black francolin (*Francolinus francolinus*) in northern Pakistan. This study assessed egg dimensions, clutch size, hatching, fledging, and overall breeding success across different habitats and nests ($n = 25$) at Totali Game Reserve, Buner. Generalized linear models (GLMs) were used to analyze the effects of nest site characteristics and nest traits on breeding parameters. Egg dimensions were consistent across sites whereas bush nests had slightly wider eggs. The average clutch size was 5.9 ± 1.7 eggs, with an average of 4.8 ± 1.0 hatchlings per nest. A total of 111 chicks fledged, averaging 4.4 ± 1.0 per nest, yielding an overall breeding success rate of 75.5%. Nests containing six eggs had higher hatching success (76.6%). GLMs results showed a significant positive relationship between clutch size and hatchling, while nest site and traits had no significant effects. However, fledgling success was positively influenced by hatchling numbers, with nests in wetland habitats yielding significantly more fledglings (4.6 ± 0.9) than those from dryland habitats (4.0 ± 1.2). These findings suggest Black Francolins prefer nesting in wetland areas in bushes, likely due to better protection and favorable conditions.

Ecological studies on francolins have gained significant attention because these birds serve as crucial indicators of environmental health ^{[1][2]}. Researchers have focused on these birds to explore the consequences of habitat changes and human-induced disturbances ^[3]. The black francolin (*Francolinus francolinus*) is distributed and breeds from Asia to the western Palearctic ^{[4][5][6]}. They have adapted to diverse habitats, and their breeding ecology ^{[7][8]}, and their presence or absence provide significant information about the integrity of ecosystems ^{[7][9]}. The black francolin exhibits a broad geographical distribution throughout Eurasia, extending from Cyprus and southern Turkey through the Middle East to South Asia ^[5]. Research conducted in Iran and the Himalayan region has investigated its habitat preferences, population densities, and breeding ecology, using MaxEnt modeling, which identified optimal habitats within the Sistan region ^{[9][10]}. Black francolin species are taxonomically classified into six subspecies: *F.f francolinus*, found in Cyprus, Turkey, Iraq, and Iran; *F.f arabistanicus*, inhabiting southern Iran and

western Iran; *F.f. asiae*, native to northern India; *F.f. henrici*, occurring in north Pakistan and western India; *F.f. bogdanovi*, distributed across Iran, Afghanistan, and Pakistan; and *F.f. melanonotus*, present in eastern India, Sikkim, and Bangladesh [5]. However, field observations and morphological characteristics have confirmed that the black francolin population in Totali Game Reserve belongs to the subspecies *F. f. henrici*. Therefore, it is essential to assess the influence of broader environmental factors, such as habitat degradation, human disturbance, and climate variability, on the success of black francolin breeding. Our study employs the Totali Game Reserve as a representative model and investigates the breeding ecology and generates broader insights into the habitat selection and success of black francolin breeding.

Successful breeding and survival depend on specific habitat conditions, such as vegetation cover and food availability [11]. In addition to Pakistan and India, successful breeding populations have been reported in Iran, Cyprus, and Bangladesh [12][13][14]. Their global distribution is influenced primarily by extrinsic factors, such as agricultural development, and habitat modification, and intrinsic factors, such as environmental adaptability and dietary flexibility [15]. Human activities, including hunting and poaching, worsen these challenges, resulting in higher mortality rates and lower breeding success during critical breeding periods [16]. Prior studies have indicated that habitat serves as a framework for reproductive strategies, impacting traits, i.e., clutch size and parental investment across various environments [15]. Avian research on breeding biology has shown that habitat loss significantly affects nesting success and parental investment, which, in turn, increases species vulnerability, with the black francolin being no exception [17].

Several studies have reported the significant impact of nesting habitats, i.e., wetlands and drylands, on hatching success [18]. Owing to their location within vegetation, bush nests provide better protection than field edge nests against strong winds and predation. We found that hatching success was positively associated with the number of bush nests. Nest site selection has been linked to reproductive characteristics in various bird species, including the black francolin [19][20]. Parental age significantly influences clutch size in black francolins, with both younger and older parents generally producing smaller clutches [21][22]. Inexperienced younger breeders typically have lower productivity [23][24], with low breeding success frequently linked to poor nesting site selection and occupancy patterns [25]. Environmental factors also play a significant role in the interaction between age and breeding success. A previous study on collared flycatchers (*Tyrannidae* spp.) revealed that both young and old females laid smaller clutches under poor environmental conditions, whereas middle-aged females maintained consistent clutch sizes regardless of environmental quality [22]. Furthermore, physiological changes associated with aging contribute to variations in clutch size. Older female birds, including black francolins, may have higher yolk deposition rates, leading to larger eggs and potentially larger clutches, as they reach their reproductive peak [26].

Young black francolin (first-time breeders) often lay their eggs later in the season than older pairs because experienced older francolins are better at selecting the optimal nest sites compared to other bird species [21][27]. These less favorable sites increase the vulnerability to harsh weather conditions and predation [24][28], which can significantly reduce brood survival rates and breeding success. Black Francolin nest site selection and high chick productivity are influenced by key ecological factors, such as cultivated fields with abandoned land, forest edges, relatively high altitudes, and access to water and food resources [11][18].

Our research limitations include a dataset focusing on a single year and a single breeding season, which limits its broad applicability. Further, key environmental factors such as predation, food availability, and climate variation were not extensively analyzed. Additionally, human disturbance and its effects on nesting behavior were not fully assessed.

Future research should focus on and incorporate multiyear and seasonal data, larger sample sizes, and ecological modeling to understand the long-term breeding trends and habitat dynamics, improving the conservation strategies for black francolin species. In the Totali Game Reserve, this study of the breeding ecology of black francolins highlighted their ecological success, particularly, range expansion, breeding, and adaptation. Our findings indicated a preference for wetland habitats with nests being placed in bushes because these habitats offer more secure features for nest sites and placement. The vegetation structure appears to be a key factor in the selection of nesting sites among black francolins. To gain deeper insights into the nest-site selection process for the black francolin, ongoing monitoring of their nesting ecology and reproduction biology across this protected region is highly recommended. We identified factors influencing their spatial expansion and predicting habitat use patterns and trends in population dynamics. The current research can ultimately contribute to developing conservation strategies and mitigating the ecological impacts of habitat alterations.

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