Research Article
Volume 14:1, 2026

Journal of Biodiversity & Endangered Species

ISSN: 2332-2543 Open Access

Rediscovery and Conservation of Grey Francolin in Bangladesh: Insights from the Upper Ganges Barren Land and Char Majardiyar Regions

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Abstract

This study presents the rediscovery and conservation of the Grey Francolin (*Ortygornis pondicerianus*) in Bangladesh, with a particular focus on the Upper Ganges Barren land and Char Majardiyar regions. Grey Francolin, which had been notably absent from documented records for over 150 years, has recently been observed in these geographical areas. This new observation holds considerable importance in avian conservation. This study provides a comprehensive overview of the strategies utilized for monitoring and researching avian species, specifically focusing on line transect surveys and statistical analysis. These methods were implemented throughout the designated transects in the designated study region. This study examined habitat preferences, population dynamics, and dangers encountered by the Grey Francolin, including habitat degradation and pesticide utilization. The results of this study provide insights into the patterns of population density and distribution, as well as the effects of vegetation structure on the species. This study highlights the significance of conservation endeavors, proposing tactics for the preservation of habitats and the mitigation of dangers caused by human activities. This study enhances comprehension regarding the ecological significance of the Grey Francolin and emphasizes the necessity for well-informed conservation strategies in response to the evolving landscapes of Bangladesh.

Keywords: Grey Francolin • *Ortygornis pondicerianus* • Bangladesh • Avian conservation • Habitat preferences • Population dynamics • Ecological research • Conservation strategies

Introduction

The species of Francolin, including the Grey Francolin (*Ortygornis pondicerianus*) [1], are among the largest in the genus and belong to the family Phasianidae, within the order Galliformes [2]. Recent advances in phylogenetic analysis have led to the re-categorization of the Grey Francolin as a subspecies, moving it from the monotypic genus Francolinus to Ortygornis [3]. This taxonomic revision highlights the importance of ongoing research to understand the distribution and status of this species. According to the regional IUCN Red List of Bangladesh the grey Francolin's status is classified as regionally Data Deficient (DD) [4].

The history of the Grey Francolin in Bangladesh is of particular interest. Historically, three species of Francolinus were reported in Bangladesh: The Black Francolin (*F. francolinus*), the Swamp Francolin (*F. gularis*), and the Grey Francolin (*O. pondicerianus*) [5]. The Grey Francolin can be found in south-eastern Iran and Pakistan, and up to India, Bangladesh, and northern Sri Lanka [5]. Colonel R. C. Tytler, a noted amateur naturalist and member of the Native Bengal Infantry, collected a specimen of the Grey Francolin in Dhaka, Bangladesh, in 1852. This historical documentation, found in the book "The Annals and Magazine of Natural History," provides crucial evidence of the bird's presence more than 160 years ago [6]. Despite this historical record, subsequent reports of the Grey Francolin in Bangladesh were notably absent. For more than a century and a half, there were no confirmed sightings of this species in the wild until 2018, when it was rediscovered in the upper Ganges barren land located at Rajshahi [7].

The existence of the Grey Francolin remained largely unconfirmed in the region for a significant period. However, the calls of these birds left us with little doubt that they continued to inhabit the untouched parts of Char Majardiyar [8].

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Received: 12 December, 2024, Manuscript No. JBES-24-155006; **Editor assigned:** 17 December, 2024, PreQC No. JBES-24-155006 (PQ); **Reviewed:** 31 December, 2024, QC No. JBES-24-155006; **Revised:** 13 February 2026, Manuscript No. JBES-24-155006 (R); **Published:** 20 February 2026, DOI: 10.37421/2332-2543.2026.14.601

The investigation focused on the reemergence of the Grey Francolin species in Bangladesh, which had been extinct for more than a century. The recent rediscovery of this particular species has prompted inquiries on its current status, geographical distribution, and preferred habitat conditions within an evolving ecosystem. The primary objective of this study was to ascertain the conservation status of the species and enhance our comprehension of its ecological dynamics within the region. The present study aims to assess the status and distribution of the Grey Francolin (*Ortygornis pondicerianus*) species in Bangladesh, with a specific focus on the upper Ganges desert region and Char Majardiyar. The present study investigates the habitat preferences, behavioral patterns, and survival obstacles of this particular species within a densely populated and ever-changing environment. The primary objective is to disseminate information about conservation efforts and safeguard the recently identified avian species. The present study investigates the distribution, population dynamics, and habitat utilization of the Grey Francolin (*Ortygornis pondicerianus*) species within the geographical boundaries of Bangladesh, with a specific focus on the upper Ganges barren land and Char Majardiyar regions. The investigation also explores the conservation concerns of this particular species. The ongoing investigation informs our evaluation of the ecological and conservation requirements of the Grey Francolin species in Bangladesh.

Material and Methods

Study area

The survey area is situated approximately 7 kilometers southwest of Rajshahi city, encompassing the Padma barren land or Padma char land, and is characterized by an altitude of 23 meters above sea level. It experiences a temperate climate more specifically, a monsoon-influenced humid subtropical climate. The climatic conditions are marked by an average annual temperature of 25.3°C and an average annual rainfall of 1630 mm [9].

The selection of the survey area size, which was 8.89 square kilometers, was determined after taking into account several factors. The primary objective of this study was to encompass a statistically significant sample of the Padma Char area, which has been the site of a recent rediscovery of the Grey Francolin species. The chosen size was determined with the intention of achieving a harmonious equilibrium between encompassing a significant section of the bird's prospective habitat and maintaining feasible survey logistics within the constraints of the available resources. In relation to the designation of the location as a potential home for Grey Francolin, it is noteworthy to mention the absence of previous pilot studies or existing studies pertaining to this particular area. The selection process was guided by ecological factors, which involved observing the presence and behavior of the species in the upper Ganges desert terrain at Rajshahi. Five transects (A1, A2, A3, A4, and A5) were chosen at random, and each transect was taken at 800 m, which is based on grey francolin habitat (Figure 1). The dominant plant species of the study area are *Prosopis glandulosa*, *Justicia adhatoda*, and *Calotropis procera*, and the grass species are *Eleusine compressa*, *Heteropogon contortus*, *Cyonodon dactylon*, herb, and shrub species are *Solanum xanthocarpum*, *Argemone mexicana* linn, *Alternanthera sessilis*, *Ageratum conyzoides*.

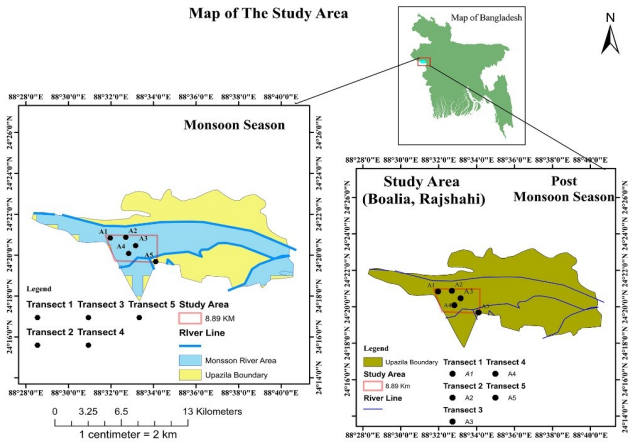

Figure 1. Map of the study area.

Study design

The survey was conducted between November 2020 and April 2021, coinciding with the non-breeding season of the Grey Francolin. A total of eight field visits were conducted within the designated time frame in the upper Ganges barren land of district Rajshahi. The population of Grey Francolin was estimated using the line transect approach proposed by Burnham. The prescribed protocol includes the methodical traversal of predetermined transect lines and meticulous monitoring of target species. Preliminary surveys were done in order to identify regions characterized by high populations of Grey Francolin. The research zone was initially divided into five transects through the use of preliminary surveys. It was anticipated that the species under investigation would be present in high numbers within each transect. Although the five transects under consideration exhibit varying ecosystems, it is noteworthy that all of them are situated within the Upper Ganges Barren Land region of Rajshahi. The term "habitat conditions" encompasses several ecological components such as flora, food availability, water resources, and other relevant factors. The survey employed a systematic approach in selecting transects that were representative of the habitat conditions in order to investigate the habitat preferences of Grey Francolin and the differences in microhabitat within the Upper Ganges Barren Land. The objective of this methodology was to get insights into the distribution and ecological characteristics of species within the examined geographical area. The Gray Francolin was searched by direct (sighting) and indirect (calls were recorded) methods. Each transect line was walked by two people at a moderate speed of 2-3 km/hour in the morning (0500 to 0800 h) and in the evening (1600 to 1800 h). The data were collected fortnightly from each transect. Each line transects covered an average band of about 80 m on each side, as records suggested an approximate distance of sighted birds from the transect line; hence, a uniform transect width of 80 m (0.08 km) was

fixed for the analysis of line transect data. A visual estimate is a widely employed technique for evaluating the proportion of vegetation cover.

- **Bare land percentage:** This study estimates the percent of land without vegetation. Use a 1-square-meter grid or quadrat to visualize the region of interest. Make an estimate of the exposed terrain in this space. This study estimates the percentage of land covered by herbaceous vegetation, such as grasses, forbs, and other plants. Use the grid or quadrat used to measure bare terrain to estimate herbaceous vegetation.
- **Shrub coverage estimate:** Provide an estimate of shrub land cover. Use a grid or quadrat to estimate shrub cover, similar to previous methods.
- **Shrub height:** Measure shrub height at numerous research sites. A measuring tape or ruler can be used to measure the shrub's height from base to apex.

Along with field observations, questionnaires were used to identify potential risks to the Grey Francolin population in the research area. The surveys were carefully planned to collect data on pesticide use, hunting, habitat degradation, and other species-impacting factors. Local communities and stakeholders in district Rajshahi's Upper Ganges Barren Land were surveyed using structured questions. Two main goals drove the questionnaire. Initially, data on human activities and practices that could affect Grey Francolins was collected to supplement field observations.

Additionally, it engaged locals in conservation efforts. The questionnaire covers agricultural pesticide usage frequency and type. The study explores hunting behavior, including seasonal patterns, strategies, and reasons. Land use changes, development, and agriculture destroy habitat. Additional factors that may affect Grey Francolin populations, as determined by preliminary surveys and indigenous expertise. To ensure study efficacy, a variety of people and organizations were canvassed. Farmers, landowners, hunters, conservationists, and others understand Grey Francolin hazards. A broad group of individuals completed the questionnaire to learn how human activities affect the Grey Francolin species' ecosystem. This study will help build Grey Francolin conservation measures and mitigate hazards. The formula used to calculate the bird population density (per km^2) in each stand involved dividing the number of sighted birds by the transect area, which was determined by multiplying the transect length by the average transect width (0.8 km × 0.08 km=0.064 km^2).

Statistical analysis

The data for Grey Francolin were collected for the purpose of distribution modeling. The data analysis involved several statistical tests and calculations:

Shapiro-Wilk test: This test was employed to assess the normality of the data distribution. It helps determine whether the data follows a normal (Gaussian) distribution.

Kruskal test: The Kruskal test was used to evaluate the differences in data among multiple groups or treatments. It assesses whether there are significant differences between the groups.

Mean and standard deviation calculation: The mean (average) and standard deviation of the data were calculated using the conventional statistical method. The mean provides a measure of central tendency, while the standard deviation indicates the data's dispersion or variability.

Dunn test: Pair-wise comparisons were conducted using the Dunn test. This test is applied when significant differences are detected in the Kruskal test, allowing for comparisons between specific groups to identify which pairs differ significantly. The analysis was done using R (4.0.3, 2020). Considering a non-random distribution is necessary to select appropriate statistical tests, ensure the validity of results, and maintain transparency in the research process, and it demonstrates the researchers' commitment to conducting sound statistical analyses and drawing reliable conclusions from the data.

Results

A total of 499 Grey Francolins were observed in five transects. Through a comprehensive study conducted on Grey Francolin populations over five unique transect sites, we have noticed a gradual augmentation in both the observed number of individuals and the population density per square kilometer. According to the data shown in Table 1, transect A1 had the lowest recorded density, with a total of 21 individuals, corresponding to an average of 29.17 Francolins per square kilometer. The aforementioned pattern exhibited a progressive increase over the transects, reaching its peak in transect A5, where a total of 188 individuals were documented, resulting in a density of 46.08 Francolins per square kilometer. The standard deviations seen in the data indicate that there is variation in the distribution of the variable across the transects. Specifically, transects with higher densities tend to have a greater degree of dispersion. The results of this study suggest that the distribution of Grey Francolin populations is varied, potentially due to a combination of environmental conditions, habitat suitability, and variations in observations along the surveyed transects.

Transects	Number of individuals sighted	Density per km^2
A1	21	29.17 ± 21.65

A2	25	34.72 ± 13.66
A3	124	40.79 ± 19.43
A4	141	45.19 ± 25.1
A5	188	46.08 ± 31.67

Table 1. Density of Grey Francolin in different transect sites.

Table 2 displays a comparative analysis of Grey Francolin density among different transect sites. This inference is supported by the inclusion of Z values and adjusted p-values (P.adj) in the table. The primary findings derived from the tabular data are as follows: The Z values in this study serve as the test statistic for evaluating the differences in median densities across pairs of sites. On the other hand, the P.adj values are the adjusted p-values that take into consideration the issue of multiple comparisons. A widely accepted criterion for establishing statistical significance is a threshold of 0.05. Nevertheless, the adjusted p-values presented in the analysis are either equal to 1 or in close proximity to 1, suggesting that there is no statistically significant variation in Grey Francolin density across the three sites. It is worth noting that just one comparison (A1-A4) yields a P.adj value that deviates from 1, with a value of 0.568505. However, even this value remains above the conventional significance threshold of 0.05, further supporting the conclusion that there is no significant difference.

S. no	Comparison	Z	P.adj
1	A1 - A2	-0.80936	1
2	A1 - A3	-1.60213	1
3	A2 - A3	-0.57293	1
4	A1 - A4	-1.90446	0.568505
5	A2 - A4	-0.87273	1
6	A3 - A4	-0.48408	1
7	A1 - A5	-1.74786	0.804877
8	A2 - A5	-0.69259	1
9	A3 - A5	-0.17739	1
10	A4 - A5	0.340017	1

Table 2. Pair wise comparison of Grey Francolin density across transect sites.

The density of Grey Francolin, perhaps representing the number of individuals per square kilometre, is depicted in (Figure 2) using a box plot. The study sites are denoted as A1 through A5. Each box plot visually represents the median, Interquartile Range (IQR), and range of the dataset. The median is depicted by a line positioned within the box, while the IQR is represented by the box itself. The range of the data is illustrated by the whiskers. Data points that fall outside the whiskers are considered outliers. Based on the box plot, it is evident that site A1 has the most extensive range of data, encompassing outliers that deviate both above and below the norm. This observation suggests a notable degree of variability in the density of Francolins at this particular site.

According to the data shown in site A2, it can be observed that the Interquartile Range (IQR) is more condensed and has a reduced number of outliers in comparison to site A1. This suggests that site A2 displays a lower degree of variability.

The patterns seen in sites A3, A4, and A5 exhibit similarities, while site A3 displays a little higher median density.

The observed median density of Francolin has a comparable pattern across A2, A3, A4, and A5, with a significantly reduced value seen for A1.

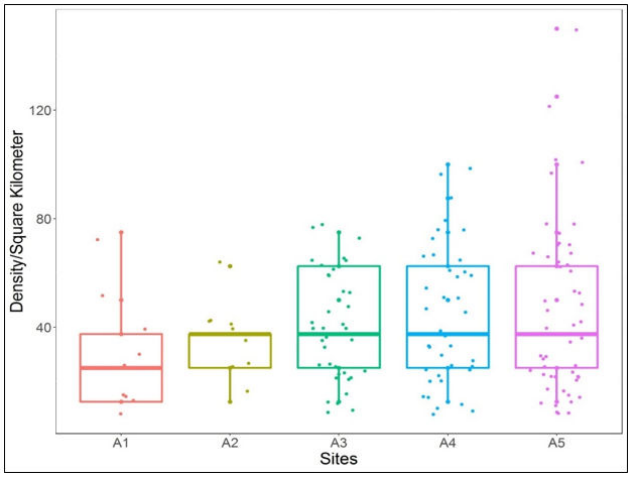

Figure 2. Grey Francolin density in different study sites.

Based on the integration of data from both the box plot and the Table 2, it can be inferred that there is a lack of statistically significant disparities in the density of Grey Francolins among the five study sites, despite the presence of some apparent variability in the raw data. This observation suggests that the observed differences lack sufficient consistency to attain statistical significance, given the inherent variability within each site.

Impact of vegetation structure

Table 3 presents a statistical summary derived from a regression model aimed at predicting the impacts of different vegetation structures on the group size of Grey Francolin. The following analysis provides an interpretation for each individual row in the table.

The intercept refers to the anticipated value of the dependent variable, specifically the group size of Grey Francolin, when all predictors, namely vegetation structures, are set to zero. The estimated value is considerable (93.55), however, the standard error is also substantial (122.40), resulting in a relatively low z-score (0.765) and a significant p-value (0.445). The obtained p-value indicates that there is no statistically significant difference between the intercept and zero at conventional levels of significance, such as 0.05.

The coefficients pertaining to bare ground, herb, and shrub show the anticipated alteration in group size when there is a one-unit increment in the corresponding vegetation structure, while keeping all other variables constant. In all three cases, the coefficient exhibits a negative value of -0.93, indicating a negative correlation between the growth of vegetation structures and group size, implying that an increase in vegetation structures is linked to a decrease in group size. Nevertheless, it is worth noting that the standard errors exhibit a considerable size of 1.22 in relation to the coefficients. Additionally, the z values demonstrate a relatively modest magnitude of approximately -0.75, resulting in elevated p-values of approximately 0.45. The observed high p-values suggest that the coefficients lack statistical significance, implying the absence of a statistically meaningful association between the factors and the group size of Grey Francolin according to this research.

The coefficient for shrub height is 0.00, indicating that there is no significant relationship between shrub height and group size. This is supported by a standard error of 0.00, further suggesting that changes in shrub height do not affect group size. Nevertheless, there appears to be an inconsistency between the provided z value of -0.749 and the p-value of 0.454, as they do not align with the coefficient and standard error values of 0. The presence of a standard error of 0 in the table raises concerns as it is uncommon for such a value to lead to a computation of the z value or a p-value larger than 0.

In general, the table indicates that there is no statistically significant impact of the factors used in the model on the size of Grey Francolin groups. This conclusion is drawn based on the observation that all p-values exceed the commonly accepted significance level of 0.05. It is important to acknowledge that the standard errors exhibit a rather substantial magnitude in relation to the coefficient values, so signifying a considerable degree of uncertainty in the estimations. The uniformity of the p-values across the predictors may indicate potential issues with the model's specification or the omission of significant variables from the analysis.

Coefficient	Estimate	Std. Error	z value	Pr(>|z|)
Intercept	93.55	122.4	0.765	0.445
Bare land	-0.93	1.22	-0.756	0.449
Herb	-0.93	1.22	-0.758	0.448
Shrub	-0.92	1.22	-0.749	0.454
Shrub height	0	0	-0.749	0.454

Table 3. Estimate size of vegetation structures on Grey Francolin group size.

The scatter plots (Figure 3) depict trend lines that illustrate the correlation between many ecological variables and the size of a Francolin group.

The presented graphic illustrates the relationship between the percentage of bare land and group size. The observed trend line exhibits a negative slope, indicating an inverse relationship between

the proportion of barren land and the group size. This observation suggests a potential preference of the studied species for habitats characterised by a lower proportion of bare land, or alternatively, a correlation between less plant cover and smaller group sizes. The plot illustrates the relationship between group size and the proportion of herbaceous (vegetative) cover, displaying a declining trend line. Similar to the vacant land area, this finding suggests that greater group sizes are correlated with decreased proportions of herbaceous vegetation coverage. The proposition may appear contradictory, unless higher herb percentages are indicative of denser vegetation, which may not be conducive to supporting bigger group numbers for the species under consideration. The presented plot illustrates the relationship between the percentage of shrub cover and group size. It reveals an upward trend line, indicating that as the shrub cover increases, there is a corresponding increase in group size. This observation suggests that the species exhibits a preference or higher level of adaptability in habitats characterised by a greater abundance of shrub cover.

The presented plot depicts the relationship between shrub height, measured in centimetres, and group size. However, no discernible trend can be observed from the data. The dispersion of the data points is greater, and the slope of the trend line is rather shallow, suggesting a potential lack of a robust correlation between shrub height and group size in this particular species. Alternatively, it is possible that unaccounted variables, not depicted in the graph, exert a more substantial influence on group size. The confidence interval, denoted by the colored area surrounding the trend lines in each graph, serves to provide an estimate of the range within which the true trend line is expected to fall with a specified level of confidence, often 95%. The greater the extent of the grey region, the lower the level of certainty regarding the observed trend. It is imperative to acknowledge that although these graphs exhibit correlations, they do not inherently imply causality.

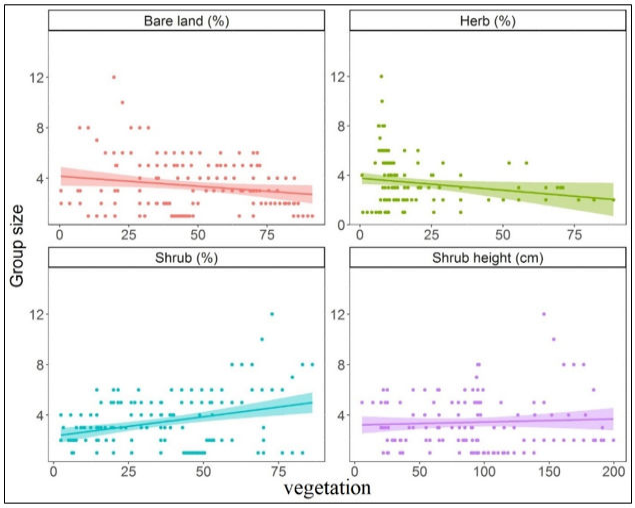

Figure 3. Relationship between group size with vegetation structures, bare land (%), herb (%), shrub (%), and shrub height (cm) potential threats to the Grey Francolin population in the study area:

Potential threats to the Grey Francolin population in the study area: The study aims to examine the correlation between potential threats and the population dynamics of the Grey Francolin. The Grey Francolin may be adversely impacted by the frequent use of pesticides, since it can lead to a decrease in their available food sources, such as insects and seeds, or result in direct toxicity. Pesticides can potentially have indirect impacts on the quality of their habitat. Hunting practises: Despite the absence of explicit indications of hunting pressure from the respondents, it is important to consider the possible threat posed by hunting, particularly if it is being carried out in adjacent areas or if the respondents do not accurately represent the wider community.

Habitat destruction is a significant risk to the Grey Francolin species as it involves the conversion of land for agricultural purposes and fish farms. This process directly diminishes the available habitat for the species, potentially leading to a reduction in suitable living areas and an increased likelihood of population isolation.

The findings presented in Table 3 and the scatter plots indicate a correlation between vegetation structure and the size of Grey Francolin groups. This implies that alterations in vegetation resulting from either human intervention or natural phenomena may have an influence on the habitat choices and social organization of these avian species. The analysis of Table 1 and Figure 2 reveals that there is discernible variability in population density throughout the different transects. This variability can potentially be attributed to disparities in habitat quality and the presence of possible threats. Transects exhibiting higher population densities may potentially serve as an indication of more favorable habitat conditions or a reduced level of effect from various threats.

Discussion

The research conducted on the Grey Francolin (*Francolinus pondicerianus*) in the Upper Ganges Barren Land of District Rajshahi has yielded significant findings regarding the species' distribution, habitat, and the risks it faces. Several significant findings have been revealed regarding the status and conservation of Grey Francolins in the region, as a result of conducting field observations, collecting data, and performing statistical analyses.

The topic of discussion pertains to distribution modelling and the concept of non-random distribution: The project commenced with the primary goal of conducting distribution modeling in order to gain insights into the geographic extent of Grey Francolins inside the designated research site. The process of data gathering and analysis yielded valuable insights, with one notable finding being the non-random distribution pattern observed in Grey Francolins. The significance of this discovery, as evidenced by the outcomes of the Shapiro-Wilk test, underscores the necessity of employing specialized statistical methodologies when analyzing and interpreting data pertaining to this particular species. Recognizing the presence of a non-normal distribution played a crucial role in the selection of suitable statistical tests, thus preserving the integrity of the findings and upholding transparency in the research endeavor.

Selection of habitat and transects: The careful selection of habitat and transects played a pivotal role in the study. A survey was conducted on a designated area measuring 8.89 square kilometers located on the Padma Char land. The rationale for this selection was based on the species' capacity to adapt to cultivated crops, rendering

it highly suitable for examination in agricultural environments. Within this designated area, a total of five transects were picked in a random manner, with each transect having a length of 800 meters. The identification of the primary plant species in the designated research area has yielded valuable insights into the likely habitat preferences of Grey Francolins. Although there were modest changes in habitat conditions among the transects, all of them were located on the Upper Ganges Barren Land in Rajshahi, which ensured a full representation of microhabitat variations.

The process of estimating population size and conducting statistical analyses: The investigation of Grey Francolins' population employed the line transect approach, which yielded a reliable assessment of population density per square kilometer within each transect. The Kruskal-Wallis test was utilized to evaluate the presence of significant differences among many groups, while the Dunn's test was employed to perform pairwise comparisons between groups. The non-parametric tests were chosen based on the identification of a non-random distribution in the data, ensuring the suitability of the statistical analyses. The findings of the study revealed notable disparities in Grey Francolin populations over several transects, therefore providing a basis for future research endeavors aimed at exploring the reasons that contribute to these variances.

The utilization of questionnaires in the context of threat assessment: In order to conduct a comprehensive assessment of the potential dangers faced by Grey Francolin populations, surveys were distributed to local communities, individuals, and stakeholders. The survey encompassed several subjects like the utilization of pesticides, hunting methodologies, the degradation of habitats, and other pertinent variables. The comprehensive evaluation of anthropogenic impacts on the species was made possible by the participation of a wide range of respondents, encompassing farmers, landowners, hunters, and conservationists. The data collected through the administration of questionnaires played a vital role in enhancing the field observations and statistical analyses conducted in this study.

Conclusion

In conclusion, the Upper Ganges Barren Land of District Rajshahi Grey Francolin study revealed important information on their geographical dispersion, habitat preference, and potential threats. The study illuminates Grey Francolin population dynamics in agricultural settings and non-random dispersal patterns. The presence of probable risks like pesticides and habitat degradation emphasizes the importance of conservation efforts in the area. Future Grey Francolin investigations must use specific statistical methods due to the non-random distribution. This study provides a foundation for future research on reducing this species' conservation challenges. Overall, this study adds to the Grey Francolin literature in the research region. It provides a foundation for well-informed conservation strategies to protect this bird species from the dynamic agricultural landscapes and human activities that threaten their existence. Habitat destruction and pesticide use are the main threats to this valuable ecosystem asset. Their predatory performance against grasshoppers, crickets, and locusts should be studied in the future. To safeguard birds that help farmers by eating crop pests, conserve foraging grounds, promote pesticide stewardship, and stop unlawful shooting. The Grey Francolin's numbers and range in Bangladesh have declined due to poaching and bushy vegetation conversion to farmland. The deep scrub bush that hides in it when disturbed is vanishing. No effective conservation program exists for this species. Posters were posted in homes, schools, institute walls, and adjacent markets to raise awareness of the need to conserve these birds. A vigorous effort to maintain and maybe expand a suitable matrix of habitats and eradicate hunting through awareness campaigns and legal enforcement would be needed to recover the population. Human-mediated wildlife reshuffling raises biodiversity conservation concerns and requires in-situ conservation planning.

Acknowledgements

Encouragement from the Assistant Professors Md. Mahbub Alam and Muntasir Akash, Department of Zoology, University of Dhaka, during the preparation of this manuscript is duly acknowledged.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the author(s) used (ChatGPT service) in order to (Improve readability). After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

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How to cite this article: Rashid, Naim Ur and Gulshan Ara Latifa. "Rediscovery and Conservation of Grey Francolin in Bangladesh: Insights from the Upper Ganges Barren Land and Char Majardiyar Regions." *J Biodivers Endanger Species* 13 (2025): 601.