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A STUDY ON BREEDINGAND REPRODUCTIVE SUCCESS ON GREY PARTRIDGE (FRANCOLINUS PONDICERIANUS) IN THEIR NATURAL HABITAT IN RAJASTHAN

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Abstract
Compared to other francolin species in India, the Grey Francolin (Francolinuspondicerianus) has received fewer scientific studies despite its vast distribution. This research reveals the habitat preferences of the Grey Francolin in the Kutch district of Gujarat's Bhuj Taluka, a region with a high human population density. It illustrates how the altitude of the vegetation and its impact on the species' occurrence throughout the year. It also emphasizes how the choice of habitat, behavior, and presence of the species are influenced by crop pattern, kind of agriculture border, and other agricultural characteristics. There was no discernible relationship between bird behavior and environment type. They consume grains from spilt rice fields and termites. Males battle among themselves and make loud, repeated calls. It was determined that two shrubs, six stunted trees, and four species of tall grasses all provide as habitat for birds. 193 birds were discovered 1,000 m away from human habitations, indicating that birds chose to reside in remote areas. The study region still serves as a good habitat for Grey Francolin populations; hence it has to be protected.

Keywords:*Reproductive,Grey Francolin,FrancolinusPondicerianus,Crop*

1. INTRODUCTION

The Grey Francolin (Francolinuspondicerianus) is commonly found in India dry Indus plains and has spread into Sindh's Thar Desert, Punjab's Thala Desert, and Sindh's Thala and Chohlistan Deserts. The species can also be found in the Margalla hills of Islamabad, the salt range and agro-forestry tracks of the Poth war Plateau in the Punjab, the Cherat and Kohat districts of Khyber Pakhtunkhwa Province, and the lower hills of the Makram and Labella districts in Balochis tan The bird is typically seen foraging in open, cultivated areas and grasslands that are intermingled with scrubby woodlands; it is infrequently seen in India over an elevation of 1200 m. One of the most well-known bird songs of the

countryside, the Grey Francolin's calls are primarily made around dawn and night Because it is viewed by locals as a cheap source of meat, the Grey Francolin has remained a favorite game bird on the Indian subcontinent and is still hunted for sustenance At local fairs, this bird is also utilized for cockfighting The species is a favorite of farmers who believe that this bird works as a biological control agent of insect pests in India by consuming vast quantities of harmful insects, as well as their eggs and larva . Terrestrial birds like the Grey Francolin (Francolinuspondicerianus) can be found all over the Indian subcontinent. It is a well-known topic of study in ornithology due to its unusual plumage and distinctive call. For the sake of conservation efforts and a comprehensive understanding of bird ecology, it is essential to comprehend the breeding habits and reproductive success of the Grey Francolin in its natural habitat.

Figure 1: FrancolinusPondicerianus

India is a fantastic chance to study the breeding behavior and reproductive success of the Grey Francolin due to its different environments and abundant biodiversity. Nevertheless, despite its ecological importance, little is known about this species' reproductive ecology in India. By examining many facets of the breeding behavior and reproductive success of the Grey Francolin in its natural habitat in India, this study seeks to close this knowledge gap.Breeding behavior includes a variety of behaviors, such as courtship rituals, partner choice, nest site choice, and parental care. These actions are crucial to a species' ability to reproduce. Understanding the Grey Francolin's breeding behavior can help us better understand its social organization, reproductive tactics, and environmental adaptations.A key indicator for determining the viability of a species' population is reproductive success.

Reproductive success is directly influenced by variables such as clutch size, nesting success, and fledgling survival rate. Examining the variables affecting Grey Francolins' reproductive performance can provide insight into the species' overall breeding success and its reaction to environmental changes.

The Grey Francolin is known to inhabit a variety of habitats across India, including grasslands, farms, and scrublands, which will all be included in this study. The breeding behavior and reproductive success of the species will be studied using a combination of field observations, data gathering, and statistical analyses.The results of this study will have an impact on management and conservation measures. It will be easier to implement focused conservation strategies to protect Grey Francolin populations and their habitats if breeding behavior is understood. Furthermore, by laying the groundwork for future studies on other bird species, this study will advance our knowledge of the ecology of avian reproduction.

2. REVIEW OF LITREATURE

In a fragmented habitat in India, Dharmaraja and Kaur (2020) concentrated on researching the breeding habits and reproductive success of Grey Francolins. The study looked at the species' nesting behaviors, clutch size, incubation time, and hatching success. The extended fieldwork by the researchers revealed that the grey francolin showed a predilection for nesting in shrub settings with lots of foliage. The hatching success rate was 64%, with an average clutch size of 7 eggs. The study emphasized the significance of preserving adequate habitat patches to improve Grey Francolin reproductive success in fragmented environments.

The choice of nesting sites and reproductive performance of Grey Francolin in agricultural landscapes of central India were studied by Sharma and Mishra in 2021. The researchers looked at how ground cover and vegetation density in the area affected nest site choice and reproductive success. They discovered that Grey Francolins chose their nesting sites in regions with greater densities of vegetation. The study also showed that the presence of adequate nesting sites and their closeness to feeding regions had a substantial impact on the species' reproductive success. The research underlined how crucial it is to manage agricultural landscapes in order to give Grey Francolins optimal nesting grounds.

In the western Himalayas of India, Chauhan and Sharma (2020) concentrated on figuring out how habitat features affected Grey Francolin nesting behavior and reproductive success. Variables like vegetation structure, food availability, and predation pressure were

evaluated in the study. They discovered that Grey Francolins choose grassy, densely forested regions for breeding and foraging. Higher plant height was found to have a favorable effect on a species' ability to reproduce, according to the researchers. The study also emphasized the value of improving habitat quality and lowering predation pressure to improve Grey Francolin breeding success in the western Himalayan region.

In rural areas of western India, Prakash and Patil (2021) concentrated on examining how agricultural intensification affected the breeding ecology and reproductive success of Grey Francolins. The use of pesticides, irrigation, and a variety of crop types were among the agricultural activities that were examined for their effects on the reproductive success and breeding behavior of the species. The study found that the availability of adequate nesting places and food resources for Grey Francolins was severely impacted by rising agricultural intensification. Consequently, in intensively managed agricultural landscapes, the species' reproductive success was severely decreased. The research underlined how crucial it is to use sustainable agriculture methods that lessen their detrimental effects on Grey Francolin populations.

In a protected grassland habitat in northern India, Verma and Singh (2021) looked at the Grey Francolin's breeding habits and reproductive performance. The study investigated the effects of habitat factors on the breeding ecology and reproductive success of the species, including grass height, vegetation structure, and prey availability. Researchers discovered that for breeding, Grey Francolins favored grassland areas with somewhat tall grass and high vegetation cover. Additionally, they noticed that greater prey availability had a good impact on the species' reproductive performance. In order to sustain the breeding success of Grey Francolin populations, the study underlined the need of maintaining adequate grassland habitats with ideal vegetation structure and prey quantity.

3. METHODOLOGY

3.1 Sampling Design

For 24 months, from January 2015 to December 2016, the survey was carried out. The semi-arid region of Kutch, Gujarat, is included in the study area (Fig. 1; 23°.13' to 23°.12' N and 69°.36' to 69°.38' E).

Grassland, bushland (scrub forest), woodland, agricultural land, and human settlements were all present in the area. The hottest month in Kutch is May, when average highs reach 45 °C. From July through September, the area receives spotty precipitation.

Prosopis cineraria, Prosopis juliflora, Ziziphus nummularia, and Acacia nilotica are the four most common species of local flora.

The location was chosen based on a reconnaissance study, a literature analysis, conversations with nearby farmers and birdwatchers, and accessibility throughout the year. With the use of QGIS 3.0 software, grid cells of 0.05 km2 were placed across a 5 km2 region that was chosen. The size of the grid cell (0.05 km2) was chosen to match the species' home range (0.05 km2) as described by Rana et al. (2012) in an environment similar to that of Haryana. The lower grid size makes it easier to detect birdcalls at close ranges (no more than 500 meters) in order to determine whether a species is present based on cues (Buckland, 2006; Rana et al., 2007; Kasprzykowski and Goawski, 2009).

According to Kidwai (2013) and Dutta et al. (2014), line transect sampling was employed to get the data on the species' occurrence. The procedure was slightly altered because of the study's limits on the money, logistics, time, and human resources. A handheld GPS was used to walk a randomly selected straight-line transect through an area where calling activity and the likelihood of meeting were both highest in the morning. Vegetation cover, vegetation height, and agriculturally relevant data were collected at 200 meter intervals using a pre-designed datasheet.

4. SEASONAL VARIATION:

Summer (March to May), Monsoon (June to August), Post Monsoon (September to November), and Winter (December to February) were the four seasons that made up the entire year. In the study area, a minimum of three randomly chosen line transects were walked each season (one each month). Information on the species

The information was gathered by taking walks along the paths, highways, bridges, and nullahs, as well as the easily accessible path or boundary of the agricultural field. The coordinates of the starting point, the final location, and the total distance traveled were all determined using GPS. Sightings of the species have been reported both visually and indirectly (when the bird's call was heard). Distant, weak birdcalls were disregarded so as not to interfere with the cue-based detection.

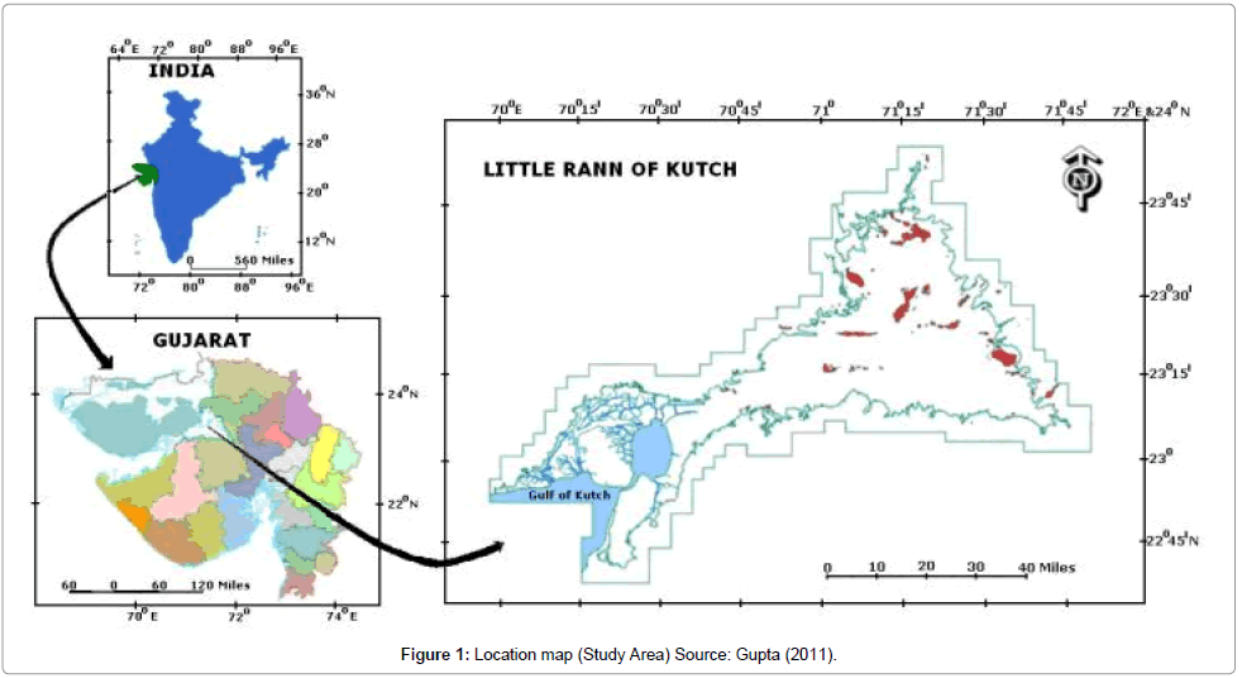

Figure 1: Location map (Study Area) Source: Gupta (2011).

Figure 2:semi-arid zone of Kutch, Gujarat

Covey size (the total number of birds in a flock) and (if available) covey composition (male/female/sub-adults/chicks) were recorded whenever possible during direct sightings. The tarsal spur, which is usually just one but sometimes two in Grey Francolin, is the only way to tell the sexes apart.When the gender was not known, the entry was marked as "unidentified." Habitat familiarity Habitat factors such as plant cover and height, crop type, border type around the agricultural area, crop status (standing/fallow), and soil type of the agriculture field (ploughed/barren) were recorded at 200 meter intervals throughout the transect since they may influence species distribution.

The most common forms of land cover (desert, agricultural, grassland, shrub, woodland, and settlement) were recorded within a 100-meter radius of each sampling station. Trees and plants: Vegetation cover was expressed as a percentage of the total area covered by vegetation within a 100-meter radius of the sampling point. Wide class intervals were used to quantify the plant cover (A=Absent, B=Very Low (0-20%), C=Low (21-40%), D=Medium (41-60%), E=High (61-80%), and F=Very High (81-100%).

The species avoids tall grasses, thus it's best to find a spot with varying grass heights (at least 60 centimeters) instead. 2) Bush: an area with ground vegetation other than grasses (less than one meter in height); 3) Woodland: an area with woody trees (taller than one meter); 4) Agriculture: an area used for agriculture; 5) Human Settlements: an area with more than five constructed houses or a colony of houses; and 6) Open: an area devoid of vegetation. Plants' Altitude: Within a 100 meter radius of the sampling point, the height of

the vegetation (height of each plant type) was recorded using broad class intervals (A= Absent, S= Short (0-20 cm), M= Medium (21-40 cm), T= Tall (41-60 cm), TT= Very Tall (>100 cm). Vegetation height and composition data were recorded at each sampling location regardless of the presence or absence of a given species. Since the species has been documented in agricultural settings before (Ali, 1945; Dharmakumarisnhji, 1955; Ali and Ripley, 1983; Rana et al., 2012), we also noted the type of boundary (hedge, fence, wall, open), the crop, its current state (standing vs. fallow), and the field's current state (barren vs. ploughed).

Garmin GPS Etrex 30X, Nikon D500 digital SLR camera, and Nikon 10x42 Monarch binoculars were employed for the accurate observation and data collecting. Using the software programs MS Excel and QGIS, the data analysis was completed using the accepted procedures. ER = number seen/km walked was used to compute the encounter rate (ER).

Prior to data analysis, the null hypothesis was examined using XLSTAT by Addi soft's ANOVA and Chi-square Test.

5. RESULTS

5.1 Seasonal variations in the species' occurrence and encounter rates

Only 87% (4.35 km2) of the entire area was able to be surveyed during the study due to a lack of available workers. There were a total of 383 locations used to compile the data on habitat types. Twenty-five transects, each averaging 2.67 0.50 km in length, were walked first thing in the morning throughout different times of the year to look for signs of the species. It took 3.48 0.44 hours on average to finish each transect. It took at least 15 minutes to collect the habitat data and other data at each of the 383 sampling points. Totaling 484 people, there were 74 direct sightings, and an additional 134 indirect sightings through auditory presence (birdcall).

The Encounter Rate (ER), (Fig. 2) of calls peaked during post-monsoon (2.260.01) and summer (2.180.08), respectively, but there was no discernible difference during the monsoon (1.820.26) and winter (1.810.45). Postmonsoon (1.260.45), monsoon (1.150.14), summer (1.110.24), and winter (0.910.05) had the highest ER of sightings. The number of sightings peaked in the summer (10.50.71) and peaked at their lowest in the winter (7.00.23). Birdcalls were recorded at their highest volume (n=134) in the summer (19.50.77) and at their lowest level (144.24) in the winter.

5.2 The demographic structure varies seasonally:

Out of the total number of sighted people (n=484), 40% could not identify their gender. Chicks made up 37% of the population, followed by sub-adults (10%), females (7%) and males (6%), and in 60% of the cases, the individuals were classified as males, females, sub-adults, or chicks. The peak breeding season occurred after the monsoon season ended in August and lasted until October.

Maximum sightings of the 181 chicks recorded occurred in the summer (35.506.36), likely as a result of better visibility than in the post-monsoon (23.502.65).

5.3 vegetation cover's impact on the species' occurrence

For each season, the average fraction of occurrence in comparison to the vegetation cover was investigated (Fig. 4). ANOVA and Chi-square were used to examine the significance of the data and the null hypothesis (R2 0.89, CI 95%, p-value 0.62, alpha 0.95).

In the summer, shrubs had the highest average incidence (1.751.10) (MeanSE), followed by agricultural (1.130.74) (81-100%), woodland (0.930.44), and grass (0.500.23) (0-20%). The highest average of occurrence during the monsoon (2.141.36) was in bushes (0-20%), followed by (2.041.10) in forest (0-20%), (1.600.61) in grass (0-20%), and (1.370.94) in farmland (81–100%). This demonstrates a considerable rise in the utilization of grass during the monsoon. Species that did not use the low (21-40%) and medium (41-60%) cover of grass during the summer apparently did so because it was not available. In the post-monsoon season, forest (0-20%) had the highest average incidence (1.821.27), followed by grass-B (1.160.96), bushes-B (1.100.86), and agriculture-E (0.830.74). In the winter, bush-B had the highest average incidence (1.250.90), followed by woodland-B (1.170.95), grass-B (0.710.60), and (0.530.41) agriculture-E.

5.4 Variations in the occurrence according to the height of the vegetation by season:

Table 1: Seasonal Variation in Encounters Rates

AVERAGE ENCOUNER RATE	
Sight (ER)	**Call (ER)**
2.3	3.2
3.2	3.6
4.3	4.2
4.6	4.9
5.3	5.2
5.9	5.9

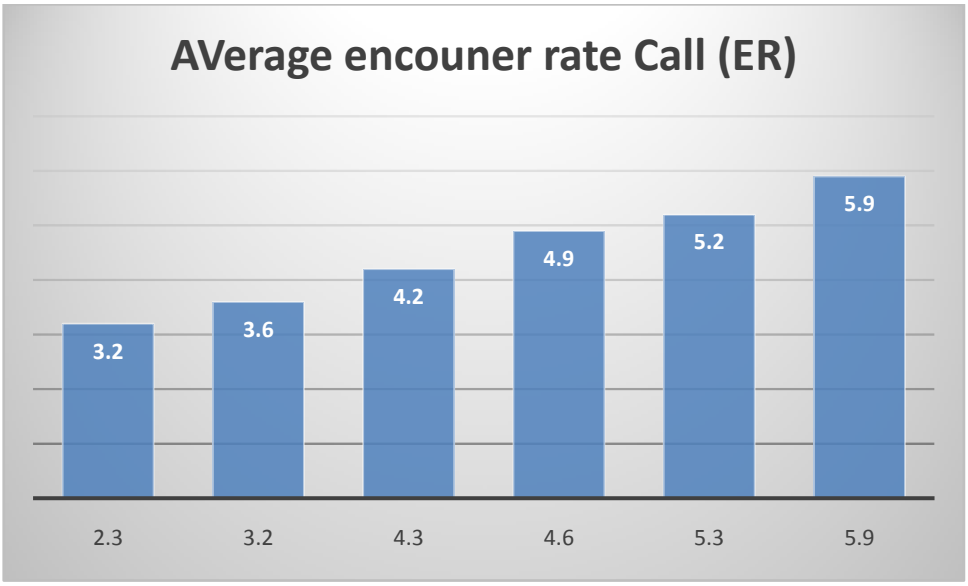

Figure 3: Seasonal Variation in Encounters Rates

Table 2: Seasonal Variation in number of Sightings

Items	Summer	Monsoon	Post-Monson	Winter
Male	**1.2**	**2.2**	**1.6**	**2.2**
Female	**2.3**	**2.5**	**1.9**	**2.5**
Sub-adult	**2.6**	**1.6**	**2.3**	**2.9**
Chick	**3.5**	**3.9**	**2.6**	**3.2**
Unidentified	**4.2**	**4.3**	**5.3**	**2.9**

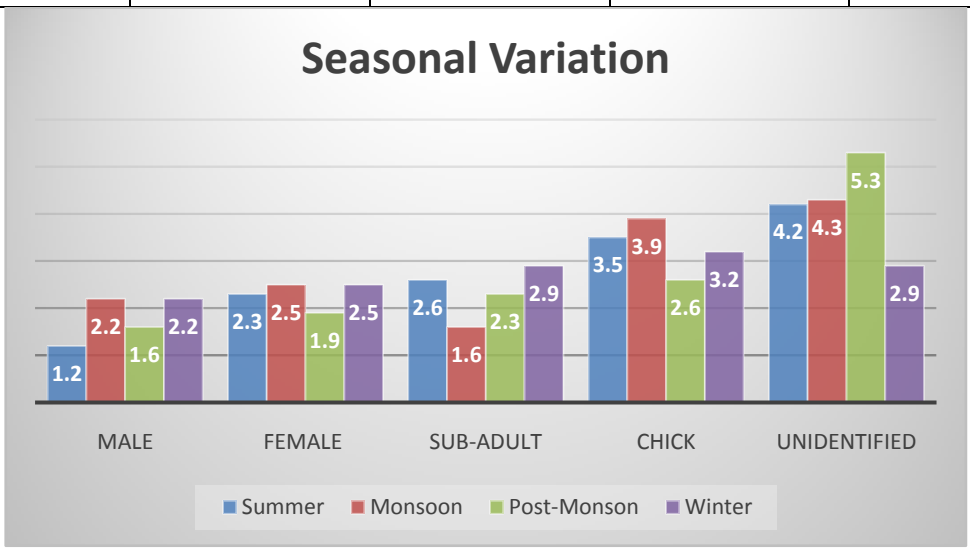

Figure 4: Seasonal Variation in number of Sightings

The average occurrence in relation to the height of various plants was examined throughout the year (Fig. 5). ANOVA and Chi-square were used to examine the significance of the data and the null hypothesis (R2 0.74, CI 95%, p-value 0.86, alpha 0.95).

In the winter, grass-S had the highest average occurrence (1.330.87), followed by agriculture-TT (1.310.97), woodland-TT (1.090.18), and bush-M (0.790.25). In the summer, woodland-T had the highest average occurrence (2.240.85), followed by agriculture-T (1.280.29), agriculture-TT (1.020.34), and grass-S (0.810.14).

In the monsoon, grass-M had the highest average incidence (1.610.54), followed by woodland-T and agriculture-T with nearly similar occurrences (0.950.41) and (0.850.12), respectively. The species (0.390.19) and (0.480.13) were also observed in grass-T and bush-T, respectively. This demonstrates the monsoon's noticeable increase in the use of medium- to-tall grass. The average number of occurrences after the monsoon was highest in the grass-S biome (1.360.75), next in the bush-M (0.910.17), then in the woodland-TT (0.910.23) with a little larger difference, and finally in agriculture-T (0.820.23).

Table 3: Effect of Vegetation cover on Occurrence of Grey Francolin

Vegetations Cover Categories	Average Percentage of Occurrence
Grass B	1.23
Grass C	1.65
Grass D	2.36
Bush B	5.12
Bush C	3.25
Woodland C	4.12
Woodland D	3.63
Woodland E	2.66
Agri. B	2.78
Agri. C	3.11
Agri. D	3.65
Agri. E	4.02
Agri. F	4.36
Open B	4.15
Open D	5.33
Settlement B	5.12
Settlement C	6.12
Settlement D	6.36
Settlement E	7.12
Settlement F	7.63

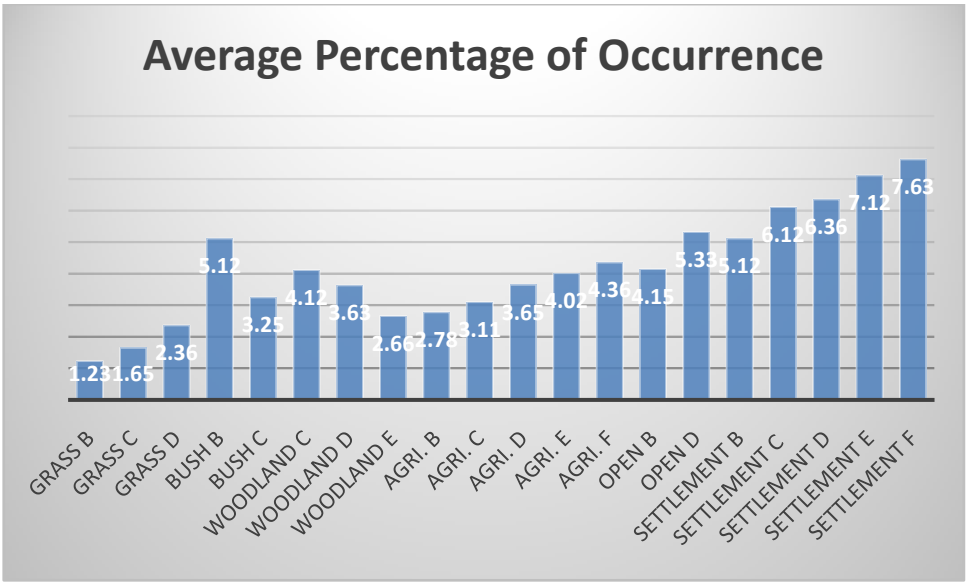

Figure 5: Effect of Vegetation cover on Occurrence of Grey Francolin

Table 5: Effect of height-range of Vegetations on occurrence of Species

Vegetation Height Categories	Average Percentage of Occurrence			
	Summer presence	Monsoon Presence	Post-Monsoon Presence	Winter Presences
Grass S	1.2	1.3	1.1	1.9
Grass M	2.3	1.6	1.6	2.6
Grass T	3.6	2.5	2.6	2.9
Bush S	4.1	1.6	2.9	3.2
Bush M	5.3	2.6	3.3	3.9
Bush T	4.3	4.1	3.5	4.2
Woodland TT	2.6	6.3	4.1	4.9
Agriculture S	3.2	3.5	4.5	5.3
Agriculture M	3.6	3.9	3.5	6.2
Agriculture T	4.6	4.2	4.6	4.3
Agriculture TT	5.3	5.2	5.3	6.3

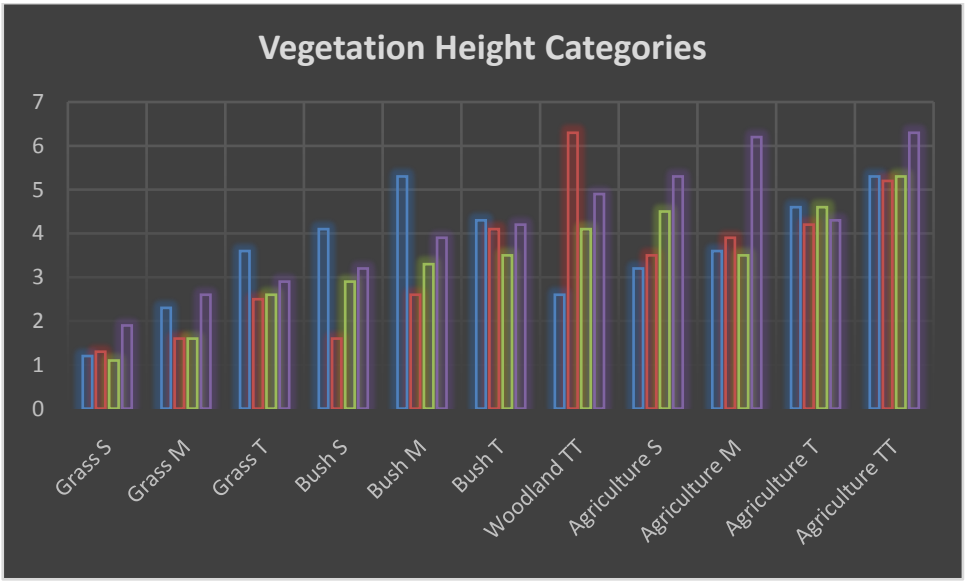

Figure 6: Effect of height-range of Vegetations on occurrence of Species

6. DISCUSSION

Summer and the post-monsoon, when the species breeds, saw a higher number of calls, which corresponds to the time of yeardescribed. This study's findings on calling behavior are consistent with those made who reported that the GF was noisier during the breeding season.

In our study, calls had a greater average encounter rate than direct sightings throughout all seasons. It might be because of the GF's skulking tendencies and versatility in terms of concealment In the event of a threat, the males are known to remain close to the nest and make warning sounds as well as from roosting locations (Rana et al., 2007; Khalil, 2015). Males call from the thick vegetation, according to a previous As Pakistani study by a result, the scientists discovered that the cue-based method was more accurate at determining the presence of the species in locations with greater vegetation cover and height. This hypothesis runs counter to finding, although it might be caused by the different habitat kinds and structures.

It was discovered that only a very small percentage of all sightings could be classified as male or female. The authors speculate that there may be two reasons for the lower proportion of male and female in the overall data. 1) The species' elusiveness and shyness preclude extended observation to examine the spurs. 2) Height of ground plants makes a male's spur difficult to see, especially from July to November. Additionally, the decrease in female sightings from summer to winter may be because to nesting and incubation activities during this time, which causes the females to become less active and avoid the

covey The probability of female mortality during the incubation stage, as observed in P. perdix by is also assumed by the authors, but further research is necessary. Additionally, it was noted that the females were more cautious and slyer, particularly when there were chicks or youngsters around, which decreased the likelihood of sightings.Authors have noted the presence of young chicks with the female outside of its established mating season (Feb-October) on a number of arbitrary visits to Kutch.Although more research is needed, it is hypothesized that a small number of pairs are reproducing in the winter, either because the previous clutch failed or because resources are readily available.

There were two breeding maxima, one from March to May and the other from August to October. The summer and the weeks following the monsoon were when chick sightings were most frequent.The findings are consistent with a previous study from Pakistan, where the majority of chicks (70–80%) were seen between February and May and breeding activity continued through August, 2013), with very little activity throughout the winter Our study demonstrates that the environment with a mosaic of bushes, crops, and grassland has a good impact on the species' overall distribution. GF favored taller vegetation throughout the summer, such as shrubs, forests, and agricultural areas. It agrees with past research that identified woodland as the species' preferred habitat in studies conducted in India The three main woodland species in this study were Prosopis juliflora, Prosopis cineraria, and Acacia nilotica.Prior correspondence between Khan (1989) in Pakistan and Tiwari (1999) in Kutch highlighted the importance of P. juliflora for the Grey Francolin, while other studies in India and Pakistan both highlighted the importance of A. nilotica.

7. CONCLUSION

In this study, there is a large bias in the distribution of GF toward bushes, woodlands, agricultural regions, and grasses. It's possible that the inclination for agriculture is

to the accessibility of water and food. It shown a strong preference for farms growing wheat, alfalfa, sorghum, and millet. According to the study, the species favors areas with hedgerows. Widespread biodiversity loss could be caused by the unchecked use of modern machinery and the rapid proliferation of monoculture systems.

The following suggestions are provided as a result for the preservation of francolins at such sites. 1) It's crucial to have places with a variety of ecosystems, such as agriculture, grassland, scrub forest, and woods 2) The perennial vegetation and hiding places in

hedgerows are essential for francolins. The species may suffer if hedgerows are replaced by a wall or fence.

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