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Influence of Elephant-Driven Vegetation Structure and Altitudinal Gradient on the Occurrence of the Endemic Mount Cameroon Francolin

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Abstract

African forest elephants (*Loxodonta cyclotis*) strongly modify vegetation structure by creating natural clearings, yet the consequences of these habitat modifications for threatened ground-nesting species such as the endemic Mount Cameroon Francolin (*Pternistis camerunensis*) remain largely understood. This poorly studied galliforme faces multiple threats on Mount Cameroon, including hunting, bushfires, and vegetation modification by elephants. Few decades ago, forests on Mount Cameroon were divided by lava flows, creating a barrier that local population of forest elephants not cross until now. The scarcity of ecological information on the Cameroon Francolin prompted us to assess its altitudinal distribution and examine how elephant-induced vegetation changes, across seasons, influence its occurrence. Surveys were conducted during the rainy season (July - August 2021) and the dry season (February - March 2022) at 44 sampling stations (22 undisturbed forest sites and 22 elephant pastures) along an altitudinal gradient from 1100 to 2300 m. Francolins were surveyed using point counts combined with playback within a 300 m radius, while vegetation structure was visually estimated within 50 m of each station. Although habitat type had only a marginal effect on Francolin occurrence, Francolins were more frequently detected in elephant pastures than in forest between 1265 and 2285 m. Vegetation density in the 1 - 3 m and 5 - 10 m strata was negatively correlated with Francolin abundance, whereas the 0 - 1 m stratum showed a positive but non-significant relationship. Occurrence probability declined significantly with increasing elevation. Seasonally, Francolins were more abundant in forest during the rainy season and in elephant pastures during the dry season, though these differences were not statistically significant. Despite limited data due to the species' rarity, our results suggest that elephant-induced habitat modification may enhance habitat suitability for the Cameroon Francolin. Long-term monitoring is needed to confirm these trends and inform conservation strategies for this range-restricted species.

Subject Areas

Plant Science

Keywords

Elephant Disturbances, Altitudinal Gradient, Ecosystem Engineer, Endemic Mount Cameroon Francolin, Vegetation Structure

1. Introduction

Recent studies report on avian population declines in Africa and Cameroon due to natural and human pressures [1]-[3], yet the impact of natural threats remains poorly known. African elephant populations are changing the dynamics of forest ecosystems. However, the direct consequences of disturbances in Central African forests by forest elephants are less well known [4]. As "ecosystem engineers", the African forest elephant (*Loxodonta cyclotis*) is a wide-ranging mega herbivore and keystone species for Afro-tropical rainforests that influences the composition and structure of the ecosystem through movement, browsing and trampling, thereby influencing the distribution and survival of numerous species [4]-[8]. These disturbances can generate positive effects such as the creation of open habitats that benefit some species [9]-[11], but they may also have negative consequences, including declines in habitat-specialist fauna [12]. Such structural changes are known to influence nesting resources, foraging opportunities, and predator prey interactions among forest birds [13] [14], while also altering understory vegetation in ways that benefit or disadvantage different taxa [15]. Studies have shown that the intensive disturbances caused by savanna elephants impact biodiversity negatively [16]-[18]. However, forest elephants' impact on ecosystems and biodiversity loss remains poorly studied. Elephant disturbances, even when non-lethal to vegetation, can weaken plants and increase susceptibility to further damage [19]-[20].

The long-term and fine-scale ecological consequences of these disturbances remain difficult to predict, as their impacts vary across space, altitude, and seasons [21]. Moreover, Afro-tropical rainforests are simultaneously exposed to natural and anthropogenic pressures including volcanic activity, climate change, bushfires, agricultural expansion, hunting, and livestock grazing that collectively exacerbate habitat degradation and biodiversity loss [2]. When combined with elephant-driven vegetation modification, these disturbances can create cascading ecological effects that challenge the persistence of sensitive species [22]. For example, studies in Asia have shown that interactions between elephant clearing and fire can contribute to population declines in ground-dwelling birds such as francolins [23] [24]. The Galliformes are particularly vulnerable to habitat alteration due to their terrestrial habits, slow movement, and reliance on dense understory vegetation for nesting and predator avoidance [25] [26]. Thus, Elephant-driven reductions in dense understory vegetation can compromise nesting opportunities and increase exposure to predators for these ground-nesting birds [27]. Mountain Galliformes with narrow distribution ranges, such as the endemic Mount Cameroon Francolin, are therefore at even greater risk [28].

There is a report that claims that elephants clearing from the Mount Cameroon Francolin's habitat would prevent it from reproducing [29], which remains to be proved, because little is known about its biology [30] and the breeding ecology of the species is not yet studied. Its nests and eggs remain undescribed. The Mount Cameroon Francolin is rare, and little is known about its habitat requirements or environmental tolerances [31]. Very little information exists on the Mount Cameroon Francolin to develop conservation strategies in favour of the species. While Mount Cameroon (habitat of Francolin), faces all kinds of threats that could lead to the deterioration range of the endemic species found there [32]. In addition to volcanic activities, bushfires, agriculture and the exploitation of non-timber forest products that degrade ecosystems [29] [33], the vegetation is overgrazing in certain areas by forest elephants. Few decades ago, forests on Mount Cameroon were divided by lava flows, creating a barrier that local population of forest elephants not cross until now [10], this isolation exacerbates the degradation of vegetation in certain areas. In 2003, a study identified 176 elephants on Mount Cameroon [34], but there's no recent update on their population status. Since then, several observations have been recorded with increasing evidence of their impact inside and outside the Mount Cameroon National Park [10] [11]. Yet, the extent to which elephant-induced changes in vegetation structure influence the spatial distribution and habitat selection of the threatened ground-nesting endemic birds like Mount Cameroon Francolin across seasons and altitudinal zones remains unknown. Understanding how this species responds to environmental variation is crucial for designing effective conservation measures. Identifying the habitat characteristics that influence its occurrence, especially under conditions of disturbance, is fundamental for protecting both the endemic Mount Francolin and other threatened taxa that share its habitat [35] [36].

This study therefore investigates how seasonality and altitude mediate the response of the Mount Cameroon Francolin to elephant-induced changes in vegetation structure within Mount Cameroon National Park. By clarifying these relationships, we aim to provide essential ecological insights that will guide conservation planning for this endangered and poorly known species.

2. Methods

2.1. Study Area

This study was conducted in Mount Cameroon National Park (4.055˚ - 4.378˚N and 9.031˚ - 9.294˚E; 58,178 ha). Mount Cameroon is situated on the coast of South-West Cameroon, such that its South-West slope rises up from the Gulf of

Guinea (**Figure 1**). It is the highest peak in West Africa. Although there is local climatic variation, the region generally has two seasons: a dry season in November - February and a rainy season March - October. Annual rainfall is 2000 - 3500 mm but can exceed 10,000 mm in Debundscha, South-West of Mount Cameroon. The heaviest rain falls during July - September [37]. Temperatures are relatively constant with monthly mean minima and maxima, respectively, of 22˚C - 24˚C and 24˚C - 32˚C [38]. The high rainfall in Mount Cameroon and seasonal change also influence on the species distribution. Forest elephants are known to have two distinct modes of ranging with dry season movements concentrated around rivers or swamps and wet season movements tracking the irregular distribution of fruit [6], which may affect the distribution of others endemic species in Mount Cameroon [39]. The sunny atmosphere in Mount Cameroon National Park has been a key driving force to the feeding and foraging activities of elephants in the area [40].

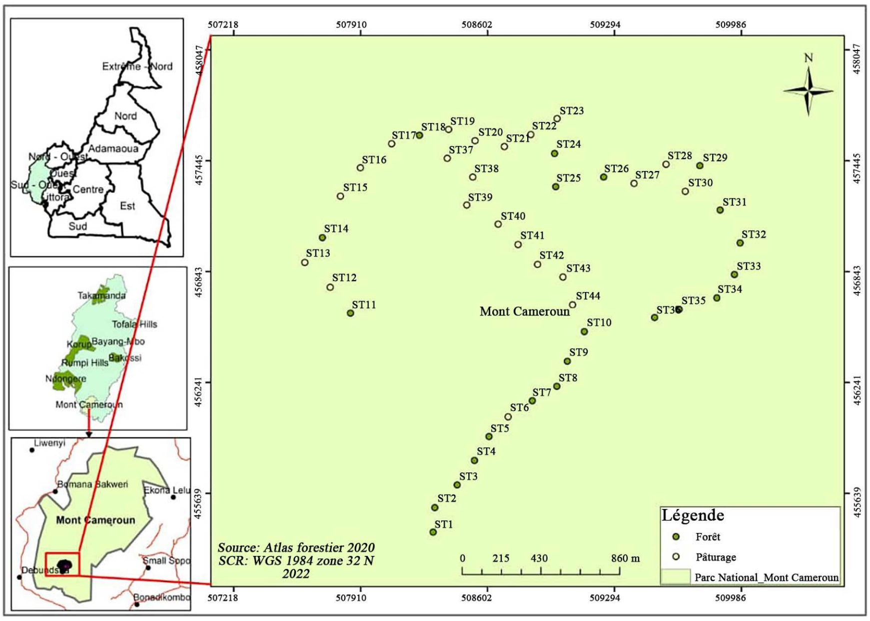

Figure 1. Geolocation of field-visited stations.

2.2. Data Collection

2.2.1. Vegetation Structure

Sampling stations were established along an altitudinal gradient and stratified by two habitat types: intact forest and clearings created by elephant activities (hereafter referred to as elephant pastures). Sites were selected to test the hypothesis that elephant-mediated alteration of vegetation structure influences francolin spatial distribution by modifying shelter availability from predators and food resources. Stations were spaced at 300 m intervals to ensure spatial independence, with coordinates recorded using a Garmin 64X GPS unit.

Vegetation structure was assessed within a 50 m radius around each sampling station. Following [41], vegetation cover was estimated across five vertical strata: 0 - 1 m, 1 - 3 m, 3 - 5 m, 5 - 10 m, and >10 m. For each vegetation layer, we noted the percentage cover, representing vegetation density within each stratum. Additional variables included shrub and bush cover (percentage) and ambient weather conditions at the time of sampling (sunny, cloudy, or rainy). Vegetation surveys were conducted once per season at each station.

2.2.2. Francolin Sampling Technique

To compare species occurrence between the two habitat types, we implemented a standardized inventory on the northeast and southeast slopes of the mountain, where several reports have indicated the presence of the Mount Cameroon Francolin [30] [32] [42]. Based on the previously study [32], we decided to use a distance of 300 meters between stations to avoid data overlap. A study showed that vocal responses of francolin could propagate up to 350 m [43].

2.2.3. Inventory Technique

We used a point count combined with playback as this method had proved effective during the previous investigation [32]. At each station, observers first listened for spontaneous call of Francolin for 3 minutes. If none was heard, the Mount Cameroon Francolin call obtained from the Chappuis collection [44] and recorded using a Radio Shack mini Amplifier-Speaker system was broadcast for 20 seconds, repeated three times, followed by a 5-minute listening period [32]. Each station was surveyed twice per season, with at least two days between visits. For each detection, we recorded GPS coordinates, time, number of vocalizations, and estimated distance to the calling individual. Surveys were conducted daily during peak activity periods: 06:30 - 11:30 and 15:30 - 17:30 [45]. Playback is particularly effective for detecting elusive or low-vocalizing birds such as galliformes, Rallidae, and Caprimulgiformes [46] [47], and has proven useful for inducing responses in francolins and flushing individuals from dense vegetation [48]. This method also provides reliable abundance estimates for habitat-use analyses [49]. A study was conducted on an altitude range of 1100 - 2300 m where the Mount Cameroon Francolin was previously observed in submontane and montane forest, montane scrub and elephant pasture [32].

2.3. Data Analysis

The version 4.1.0 of R software [50] was used to analyze the data. We used the packages readxl for data import, dplyr for data manipulation, ggplot2 and sjPlot for graphical outputs, glmmTMB for statistical modelling, and performance for model diagnostics, bbmle for model comparison and selection, and psy for focused correspondence analysis. Statistical significance was set at $\alpha = 0.05$.

2.3.1. Occurrence Analysis

To assess the influence of habitat, altitude, season, shrub density, and vegetation cover across five strata on Francolin occurrence, we fitted a logistic mixed-effects model with presence/absence as the binary response and sampling stations as random effects.

After building a full model including all predictors, we performed model selection based on AIC values and AIC weights, successively removing variables with low predictive contribution. Among the ten candidate models, Model 8, which retained only altitude and vegetation density in the 5 - 10 m stratum, provided the best balance between parsimony and predictive power ($\Delta AIC < 2$ and highest parsimony). For statistical analyses, altitude was grouped into low (1159.5 - 1500.2 m) and high (1500.2 - 2285.0 m) classes in order to assess the influence of altitudinal variation on the species' occurrence.

2.3.2. Abundance Analysis

Francolin call abundance was treated as count data. Although it met assumptions of non over dispersion and absence of autocorrelation, the data showed slight zero inflation (inflation rate = 0.94), expected for a rare species. We therefore used a zero-inflated Poisson model (ZIP) to predict abundance from nine predictors: altitude, habitat, season, shrub density, and vegetation cover across the five strata.

Model selection, based on parsimony, lowest AIC, and highest AIC weight, identified Model 5 as the best predictor. This model included vegetation density in the 0 - 1 m, 1 - 3 m, and 5 - 10 m strata, along with the habitat × season interaction. Sampling stations were included as random effects.

2.3.3. Focused Correspondence Analysis

We also applied Focused Correspondence Analysis (FCA) to evaluate correlations between Francolin call abundance and vegetation structure (shrub density and vegetation cover across strata). Unlike classical correspondence analysis, FCA allows direct testing of the null hypothesis that the correlations between the response variable and predictor variables are equal to zero, making it suited for response–predictor data structures.

3. Results

Occurrence of the Cameroon Francolin

Across the 44 study stations, the Cameroon Francolin was detected at 21 sites during the rainy season and 31 during the dry season. Natural calling activity occurred mainly at dawn and late afternoon; however, playback elicited significantly more detections than spontaneous vocalizations ($\chi^2 = 7.258$, df = 1, P = 0.007; Figure 2). Playback responses were also detected at greater distances (mean = 69.6 m) than natural calls (mean = 49.9 m).

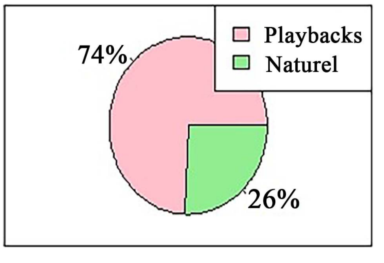

Figure 2. Francolin detection method.

Among the ten measured environmental variables, only altitude and vegetation density in the 5 - 10 m stratum significantly predicted Francolin occurrence (Table 1). The probability of occurrence decreased substantially at higher altitudes (1500 - 2285 m), where the likelihood of detection was reduced by approximately five-fold compared with lower altitudes (odds ratio = 0.15, 95% CI: 0.03 - 0.74, P = 0.020). No individuals were detected below 1265.6 m (Figure 3). Vegetation density in the 5 - 10 m stratum had a marginally significant negative effect (P = 0.053), indicating reduced occurrence in denser mid-canopy vegetation.

Table 1. Estimates, Standard Error (SE) and Z-values of the fixed effects of the binary logistic regression model for predicting the occurrence of Francolins.

Model effect	Estimate	Standard error	Z Statistic	P-Value
(Intercept)	0.44041	0.61143	0.720	0.471
High altitude (1500 - 2285 m)	−1.92078	0.82436	−2.330*	0.020
% vegetation_5 - 10 m	−0.04161	0.02155	−1.931˙	0.053

˙, *, Significant at the 10% and 5% probability levels.

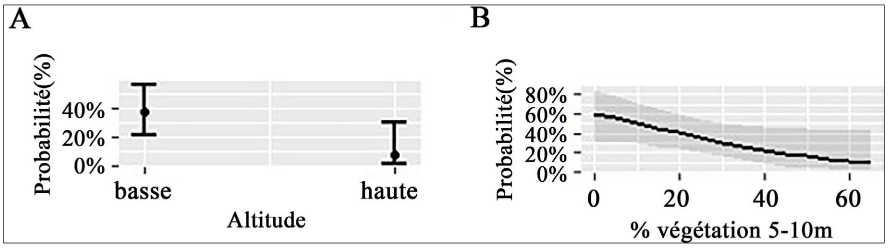

Figure 3. Predicted probability of francolin occurrence according to altitude (low/high) and vegetation density in the 5 - 10 m stratum.

Although habitat type was not significant in the full logistic model, a Fisher test indicated that Francolins were more likely to occur in elephant pastures than in forest (odds ratio = 2.327, 95% CI: 1.00 - 6.67, P = 0.035; Figure 4). Sampling effort was balanced between experimental (playback) and control stations (Fisher test, P = 0.255).

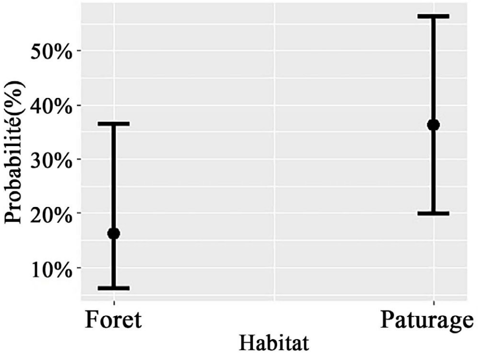

Figure 4. Predicted probability of francolin occurrence by habitat (forest/pasture).

Abundance of vocalizations (ZIP model)

The Zero-Inflated Poisson model revealed significant effects of vegetation structure on call abundance (Table 2). Abundance declined with increasing vegetation density in the 1 - 3 m ($\beta = -0.051$, $P < 0.001$) and 5 - 10 m ($\beta = -0.032$, $P = 0.028$) strata, and marginally in the 0 - 1 m layer ($\beta = -0.027$, $P = 0.068$; Figure 5). A 1% increase in vegetation cover reduced call abundance by 5% in the 1 - 3 m stratum and 3% in the 5 - 10 m stratum.

Table 2. Estimates, standard error (SE), and Z-values of the Poisson component of the ZIP (Zero-Inflated Poisson) model, fitted to predict francolin abundance in relation to altitude.

Model effect	Estimate	Standard error	Z Statistic
(Intercept)	4.67973	1.17008	3.999***
Pasture	−0.73935	0.69300	−1.067
Dry season	−2.04012	0.61529	−3.316***
% vegetation_0 - 1 m	−0.02720	0.01493	−1.821•
% vegetation_1 - 3 m	−0.05130	0.01498	−3.425***
% vegetation_5 - 10 m	−0.03215	0.01466	−2.193*
Pasture: dry season	1.67892	0.63279	2.653**

•, *, **, ***, significant at the 10%, 5%, 1%, and 0.1% probability levels.

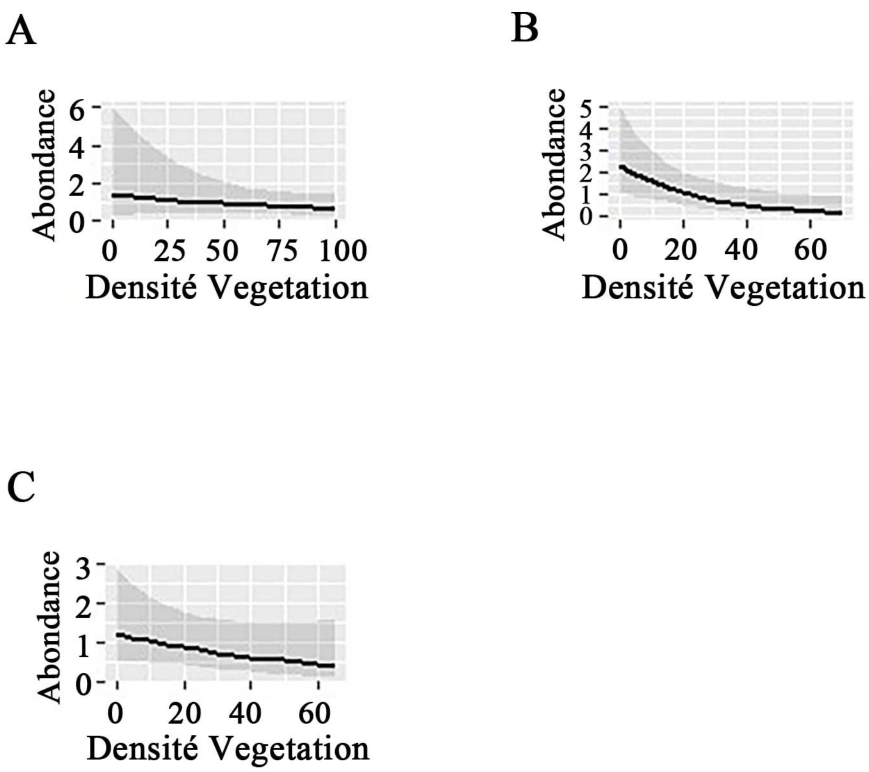

Figure 5. Abundance of francolin calls in relation to vegetation density (%) across three strata (A = 0 - 1 m; B = 1 - 3 m; C = 5 - 10 m).

A significant habitat × season interaction was detected ($\beta = 1.679$, $P = 0.008$). Call abundance was higher in pasture habitats during the dry season, but higher in forests during the rainy season (Figure 6).

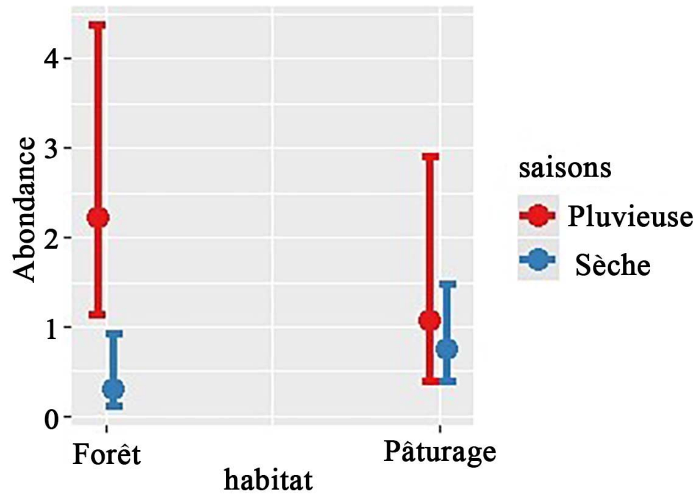

Figure 6. Francolin abundance in relation to habitat and season, with their 95% confidence intervals.

Focused Correspondence Analysis

The FCA analysis showed a weak, non-significant positive correlation between call abundance and vegetation cover at 0 - 1 m ($r = 0.2$). In contrast, strong negative correlations were found for the 1 - 3 m ($r = –0.4$, $P < 0.05$) and 5 - 10 m ($r = –0.4$, $P < 0.05$) strata (Figure 6), consistent with the ZIP model. Shrub density presented a negative but non-significant relationship with call abundance.

Vegetation strata 1 - 3 m, 3 - 5 m, 5 - 10 m, and >10 m displayed similar structural patterns, whereas the 0 - 1 m layer was distinct.

4. Discussion

This study provides the first quantitative assessment of the altitudinal distribution and effect of the modification of vegetation structure induced by forest elephant depending on the seasons on the occurrence of the endemic Mount Cameroon Francolin. Our results highlight the combined roles of altitude, vegetation structure, habitat type, and seasonality in shaping the distribution and detectability of this elusive endemic species.

Importance of playback and implications for detectability

Playback significantly increased detection probability compared with spontaneous calls, both in terms of the number of detections and detection distances. This is consistent with our previous work [32]. Studies showed that playback enhances detection of cryptic or low-density Galliformes [45] [51]. The Cameroon Francolin's low rate of natural calling restricted mainly to dawn and dusk further confirms the species' shy and secretive behaviour. Our findings therefore reinforce existing recommendations that playback should be integrated into standardized monitoring protocols for this species [32].

Altitudinal constraints on Francolin occurrence

Altitude was the strongest predictor of occurrence, with no detections below ~1265 m and a sharp decline in occurrence probability at higher elevations as previously observed [32]. Similar elevational specializations have been reported for other montane African francolins, which often occupy narrow thermal and vegetation niches [31] [52]. Several authors have demonstrated that the occurrence of mountain birds with altitude is known to follow a bell-shaped pattern, increasing from low to mid-altitudes and then declining towards the summits [53]-[55]. This pattern reflects changes in resource availability related to forest structure [56] and site productivity [57]. This suggests that the Cameroon Francolin may be limited by temperature, food availability, or vegetation structure along the mountain slope. As observed in other tropical montane birds [58], such altitudinal restriction increases vulnerability to climate-driven upward shifts of ecological zones. The reduced detection probability above 1500 m may reflect harsher microclimates and lower arthropod biomass typical of upper montane environments.

Influence of vegetation structure on occurrence and abundance

Vegetation density in the 5 - 10 m and 1 - 3 m strata had a strong negative influence on Francolin activity. Similar negative relationships between dense vegetation and detectability or habitat suitability have been found in other African understorey birds [59] [60]. Dense mid-canopy layers may hinder movement, reduce sound transmission, or lower food accessibility. In contrast, the weak relationship with vegetation at 0 - 1 m suggests that ground vegetation alone does not determine habitat suitability. This consistent with findings that francolins typically use a mix of ground and low-shrub strata for foraging and cover [61].

The negative correlations identified by the FCA further confirm that increasing vegetation clutter particularly in mid-height layers reduces the likelihood of francolins using a given site. This supports the idea that the species prefers semi-open environments with sufficient visibility for movement and predator vigilance. The selection of grassy microhabitats may also reflect nesting requirements, as documented in other francolin and Asian partridge species that conceal nests in herbaceous cover [62]. In India, for example, the Painted francolin (*Francolinus pictus*) typically breeds in modified environments such as forest clearings or lightly wooded areas with scattered shrubs and trees [63]. Moreover, multiple Galliforme species especially hill partridges have been shown to survive or even thrive in secondary habitats, including forests modified by elephant activity. The Orange-necked Partridge, for instance, exhibits strong ecological performance in such altered landscapes [64]. These similarities indicate that partial habitat openness, structural heterogeneity, and moderate disturbance may enhance detectability or ecological suitability for some Galliformes.

However, the habitat tolerance we observed in the Cameroon Francolin contrasts sharply with the strict forest dependence reported for other Galliforme species. The chestnut-bellied partridge (*Arborophila javanica*) is restricted exclusively to intact natural forest [65]. Similar patterns have been documented for the Sichuan Partridge and the Hainan Partridge (*Arborophila ardens*), both of which rely entirely on undisturbed primary forest [66]. Red-winged Francolins (*Francolinus levaillantii*) likewise do not tolerate pasturelands and remain confined to unmodified habitats [23]. Such species are well-known for their sensitivity to habitat alteration and are often considered bio indicators of environmental change due to their dependence on stable forest structure [24] [26].

Habitat-specific and seasonal patterns

Although habitat type was not significant in the full model, Fisher's test indicated a higher occurrence of the Cameroon Francolin in elephant-maintained pastures compared to forest. Open pastures created by elephants are known to support high herbaceous productivity and increased invertebrate abundance [6] [67], potentially enhancing foraging opportunities for francolins. Comparable associations with semi-open montane mosaics have been reported for other francolin species [61], and studies from elephant-inhabited forests in Ghana [68] and on Mount Cameroon [11] indicate that elephant foraging areas are not inherently unsuitable for forest bird communities. However, on Mount Cameroon, elephant-mediated habitat modification interacts with multiple anthropogenic pressures, notably bushfires deliberately set by hunters to facilitate access or flush game. These fires can readily propagate through the herbaceous layers of elephant-maintained pastures, increasing fire frequency and spatial extent beyond natural background levels. Similar interactions between natural disturbances and human-induced fire have been shown to produce cascading effects on bird communities, including shifts in species distribution, degradation of nesting substrates, and reduced reproductive success, particularly among understory species [23] [27] [69] [70].

While moderate elephant disturbance alone may generate habitat heterogeneity that benefits some ground-dwelling birds, recurrent fire in these open habitats may counteract such benefits by reducing ground cover, destroying nests, and simplifying vegetation structure. Previous studies have suggested that elephant activity can already lower the availability of dense ground cover required for nesting [27] [29], and when combined with anthropogenic threats, these effects may be amplified. Nevertheless, within the temporal scope of this study, elephant-induced vegetation changes did not appear sufficiently severe to threaten the persistence of the Mount Cameroon Francolin. Instead, these modified habitats may represent a dynamic balance between resource enhancement and disturbance. Field observations of francolin footprints on elephant dung further suggest active exploitation of dung-associated invertebrates, highlighting a functional link between elephant activity and francolin foraging behavior. It is therefore plausible that elephant foraging areas provide short-term advantages by improving food availability and movement efficiency. However, under scenarios of increasing fire frequency and human pressure, this balance may shift, potentially increasing risks for the Cameroon Francolin and other endemic, ground-nesting, and understory bird species. These findings underscore the importance of incorporating fire management and the regulation of hunting practices into conservation planning on Mount Cameroon, alongside the maintenance of natural disturbance regimes.

Seasonal variations appear to be the main factor driving temporal fluctuations in the abundance and distribution of birds, which are generally linked to climatic seasons reflecting seasonal changes in the availability of food resources [71]. These variations also seem to influence the distribution of the Mount Cameroon Francolin. Indeed, we observed an apparent seasonal variation in the number of francolins across habitats depending on the season. The significant habitat × season interaction suggests that Francolin activity responds to seasonal variation in resource distribution [72]. Higher call abundance in pastures during the dry season may reflect increased concentration of food resources in open habitats, while the greater activity in forests during the rainy season likely corresponds to higher invertebrate availability under humid conditions [73]. Seasonal habitat shifts have been documented in several African mountain birds [41] [74] and may reflect behavioural flexibility in response to resource pulses. Thus, the Cameroon Francolin could be more abundant in the lower strata with dense forest vegetation in search of berries, seeds and insects for its food as for many avian species [75].

Conservation implications

The species' dependence on mid-elevation habitats and relatively open vegetation has important conservation implications. Increases in vegetation density driven by forest regrowth, declines in elephant populations, or fire suppression may reduce habitat suitability. Elephant-maintained pastures appear to provide key habitat, indicating that megafauna-driven habitat dynamics can indirectly benefit the species and represent, a positive example of "ecosystem engineering" effect [67]. The species' restricted elevational range further heightens its vulnerability to climate change, which is expected to shift and compress suitable habitats upslope [58] [76]. Conversely, in spatially constrained systems such as Mount Cameroon where lava flows have isolated elephant populations and limit their movements [10], locally high elephant densities may result in excessive vegetation modification, leading to overgrazing and habitat degradation. Such impacts could negatively affect the endemic Mount Cameroon Francolin, by reducing nesting cover and increasing exposure to predators.

5. Conclusion

Overall, Francolin occurrence and vocal activity are strongly shaped by elevation, vegetation structure and seasonal habitat dynamics. Playback is essential for reliable detection and should be incorporated into long-term monitoring. Conservation efforts and continuous ecological monitoring should be prioritized in semi-open montane habitats particularly elephant pastures within the mid-elevation belt of Mount Cameroon, where habitat suitability appears highest. Importantly, future research should move beyond patterns of occurrence and activity by directly linking specific habitat types to measures of reproductive success, such as nesting success and chick survival, to provide a more definitive assessment of habitat quality and inform targeted conservation strategies.

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Conflicts of Interest

The authors declare no conflicts of interest.

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