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### Post-release monitoring of a critically endangered galliform subspecies, *Francolinus bicalcaratus ayesha*, in Morocco: a field study using playback call counts

Saâd Hanane<sup>a</sup> & Abdeljebbar Qninba<sup>b</sup>

<sup>a</sup> Forest Research Center, Haut-Commissariat aux Eaux et Forêts et à la Lutte Contre la Désertification, Avenue Omar Ibn El Khattab, BP 763, 10050, Agdal-Rabat, Morocco

<sup>b</sup> Université Mohammed V-Agdal, Institut Scientifique de Rabat, Avenue Ibn Battouta, BP 703, 10090, Agdal-Rabat, Morocco

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## Post-release monitoring of a critically endangered galliform subspecies, *Francolinus bicalcaratus ayesha*, in Morocco: a field study using playback call counts

Saad Hanane<sup>a\*</sup> and Abdeljebbar Qninba<sup>b</sup>

<sup>a</sup>Forest Research Center, Haut-Commissariat aux Eaux et Forêts et à la Lutte Contre la Désertification, Avenue Omar Ibn El Khattab, BP 763, 10050, Agdal-Rabat, Morocco; <sup>b</sup>Université Mohammed V-Agdal, Institut Scientifique de Rabat, Avenue Ibn Battouta, BP 703, 10090, Agdal-Rabat, Morocco

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The Double-spurred Francolin *Francolinus bicalcaratus ayesha* is a critically endangered galliform subspecies in Morocco. To improve the viability of this threatened population, 300 captive-bred francolins were released into the Didactic Lot of the Royal Moroccan Federation of Hunting, and post-release monitoring was conducted. In this study, we used playback call counts to assess differences in habitat use and temporal variations in vocal activity of Double-spurred Francolins. The number of male calls per point count was significantly higher in the wooden matorral (WM) than in the non-wooden matorral (MT). The male responses per point count also increased depending on date, reaching a maximum in the first 10 days of March. The pattern was similar in the two habitats, although the maximum average call rates were significantly different [WM = 1.575 (95% CI: 1.394–1.780), MT = 0.481 (95% CI: 0.393–0.589)]. We suggest that call counts collected during this period could be used to index the annual change of the released population in that area. Further researches are, however, needed to (1) estimate the current population size of the released francolins and (2) characterize the habitats used within this protected area.

*Francolinus bicalcaratus ayesha* –Galliformes būriui priklausančio dvipentinio frankolino kritiškai grėsmingos būklės endeminis porūšis Maroke. Nykstančios populiacijos gyvybingumo padidimui į Karališkosios Maroko medžiotojų federacijos bandomuosius plotus buvo išleista 300 nelaisvėje išaugintų *F. bicalcaratus ayesha* individų. Monitoringo metu atlikta jų balsų apskaita naudojant balsų įrašus, įvertinti biotopo pasirinkimo skirtumai ir vokalinio aktyvumo dinamika. Viduržemio pajūrio srities sumedėjančių augalų matoralyje (SAM) užregistruota žymiai daugiau patinų balsų viename apskaitos taške, negu nesumedėjusių augalų matoralyje (NAM). Didžiausias patinų balsų skaičius užregistruotas pirmame kovo mėnesio dešimtadienyje. Abiejuose biotopuose pokyčiai buvo panašūs, tačiau maksimalaus balsų skaičiaus vidurkis žymiai skyrėsi [SAM = 1,575 (95% PI: 1,394–1,780), NAM = 0,481 (95% PI: 0,393–0,589)]. Manome, kad tyrimo laikotarpiu užregistruotas *F. bicalcaratus ayesha* balsų skaičius gali būti naudojamas vertinant išleistų į laisvę frankolinų skaičiaus dinamiką. Dar reikėtų įvertinti šios populiacijos dydį ir pasirinkamus biotopus.

**Keywords:** Double-spurred Francolin; playback call counts; Morocco

### Introduction

The reintroductions, defined as an attempt to establish a species in areas within its historical range where it is extinct, have become an accepted intervention in conservation (Seddon, Armstrong, and Maloney 2007; Armstrong and Seddon 2008). The realization of such programs is often done via the release of captive-bred individuals (IUCN 1998; Moorhouse, Gelling, and Macdonald 2009; Bernardo et al. 2011). Reintroductions are somewhat useful if post-release monitoring programs were not established. Indeed, the latter are of major importance in (i) assessing the success of the release operation (IUCN 1998), (ii) helping knowing the factors that influence population reestablishment following their release (Armstrong and McLean 1995; Sarrazin and Barbault 1996; Bernardo et al. 2011), and (iii) filling in the gaps in terms of the knowledge (population biology, community ecology, and conservation) of the species involved (Burnside et al. 2011).

The Double-spurred Francolin *Francolinus bicalcaratus* (Linnaeus, 1766) occurs in tropical West Africa with an isolated subpopulation in Morocco. *Francolinus bicalcaratus ayesha* is an endemic galliform subspecies to Morocco (Thévenot, Vernon, and Bergier 2003). It is listed as critically endangered (Thévenot, Vernon, and Bergier 2003) and currently occurs in the hinterland of Rabat-Casablanca in localities near Sidi Yahia des Zaër, Sidi Bettache, and Ben-Slimane (Thévenot, Vernon, and Bergier 2003).

This subspecies is known to be a very local resident (Thévenot, Vernon, and Bergier 2003). The population of *Francolinus bicalcaratus ayesha* has been reduced through hunting and habitat destruction (Thévenot, Vernon, and Bergier 2003).

Given this situation, the reestablishment of a viable breeding population of this francolin is desired to restore its status. Consequently, as part of its strategic efforts to strengthen wild populations, the High Commissariat for Water, Forests and Desertification Control of Morocco

\*Corresponding author. Email: [sd\\_hne@yahoo.fr](mailto:sd_hne@yahoo.fr)

has released 300 Double-spurred Francolins at the Didactic Lot of the Royal Moroccan Federation of Hunting (DLRMFH), which is located within a historical range of the species. This action has been done in conjunction with these two partners, the Royal Moroccan Federation of Hunting and the captive breeding centre Domaine la Gazelle-Gibiers.

These 300 francolins came from the livestock domain called Domaine la Gazelle-Gibiers (DGG). The managers have been authorized to collect eggs from a relict natural population at the Ain Sferjla Royal Reserve. The eggs were incubated in the DGG to give birth to our francolins. Releases took place in late winter (November 2011). Birds were soft-released after keeping them for two weeks in an acclimatization pen of 2.5 ha which contained 20 aviaries of 20 × 10 m each. Water and food were provided within the aviaries and, after the release of birds, over the entire site at specific water and feed points. In each aviary, the francolins were released in flocks, aviary by aviary, with a time interval of one hour between flocks. With regard to health status, all of the 300 francolins were free from parasites and other diseases.

In this paper, we present detailed data on the post-release monitoring of reintroduced captive-bred Double-spurred Francolins in Morocco over a 24-month period using playback call counts. This technique is nowadays commonly employed to increase the detection of many secretive bird species (Conway et al. 1993; Zuberogoitia and Campos 1998; Brambilla and Rubolini 2004), such as Galliformes (Ponce-Boutin 1992; Evans et al. 2007; Kasprzykowski and Goławski 2009; Jakob et al. 2010; Fuller et al. 2012; Jakob, Ponce-Boutin, and Besnard 2014).

Our monitoring is in its first phase, which includes collecting quantitative data on the use of habitats and the chronological change in the intensity of Double-spurred Francolin calls following the release. We aimed, therefore, to determine whether there is a spatio-temporal variation in the number of male Double-spurred Francolin calls. If so, we attempted to answer the two following questions:

How does the number of male Double-spurred Francolin calls vary spatially depending on habitat type?

How does the number of male Double-spurred Francolin calls vary temporally depending to year and date?

## Study area and methods

### Study area

Double-spurred Francolins were reintroduced and monitored at the Didactic Lot of the Royal Moroccan Federation of Hunting (34°00'80"N, 6°28'25"W), which is located within the Ma'amora forest, Morocco (Figure 1). This forest is considered a Biological and Ecological Interest Site by the Moroccan Protected Areas Study (AEFCS 1996). The DLRMFH is a fenced area of about

350 ha. It is situated nearby the city of Sidi Allal Al Bahraoui, at 210 m a.s.l, upon the canton C (Figure 1) wherein the annual precipitation averages 450 mm. The average monthly temperatures vary from 12 °C (January) to 25 °C (July–August). This region is characterized by dry and hot summers and mild winters (semi-arid bioclimate). The study site is controlled intensively mainly for not allowing the input of the livestock, which is dominated by sheep in this region.

Within this part of Ma'amora, the forest landscape is dominated by two habitats: (i) the non-wooden matorral (MT), 190 ha, mainly composed of the needle-leaved broom *Teline linifolia*, Mediterranean dwarf palm *Chamaerops humilis*, sage-leak rock rose *Cistus salviifolius*, and Spanish lavender *Lavandula stoechas*, and (ii) the wooden matorral (WM), 160 ha, covered mainly by cork oak trees in association with the aforementioned shrub species in the matorral.

### Release

As stipulated in the IUCN guidelines (1998), the DLRMFH was selected as a suitable release site for reintroduction because: (i) there are no longer Double-spurred Francolins in the Ma'amora forest to the extent that the species has disappeared from this area (Thévenot 1991; Cherkaoui et al. 2007, 2009), (ii) it is within the former range of the species (Thévenot, Vernon, and Bergier 2003), and (iii) it contains suitable habitats for the species (De la Perche 1992; Thévenot, Vernon, and Bergier 2003). The success of such reintroduction program is often known to be dependent upon the suitability of habitats at the release site (Ewen and Armstrong 2007; Bennett et al. 2013).

### Data collection

The fieldwork was carried out between December and June in 2012 and 2013. As the Double-spurred Francolin is a territorial species (the male sings to attract the female and to defend its territory) (Alaoui 2001) and as the released birds were unbanded, we used the playback calls that stimulate territorial calls in response. Because there are two distinct habitats (MT and WM) at the DLRMFH, we adopted a stratified random sampling. On each studied habitat, four permanent transects were randomly established (total data-set: eight transects). On each transect (1.2–1.5 km), four points were established. The point transects were run 14 times over the season (twice a month from December to June).

The four points were spaced 0.3 km apart to avoid double counting. We estimated the number of calling Double-spurred Francolin males based on three-min stays at each listening point. We played Double-spurred Francolin calls from a laptop via VLC media player and two speakers (5 W each). One cycle of Double-spurred Francolin male territorial calls was played during playback. Each call was played for 10 s, and responses were noted

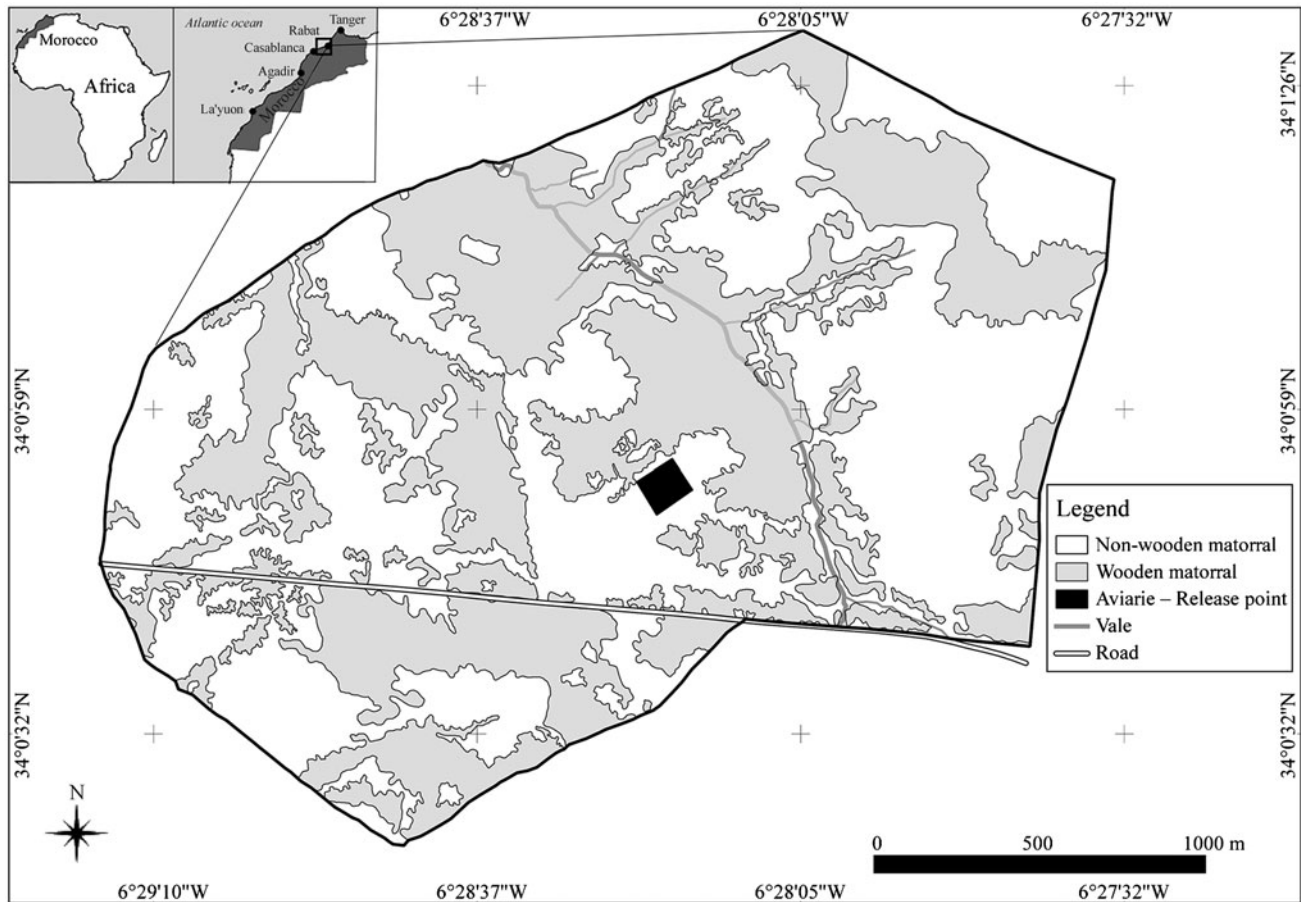


Figure 1. Location of the study area (Didactic Lot of the Royal Moroccan Federation of Hunting in Mamora forest and nearby the city of Sidi Allal Al Bahraoui, Morocco), showing the release site of reintroduced Double-spurred Francolin *Francolinus bicalcaratus ayesha*.

in the ensuing 60 s. This process was repeated thrice toward each cardinal point, to give a total of three successive playbacks. The number of different individuals heard was recorded.

All playback surveys were conducted during four hours following the sunrise because calling activity is known to be stronger during this period (Heinze and Krott 1979). Our protocol was performed only in good meteorological conditions (no wind or rain) to get a good vocal amplitude in response.

#### Data analysis

Statistical analyses were performed using R, version R2.12.2 (R Core Development Team 2009). We modeled the number of calls per point count depending on habitat, year and Julian date using generalized linear models (GLMs) with a Poisson distribution and a log link function (McCullagh and Nelder 1989). We expressed our results in the number of males heard per point count (index of abundance) (Westbrooke, Etheridge, and Powlesland 2003; Spurr, Borkin, and Drew 2012). We tested if there is a significant relationship between the number of male calls and Julian date. This proved to be

not significant ( $F = 0.058$ ,  $p = 0.954$ ), we can thus consider the statistical independence of the data.

The ratio of residual deviance to residual degrees of freedom after the dependant variable was fitted in the model was close to 1, indicating that the data were not overdispersed (Dean 1992; Smith and Heitjan 1993). We, thus, developed an all-inclusive set of candidate GLMs using the multi-model inference (Burnham and Anderson 2002). The explanatory variable (habitat, date, and year) were thus tested alone, in addition and in interaction.

The data covariate was considered linearly and quadratically (in order to detect any optimum). For each model, Akaike information criteria (AIC) were calculated from the general formula  $AIC = -2 (\log \text{likelihood}) + 2K$ , where  $K$  is the number of parameters. The model with the lowest AIC was selected as the best fitting model.

We corrected AIC for a small sample size using AICc (Burnham and Anderson 2002). To test whether the residuals of the best model are normally distributed, and thus acceptable, the goodness-of-fit (GOF) test was performed. In the text, data are expressed as mean  $\pm$  1 SE.

Table 1. Parameter estimates of the best model GLM (Poisson-distribution and a log link-function) fitted on the data-set of the number of male Double-spurred Francolin *Francolinus bicalcaratus ayesha* calls per point count in the Didactic Lot of the Royal Moroccan Federation of Hunting, in 2012 and 2013, Morocco.

	Estimates	SE	Z value	Pr (> z )
Intercept	-3.299	$2.401 \times 10^{-1}$	-13.74	<0.001
Habitat	1.186	$1.102 \times 10^{-1}$	10.76	<0.001
Date	$4.863 \times 10^{-2}$	$4.402 \times 10^{-3}$	11.05	<0.001
Date <sup>2</sup>	$-2.296 \times 10^{-4}$	$2.044 \times 10^{-5}$	-11.23	<0.001
Residual deviance	888.27			
df	802			
GOF	0.0579			

Table 2. Model comparison procedure performed on the data-set of the number of male Double-spurred Francolin *Francolinus bicalcaratus ayesha* calls in the Didactic Lot of the Royal Moroccan Federation of Hunting in 2012 and 2013, Morocco. Only 10 best models are shown (out of 30 examined). AICc is Akaike's information criterion for small samples,  $\Delta AICc$  is the scaled value of AICc,  $W_i$  is the Akaike weight, and  $W_i$  cum is the cumulate Akaike weight. HB = categorical habitat effect, Y = categorical year effect, D = linear date effect, and D<sup>2</sup> = quadratic effect of date.

	AIC	$\Delta AIC$	$W_i$	$W_i$ cum
HB + D + D <sup>2</sup>	1541.1	0	0.46	0.46
HB + Y × D + D <sup>2</sup>	1543.3	2.2	0.15	0.61
HB × D + D <sup>2</sup>	1543.6	2.5	0.13	0.74
HB + Y + D + D <sup>2</sup>	1543.8	2.7	0.12	0.86
HB × Y + D + D <sup>2</sup>	1544.6	3.5	0.08	0.94
HB × Y × D + D <sup>2</sup>	1545.6	4.5	0.05	0.99
AN × D + D <sup>2</sup>	1679.1	138	0.00	1
D + D <sup>2</sup>	1679.6	138.5	0.00	1
Y + D + D <sup>2</sup>	1681.3	140.2	0.00	1
HB + D <sup>2</sup>	1709.8	168.7	0.00	1

**Results**

The best model retained an effect of the habitat and the linear and quadratic effect of the date (Tables 1 and 2). Our results show a significant spatio-temporal variation in the number of male Double-spurred Francolin calls per point count. Indeed, this model (Table 1) showed that this number did not vary over the two study years ( $p = 0.358$ ) and over the two years at each habitat ( $p = 0.853$ ). However, this same number significantly varied between the two habitats, being higher in the WM than in the non-wooden one ( $p < 0.001$ ) (Figure 2). In 2012 and 2013, the maximum of male calls recorded was six in the WM and two in the non-wooden one.

From a temporal point of view, the male responses per point count increased depending on the date reaching an optimum within the first 10 days of March (day 100) and then decreased until complete arrest in late June (Figure 2). However, in the two habitats, the overall pattern was similar although the optimums were significantly different [WM = 1.575 (95% CI: 1.394–1.780); MT = 0.481 (95% CI: 0.393–0.589)]. Furthermore, the number of transects with at least one male call was four (100%) in the WM and two (50%) in the non-wooden one, respectively, in 2012 and 2013.

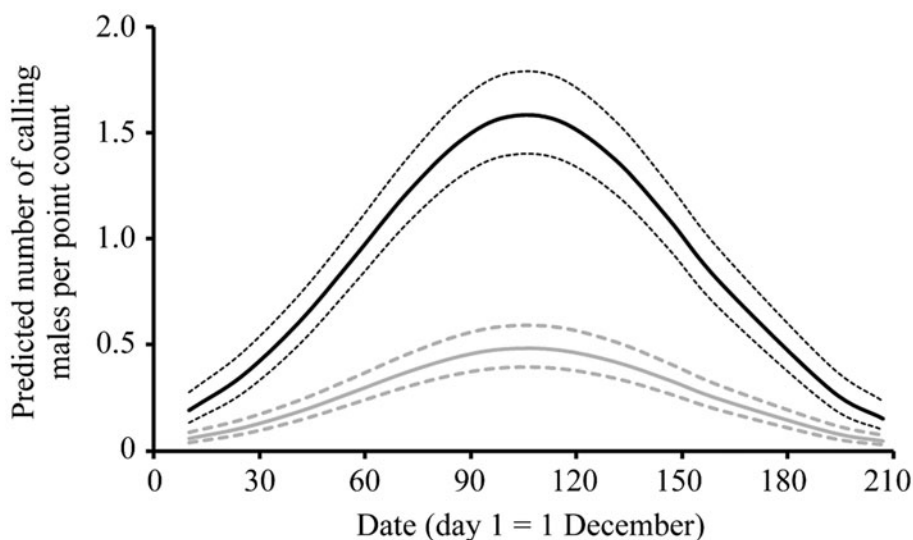


Figure 2. Relationship between the predicted number of male Double-spurred Francolin calls *Francolinus bicalcaratus ayesha* and date in the Didactic Lot of the Royal Moroccan Federation of Hunting. Gray lines are for the MT, dark lines are for the WM. Dashed lines are lower and upper 95% confidence limits.

## Discussion

This study demonstrated that the number of singing males per point count markedly varied depending on the date and habitat type. This result is in agreement with the general view of galliform species. Indeed, in the Red-legged Partridge for instance, it is now admitted that aural counts stimulated by playback vary depending on several parameters like hour, date, season, habitat, and site (Pépin and Fouquet 1992; Jakob et al. 2010; Jakob, Ponce-Boutin, and Besnard 2014). In studying the Nahan's Francolin, another threatened African forest galliform, Fuller et al. (2012) have also reported an important variation between three studied sites in Uganda. These recent studies show the efficiency of such aural technique for detecting possible spatio-temporal variations for the Galliformes (Kasprzykowski and Goławski 2009; Jakob et al. 2010).

With regard to habitat occupation, our results showed that this subspecies preferred the cork oak WM. From a methodological point of view, this result confirms once again that the use of playback can allow determining habitat preference as reported by Jenkins and Ormerod (2002), Kasprzykowski and Goławski (2009), and Rempel et al. (2013). From the habitat use point of view, the attraction of Double-spurred Francolins for this typically forest habitat has been often announced in Morocco (Thévenot 1976; De la Perche 1992; Thévenot, Vernon, and Bergier 2003), although this has not been studied quantitatively. So why do the Double-spurred Francolins use the WM more? As reported for most Galliformes, it could be a strategy to maximize thermoregulatory benefits and to avoid predation (Eiserer 1984; Beauchamp 1999; Xu et al. 2010). Indeed, the species was sometimes seen roosting on branches of cork oak trees. According to Fisher et al. (2004) and Xu et al. (2010), roosting behavior is likely to be an important determinant of individual fitness.

On the other hand, a significant variation was recorded in the number of singing males according to the date. Indeed, the maximum of male Double-spurred Francolin calls was recorded in March. This result is important, by informing on the optimum mating period of this galliform at the DLRMFH. It has also another merit, particularly in terms of upcoming scientific monitoring. The knowledge of that optimum period is a prerequisite for assessing the population change in the DLRMFH from year to year. Indeed, the annual collection of call counts during this optimum would be efficient to detect a possible trend of this population in the near future. We, therefore, suggest that call counts collected during the first 10 days of March could be used to index the annual change of that released population as that was proposed for another francolin species, the Graywing Francolin *Francolinus africanus* in South Africa by Little and Crowe (1992).

The number of call counts during this specific period would be also efficient to estimate the size of this

population and to characterize habitats used by this threatened species (Downey et al. 2006; Cummins et al. 2010). Nijman (2007), in assessing the effects of vocal behavior on abundance estimates of the Great Argus Pheasant *Argusianus argus*, also worked at the period when the birds were highly vocal. In studying the efficiency of using song playback during call count surveys of Red-legged Partridges *Alectoris rufa*, Jakob et al. (2010) worked during the highest calling activity period (March–mid-April). In the same way and regarding the same species, Ciuffardi and Spanò (2013) worked from mid-March to mid-April.

In summary, our results at the DLRMFH indicate that Double-spurred Francolins use the WM more than the non-wooden one and that there is an optimal spring period of singing activity. A second monitoring phase will be conducted with a view to:

- estimating the current population size of the released francolins;
- characterizing the habitats used within this protected area; and
- acquiring knowledge of the roosting behavior and roost selection.

Such knowledge could aid in the conservation of this critically endangered galliform subspecies in Morocco.

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