

# Abundance and habitat utilisation by Galliformes in the Sariska Tiger Reserve, Rajasthan, India

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**Abstract** We used a Distance Sampling line transect method to estimate the abundance and determine patterns of habitat utilisation of seven species of Galliformes in the Sariska Tiger Reserve, Rajasthan, India from February to May 2009. Sixteen transects, ranging from 1.8 to 2 km in length were laid with respect to bird abundance and habitat configuration throughout the 80 km<sup>2</sup> study area. The most abundant galliform species was the Indian peafowl *Pavo cristatus* with an estimated density of  $53.1 \pm 5.6$  individuals per km<sup>2</sup>. Densities were also estimated for grey francolin *Francolinus pondicerianus* ( $21.6 \pm 4.8$  individuals per km<sup>2</sup>), quail species ( $4.3 \pm 1.40$  individuals per km<sup>2</sup>) and painted spurfowl *Galloperdix lunulata* ( $2.5 \pm 0.9$  individuals per km<sup>2</sup>), but there were too few detections to enable estimate of density for black francolin *Francolinus francolinus*, rain quail *Coturnix coromandelica*, and red spurfowl *Galloperdix spadicea*. Mean estimated group size ( $\pm$  SE) was comparatively higher for quails ( $3.7 \pm 0.4$ ), followed by Indian peafowl ( $2.3 \pm 0.1$ ), grey francolin ( $2.0 \pm 0.9$ ) and painted spurfowl ( $1.9 \pm 0.1$ ). Estimated male-female sex ratios were 67:100, 50:100 and 96:100 for Indian peafowl, rain quail and painted spurfowl respectively. The latter species primarily utilised riverine forests, whereas the remaining Galliformes largely utilised scrubland and other habitats.

**Keywords** Distance Sampling, line transects, density, group size, habitat use, India

## Introduction

India has a rich diversity of partridges, quails, francolins and snowcocks that have centres of distribution in either eastern Asia, or western Asia and Africa, which is a consequence of the unique location of India at the crossroads of Asia (Carroll, 2007). About 19 Galliformes species are reported to be present in the arid and semi-arid region of India (Ali & Ripley, 1987; Grimmett et al., 1998). Of these, rain quail *Coturnix coromandelica* is the only species known to occur in all states throughout these arid and semi-arid regions (Kalsi, 2007). Grey francolin *Francolinus pondicerianus* and Indian peafowl *Pavo cristatus* are also known to occur in moist and dry deciduous forests throughout India, while black francolin *Francolinus francolinus* is found in a range of different habitat types throughout northern, western and central regions (Ali & Ripley, 1987). Painted spurfowl *Galloperdix lunulata* is endemic to India as its distribution lies entirely in the central, western and southern parts of the arid and semi-arid zones (Kalsi, 2007). Very little (empirically) is known regarding the abundance

of these different Galliformes and fewer details are available regarding patterns of habitat use by these species. In this study we present the results of a Distance Sampling line transect survey with the aim to provide some of the first empirical data on the abundance and patterns of habitat use by these seven galliform species. To achieve this goal of identifying a habitat-wise pattern of abundance of a galliform community, we carried out this study with two objectives: an estimation of galliform abundance, and an assessment of the habitat use by Galliformes with the perspective of conservation importance of target species largely restricted to those habitats.

## Methods

### Study area

The Sariska Tiger Reserve is an 881 km<sup>2</sup> area located in the Aravalli Hills ( $79^{\circ}17' - 76^{\circ}34'E$ ,  $27^{\circ}05' - 27^{\circ}33'N$ ) and consists of two distinct zones (Shahabuddin et al., 2006): the 274 km<sup>2</sup> National Park and the 607 km<sup>2</sup> Sanctuary (Fig. 1a). The climate is subtropical, characterised by distinct winter, summer, monsoon and post-

monsoon seasons. Winter commences from November during which the temperature can be as low as 3°C, and average annual rainfall is 650 mm. The Sariska terrain is undulating to hilly in nature and there are numerous narrow valleys (Sankar, 1994). The dominant vegetation is Northern Tropical Dry Deciduous forests and Northern Tropical Thorn forest (Champion & Seth, 1986). *Anogeissus pendula*

is the dominant tree species that covers approximately 40% of the forest habitat. *Boswellia serrata* and *Lannea coromandelica* grow largely on rocky patches. *Albizia lebbeck*, *Diospyros melanoxylon*, *Holoptelia integrifolia* and *Ficus sp.* are dominant plant species in moist localities (Sankar, 1994).

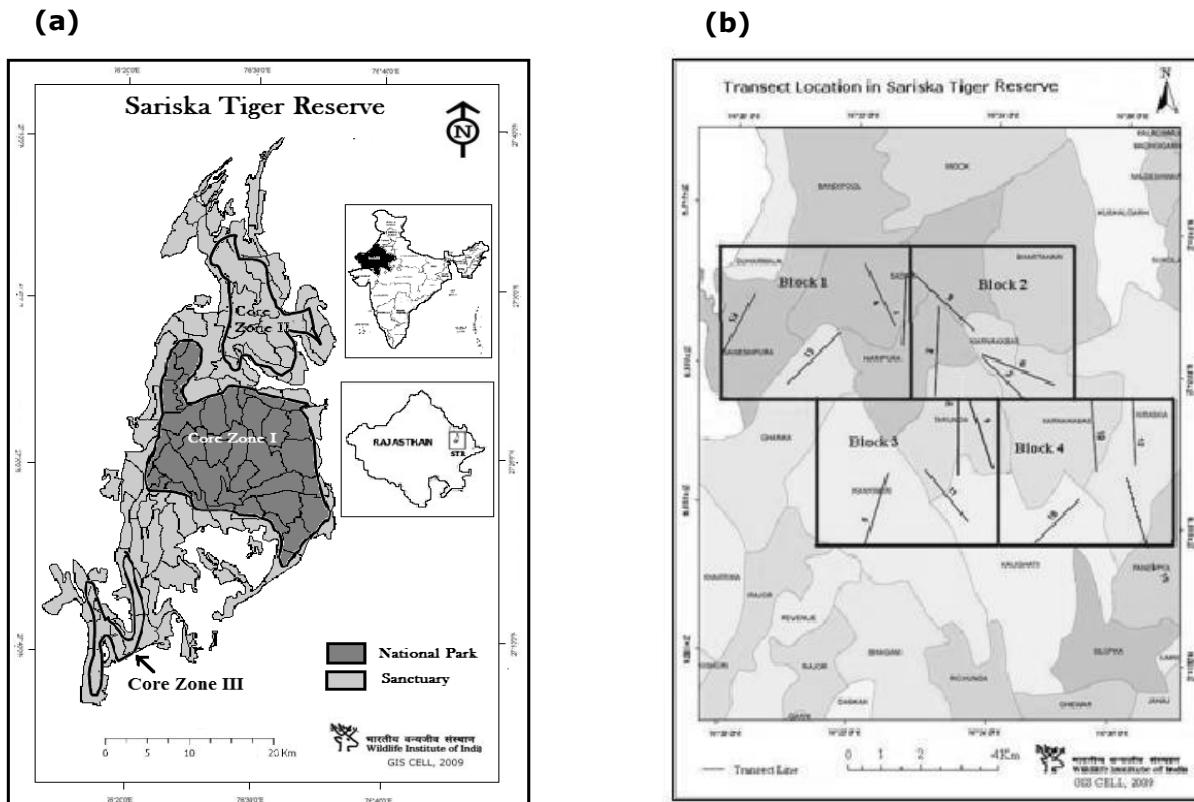


FIG. 1(a) Location of Sariska Tiger Reserve and (b) Location of intensive study area and line transects

#### **Distance sampling**

We used a Distance Sampling line transect method to estimate the populations of the seven target species (Anderson et al., 1979; Burnham et al., 1980; Buckland et al., 1993). This method has proven effective in estimating the abundance of several galliform species (e.g. Trivedi, 1993; Abbasi & Khan, 2004; Sankar et al., 2004). Surveys were conducted from February 2009 to May 2009, in the intensive study area of 80 km<sup>2</sup> within the National Park (Fig. 1a), which was divided into four sections (Fig. 1b) for the purposes of the study. Within each section we laid four line transects, ranging in length from 1.8 to 2 km and covering all major vegetation and terrain types representative of the national park. Each transect was walked three times in the morning (8:00-12:00 hrs) and late afternoon/evening (16:00-18:30 hrs) resulting in a sampling effort

of 190.8 km. For each bird contact, observers recorded the number of individuals of the target species, age, sex (if possible), angular sighting distance, sighting bearing and major vegetation and terrain types (within a 10 m circular plot). Distance data were analysed using the programme DISTANCE 6.0 (Thomas et al., 2010). Four key functions (uniform, half-normal hazard rate and negative exponential all with cosine series adjustment) were considered for analysis. Key function selection was evaluated using Akaike's Information Criteria (AIC) and chi-squared statistics were used to assess the 'goodness of fit' of each function (Burnham et al., 1980; Buckland et al., 1993). The shape criteria were examined for heaping or cluster bias (Buckland et al., 1993). Density estimates between morning and evening surveys were calculated to understand the activity patterns of the target species. Based on the total sightings

obtained from all line transects the percent availability of individual galliform species per vegetation type was calculated.

## Results

### Density estimates

A total of 1101 Indian peafowl, 370 grey francolin, 68 jungle bush-quail, 45 painted spurfowl and 3 rain quail were recorded during the surveys. Black francolin and red spurfowl were not detected during the transect surveys. Group density estimates were highest for Indian

peafowl, followed by grey francolin, painted spurfowl and quail species respectively (Table 1). Similarly, density of individuals was highest for Indian peafowl and grey francolin. Estimated densities of Indian peafowl, grey francolin and painted spurfowl were also greater during the morning period, whereas for quails, estimated densities were higher during the late afternoon/evening period (Fig. 2). Both species of quails were on average detected closer to line transects than the other five species (Table 1).

TABLE 1 Group density estimates  $\pm$  SE, mean group size  $\pm$  SE, individual density estimates  $\pm$  SE, and effective strip width (ESW  $\pm$  SE) of Galliformes within the Sariska Tiger Reserve. Numbers in parenthesis refer to sample sizes. \* Data for jungle bush-quail and rain quail were pooled together.

Species	Group Density/sq. km	Mean group size	Individual density (birds/sq. km)	ESW	Model
Indian peafowl (n=477)	42.9 $\pm$ 4.3	2.3 $\pm$ 0.1	53.1 $\pm$ 5.6	78.6 $\pm$ 1.0	Half-normal
Grey francolin (n=170)	17.1 $\pm$ 2.2	2.0 $\pm$ 0.1	21.6 $\pm$ 4.8	52.4 $\pm$ 1.0	Half-normal
*Quails (n=20)	1.9 $\pm$ 0.5	3.7 $\pm$ 0.4	4.3 $\pm$ 1.4	18.3 $\pm$ 1.0	Half-normal
Painted spurfowl (n=22)	2.0 $\pm$ 0.7	1.9 $\pm$ 0.1	2.5 $\pm$ 0.9	28.3 $\pm$ 1.0	Half-normal

### Group structure and sex ratio

Peafowl group size varied from 1 to 14 individuals (with the highest percentage of encounters as individuals), and was considerably higher than either grey francolin or painted spurfowl (Table 2). The largest congregation of 14 individual peafowl was observed in open scrubland during the month of March. Grey francolin group size varied from 1 to 6 individuals with the highest percentage of encounters as pairs. Mean group size was highest for quail species, whose group size varied from 1 to 9 individuals and most groups contained 4-6 individuals. Painted spurfowl group size varied from 1 to 3 individuals and birds were mostly in groups of 2-3 individuals. Estimated male:female sex ratios were highest for painted spurfowl and Indian peafowl (Fig. 3), but these could not be ascertained for either grey francolin or jungle bush-quail due to the lack of obvious sexual dimorphism in their morphological characteristics.

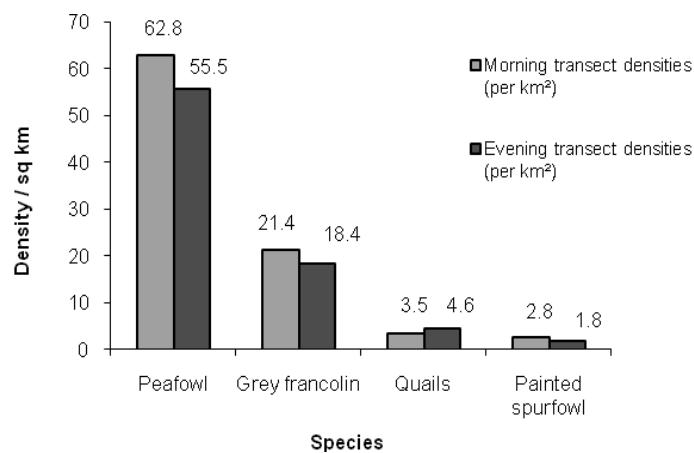


Fig. 2 Density ( $\text{per km}^2$ ) estimates of Galliformes as obtained from morning and evening transects in Sariska Tiger Reserve

### Habitat use

Both Indian peafowl and grey francolin were observed in all forest types within the study area (Table 3). Painted spurfowl were observed in four different forest types, and jungle bush-quail were observed in three vegetation types

whereas rain quail were only observed in scrubland. Scrubland was utilised by all Galliformes in Sariska. Indian peafowl (62.8%), grey francolin (78.2%) and quails (75%) were more abundant and predominantly utilised scrubland habitat, with estimated densities of  $75.3 \pm 5.4$ ,  $52.3 \pm 2.1$  and  $32.2 \pm 3.7$

TABLE 2 Group structure of Galliformes in the Sariska Tiger Reserve. \* Data for jungle bush-quail and rain quail were pooled together.

Species	No. of groups	No. of individuals	Group size (%)						Mean group size ( $\pm$ SE)
			1	2- 3	4 - 6	7 – 9	10 - 12	>12	
Indian peafowl	477	1101	50.3	31.5	14.0	3.6	0.4	0.2	$2.3 \pm 0.1$
Grey francolin	170	370	36.5	52.5	10.5	0.5	0	0	$2.0 \pm 0.1$
* Quails	20	71	11.1	38.9	44.9	5.1	0	0	$3.7 \pm 0.4$
Painted spurfowl	22	45	13.6	86.4	0	0	0	0	$1.9 \pm 0.0$

## Discussion

Only one black francolin was recorded based on casual observation in Karnakawas ( $27^{\circ}22'06''N$ ,  $076^{\circ}23'44''E$ ) during the study period, but no individuals were recorded during the line transect surveys. This species was reported as being rare in Sariska by Sankar et al. (1993). Except for Indian peafowl, few empirical data are available on the abundance and habitat use of our target galliform species in India. The data suggest that the density of Indian peafowl found in Sariska Tiger Reserve was lower than that estimated for the Gir Forest Gujarat ( $886.5 \text{ km}^2$ ) (Sankar et al., 2004). Since the data were collected during the breeding season of Galliformes (Ali & Ripley, 1987; Grimmett et al., 1998; Sathyakumar & Kalsi, 2007), clumping decreased and encounter rate was the most important variance component of density. Habitat utilisation of all the galliform species in Sariska Tiger reserve was found to be mostly of scrubland areas. Painted spurfowl, instead of being detected more in dense thorn scrub or bamboo thickets in dry stony foothills (Ali & Ripley, 1987; Sathyakumar & Kalsi, 2007) were found mostly in riparian habitats. Studies on habitat use of Galliformes in Asia have been very few, even though many species are native to this region (Ramesh, 2003).

individuals per  $\text{km}^2$  respectively (Table 4). Painted spurfowl principally were observed to be more abundant in riverine forest (73.3%) with an estimated density of  $22.1 \pm 0.8$  (Table 4).

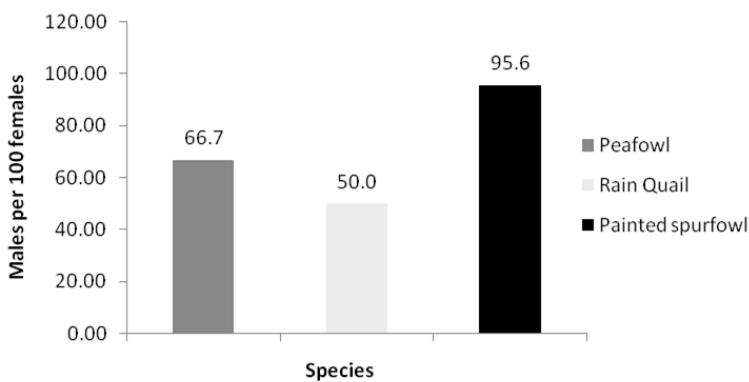


Fig. 3 Sex -ratios (males: 100 females) of Galliformes in Sariska Tiger Reserve.

The line transect method was found to be more convenient as most of the birds were detected close to the line making the detection and counting easier. Past research has also suggested that line transects produce more accurately estimated densities of bird species than point counts (Järvinen, 1978; Verner, 1985; Raman, 2003). The line transect method was used in many studies to determine the abundance of Galliformes, for example, abundance and habitat use of grey francolin in Gursikaran (Abbasi & Khan, 2004), distribution and habitat requirements of painted francolin in Jamnagar (Kaul & Howman, 1992) and for estimating abundance of peafowl in Gir National Park (Trivedi, 1993; Sankar et. al., 2004).

TABLE 3 Percentage use of different vegetation types by Galliformes in the Sariska Tiger Reserve depending on the individual sighting of a species. ANO = *Anogeissus* forest; BOS = *Boswellia* forest; ACMIX = *Acacia* mixed forest; ZWL = *Zizyphus* woodland; BUMIX = *Butea* mixed forest; RIV = Riverine forest; SL= Scrubland.

\*\* Data for jungle bush-quail and rain quail were pooled together.

Species	ANO		BOS		ACMIX		ZWL		BUMIX		RIV		SL	
	Total	%	Total	%	Total	%	Total	%	Total	%	Total	%	Total	%
Indian peafowl	7	1.4	6	1.2	93	19.4	12	2.5	26	5.6	33	6.9	300	62.9
Grey francolin	2	1.2	3	1.8	6	3.5	17	10	8	4.7	1	0.6	133	78.2
**Quails	0	0	0	0	3	14.7	0	0	2	10.3	0	0	15	75.0
Painted spurfowl	4	17.7	1	4.4	0	0	1	4.4	0	0	16	73.3	0	0

The estimation of higher densities across the species may be due to their sightings close to line transects or due to the under estimation of distances while collecting data. Since the accuracy of distance estimation data was checked regularly through a laser range finder, there are lower chances for the second reason to be the cause of high density in the study area. The differences in species density between morning and evening surveys may be

attributed to their respective temporal activity pattern. Other possible reasons for the inter-specific differences in density include food and water availability and favourable habitat conditions in the study area. However, there are not enough publications to support this possibility and it can only be assumed that these factors may play an important role for the differences in the estimated densities of Galliformes in Sariska Tiger Reserve.

TABLE 4. Density (per km<sup>2</sup>) of Galliformes in different vegetation types of Sariska Tiger Reserve.  
\*Density ± standard error/ km<sup>2</sup>

Vegetation types	Galliformes species			
	Peafowl*	Grey francolin*	Quails*	Painted spurfowl*
<i>Anogeissus</i> dominated forest	28.2 ± 1.7	19.5 ± 0.6	0	0
<i>Boswellia</i> dominated forest	22.3 ± 0.8	22.7 ± 1.0	0	0
<i>Acacia</i> mixed forest	63.9 ± 4.2	33.2 ± 2.2	31.0 ± 2.1	12.1 ± 0.9
<i>Zizyphus</i> mixed forest	40.6 ± 2.5	43.1 ± 0.4	1.9 ± 0.8	0
<i>Butea</i> mixed forest	30.4 ± 1.9	31.0 ± 4.2	8.3 ± 0.2	11.3 ± 2.3
Riverine forest	34.6 ± 3.0	6.9 ± 1.1	3.5 ± 0.6	22.1 ± 0.8
Scrubland	75.3 ± 5.4	52.3 ± 2.1	32.2 ± 3.7	0

Only 14 juvenile Indian peafowl were recorded during the early part of the study period, in

February 2009. In Sariska, galliform fledglings are most often seen during either the monsoon

(July-August) or post-monsoon (September-October) (K. Sankar, pers. obs). All Galliformes, being ground nesting birds, need ground cover for laying their eggs (Sathyakumar & Kalsi, 2007). Livestock overgrazing has led to deterioration of ground cover and resulted in invasion of weeds like *Adathoda vasica* and *Cassia tora* in Sariska (Sankar et. al., 2009). Since there are changes in the global agricultural dynamics, even the grassland associated species, adapted to the human impacts on their ecosystems, may be affected in the near future (Carrol, 2007). Long-term ecological study on Galliformes in Sariska is suggested to understand their role in a semi-arid ecosystem.

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