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An assessment of abundance, habitat use and activity patterns of three sympatric pheasants in an Eastern Himalayan Lowland tropical Forest of Arunachal Pradesh, India

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ABSTRACT

Eastern Himalayan biodiversity hotspot is rich in pheasant diversity, as eleven of the seventeen pheasant species in India occur here. Despite the richness, these pheasants have been least studied in their natural habitats and their current population status, ecology and behavioural patterns are unknown. We estimated abundance, habitat use and activity pattern of three pheasants, *i.e.* Red Jungle Fowl *Gallus gallus* (RJF), Kalij Pheasant *Lophura leucomelanos* (KP) and Grey Peacock Pheasant *Polyplectron bicalcaratum* (GPP) in Pakke Wildlife Sanctuary and Tiger Reserve, Arunachal Pradesh. Data collected from line transects and camera traps were used for estimating abundance, habitat use and activity patterns. Program Oriana 4.2 was used to determine the activity pattern of three species. Questionnaire survey was conducted around the protected area to determine the conservation threats for these species. Red jungle fowl had the highest density of 12.9 individuals/km^2 and a photographic rate of 3.19/100 trap nights among all the pheasants. Shrub cover, litter cover and grass cover were positively associated ($p<0.001$) with pheasant detections, where as disturbance ($p<0.001$) was negatively correlated. 60% of habitat overlap was observed between KP and RJF. *Dillenia indica* dominated habitats were significantly correlated with pheasants detections ($R=0.34$, $p<.0001$). The mean activity of GPP, RJF and KP were 6.30 hrs ± 3.37 hrs, 7.49 hrs ± 0.14 hrs and 8.29 hrs ± 0.18 hrs respectively. Additional studies on current status of these species and management plans are critical for pheasant conservation in this critical biodiversity hotspot.

Key words: Red Jungle Fowl, Kalij, Grey Peacock, Pakke Wildife Sancuary and Tiger Reserve, Eastern Himalaya, habitat use, density, activity pattern

INTRODUCTION

Galliformes are diverse groups of birds (Keane *et al*., 2005) which is often considered among the more threatened of avian orders and globally 300 species are red listed (McGowan 2002; Brickle *et al.,* 2008). These birds have a distinct, bright and colorful plumage and are considered as biological indicators of the habitat qualality (Bhattacharya *et al.,* 2009). The Indian Himalayan region is rich in pheasant diversity with 80% of all Indian species are found here (Kaul, 2007). The Eastern Himalayan forests are richer in comparison to western Himalayas, as eleven of the seventeen pheasant species in India occur here. Pheasant population in most of their range had undergone heavy depletion due to excessive hunting for colored plumage and meat (Ramesh *et al.,* 1999). Habitat degradation or habitat loss and, hunting are major threats to this species and additionally, it is mainly involving cultural and economic interest to humans (McGowan *et al.* 1998; Ramesh, 2003). Density and abundance is essential to monitor the population of the species which is fundamental to successful conservation management (Conroy and Noon 1996). Understanding the habitat and status of the bird is the firsts step for comprehensive conservation strategy (McGowan and Gillman, 1997). However, estimating abundance and densities of Galliformes are often difficult due to shy behavior, remote and intricate habitats, dense forest cover, specific habitat preferences that vary seasonally and occuring in low densities in natural habitats (Xin *et al.,* 2003; Sathyakumar *et al.,* 2007; Miller, 2010).

Call count is a widely used technique (Brown *et al.* 1978; Keppie 1992; Rice 2003) that had number of potential bias and limitation (Watson *et al.,* 1994; Evans *et al.,* 2007). The call counts have been used to estimate the abundance of pheasants that have gregarious calling behaviours during their breeding phase (Gaston 1980; Ramesh, 2003). However, this technique is seen to be biased with sex and age (Xin *et al.,* 2003). Telemetry studies provide vital accurate information on elusive species; however it is proven to be costly and requires lot of man efforts. In absence of complete survey technique, distance sampling is reliable to produce useful information (Azar *et al.,* 2008). The only problem in distance sampling is meeting the assumption of line transect method which can be critical due to low detection probability and inaccurate distance estimation (Bibby *et al.,* 2000). Line transect methods is practically efficient and less expensive (Burnham, 1980; Buckland

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et al., 1993; Karanth and Sunquist, 1995; Varman and Sukumar, 1995). Some of the studies used distance sampling to estimate the pheasant abundances in India (Ramesh *et al.,* 2010; Haraihar *et al.,* 2010; Kidwai *et al.,* 2011). In this paper we have estimated the abundance, habitat use and activity pattern of three pheasants, *i.e* RJF, KP and GPP. In Eastern Himalaya 11 species of pheasants occur and seven species are exclusive to this region (Sathyakumar and Sivakumar, 2007). Eastern Himalaya is rich with pheasant's diversity and information on pheasants in eastern himalayan ranges is scanty as compared to the Western Himalaya. Red Jungle fowl and Kalij pheasants are common in East and West Himalayas while grey peacock pheasants are exclusively restricted to Eastern Himalayan range. These three species are evaluated as being of Least Concern by IUCN (IUCN, 2012). The KP and GPP are placed under Schedule I and are accorded highest protection and RJF is placed under Schedule IV in the Indian Wildlife Protection Act (1972).

RJF is distributed across tropical and sub tropical forests of South East Asia and in Southern China (Javed and Rahmani, 2000). KP is distributed mainly in foothills of Himalaya (<2700 m) from Indus River to Western Thailand (Lewin and Lewin 1984). GPP is restricted to North eastern part of India to China and Indochina (Fuller and Garson, 2000). Though these three pheasant species occur sympatrically in North Eastern India, there exist knowledge gaps on the species ecology. This study was attempted to fill this gap by assessing the abundance, habitat use and activity pattern of the three sympatric pheasant species and outline conservation implications in Arunachal Pradesh, Northeastern India.

Study area

Arunachal Pradesh occupies major portion of the east Himalayan region which has 82% forest cover (Arunachalam *et al*., 2004). Around 26 major tribes and 110 sub tribes inhabit and depending on the forest ecosystems. The traditional livelihood system of the people consisted of shifting cultivation, settled cultivation, and hunting and gathering of forest produces. The study was carried out in and around Pakke Wildlife Sanctuary and Tiger Reserve (PTR) 26°54′–27°16′N, 92°36′–93°09′E in the foot hills of east Himalayan region, East Kameng district of Arunachal Pradesh, India (Figure 1). The state of Arunachal Pradesh is arguably the richest terrestrial biodiversity region of the country (Mishra and Dutta 2007). Based on the biogeographic classification it falls in the Eastern Himalayan biogrographic region (Rodgers and Panwar, 1988). This region forms one of the important biodiversity hotspot and also recognized as a global eco-region. PTR is spread over 892 km^2 with an elevational range from 200m to 2000m. PTR has contiguous forest with numerous rivers and the stream and it receives rainfall from northeast and southeast monsoon with an average of 2500mm (Datta and Rawat, 2003). The vegetation of the forest was Assam Valley tropical evergreen forest (Champion and Seth, 1968) with epiphytic flora, woody lianas, and climber. The monthly temperature varies from 18^{0}C to 29.30^{0}C. Around 20 villages inhabit north, East and southern boundary of the park.

Last few years have witnessed many discoveries and range extensions of previously unknown species (Mishra and Datta, 2007). Rainfall is received from both south-west (May-September) and north-east monsoons (November-April) with average annual rainfall of 2500 mm (Datta and Rawat, 2003). Most of Places is inaccessible due to dense vegetation with hilly terrain and thick impenetrable under stories. More than 20 villages are located surrounding the park with dominant community of Nishi tribe.

METHODS

***Field methods*:** Distance sampling technique is widely used in Indian forests for determining the abundance and densities of various wildlife species (Karanth and Sunquist, 1992; Harihar, 2005; Ramesh, 2010). Direct counting of species in tropical forest is extremely difficult due to the poor visibility, low density and the dense vegetation which leads to the low detection. Hence, we used line transect and photographic capture encounter rate to estimate the abundance of the pheasants species in PTR.

Twenty line transects were laid and monitored to enumerate the abundance from September 2009 to January 2012 covering a length of 600 km (Figure 1). Intensive study area was divided in to 2km X 2km grid and we ensured that each grid cell had at least a single transect. Each transect was 2 km in length and were replicated by walking 5 times in the morning hours (4.00 am-9.00 am) by two observers. All transects were marked with GPS Coordinates and bearing of the transect using the compass. For each detection, the time, species, group size, group composition, species bearing, angle, sighting distance and sex of the individuals were recorded. Distance and angle were recorded from the centre of the cluster.

To determine the photographic encounter and activity pattern, camera trap data were used. Opportunistic and occasional encounter of the pheasants were also used. Each grid of 2km X 2 km had at least one pair of Moultrie digital camera. A total of 40 cameras were operated in 40 locations for a minimum of 40 days to a maximum of 60 days (Figure 1). Cameras were placed 3-4 meters away from the road or trails and the cameras were active 24.00 hrs with camera delay time of 60 seconds. We calculated Relative Abundance Index (RAI) for RJF, KP and GPP based on the camera trap data (O'Brien *et al.* 2003, Kawanishi and Sunquist 2004, Ramesh, *et al.,* 2012). We used 2011 camera trap data set for relative abundance estimation while 2010 and 2011 data were pooled to get the activity patterns. Relative abundance expressed number of individuals photograph divided by total number of trap nights. Consecutive photographs of the same individuals were excluded from the analysis. In each camera trap location 15 m radius plot were established to quantify the covariates (Disturbance, tree density, tree height, litter cover, shrub cover and grass cover).

***Analytical methods*:** Distance 6.0 (Thomas *et al.,* 2010) was used to analyze and estimate the line transect data for prey density estimation. Data were checked for errors

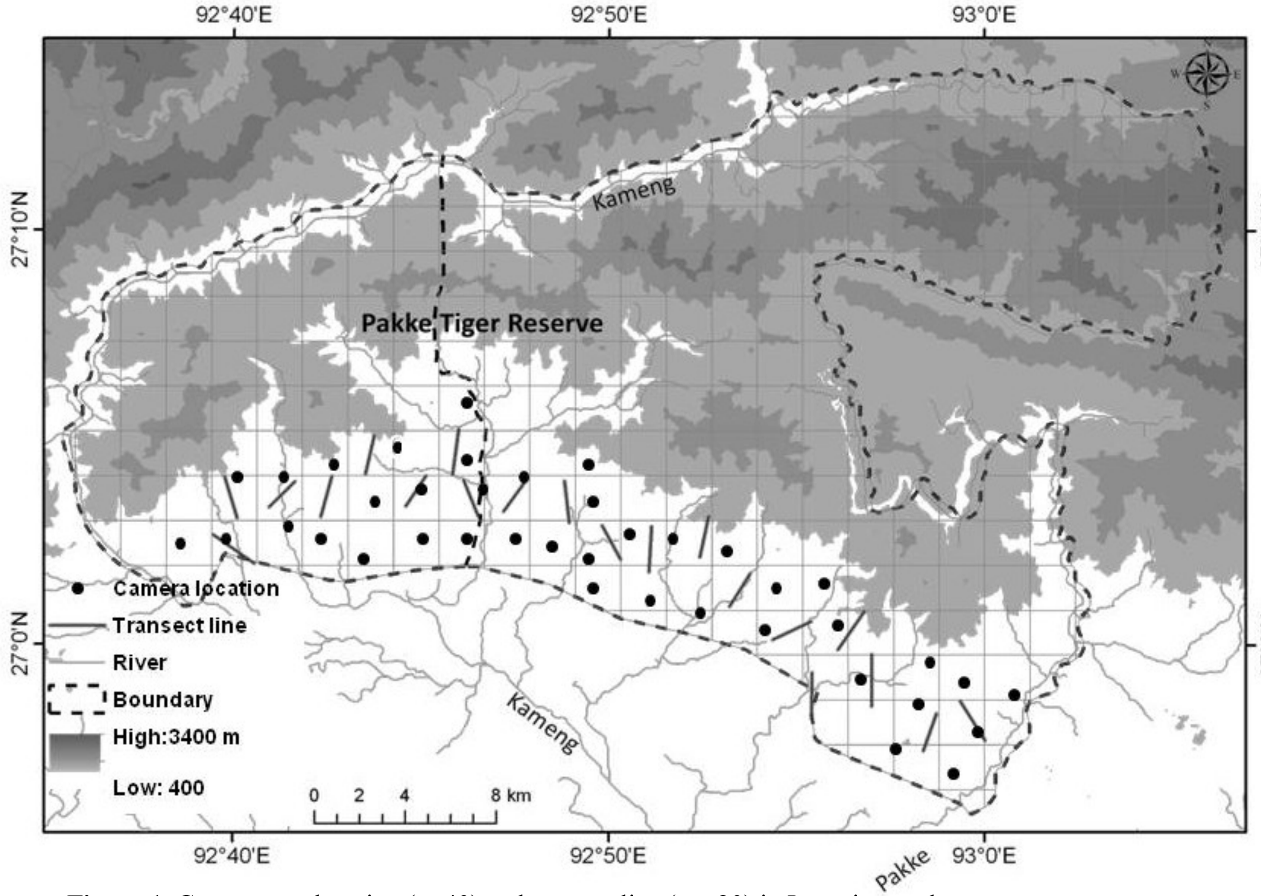

Figure 1. Camera trap location (n=40) and transect line (n = 20) in Intensive study area.

before using program Distance (Jathanna *et al.,* 2003) and exploratory analysis was carried out to check for evidence of evasive movements before detections (Buckland *et al.,* 2001). To get the better model fit, dates were truncated if necessary and the best model was selected on basis of lowest AIC (Akaike Information Criteria) value (Buckland *et al.* 1996, Burnham *et al.,* 1980). To get the better density estimates, a minimum number of sightings are required in order to model the detection function and hence the three years data were pooled together. Mean group size was calculated from the software Distance (Thomas *et al.,* 2010). Logistic regression analysis was used to see the habitat use among the species. Pianka index (Pianka, 1973) was used to estimate the habitat overlap between the species. To determine the mean activity patterns of between the species program Oriana 4.2 (Kovach, 2011) was used.

RESULTS

Abundance

The total estimated population density and photographic rate of three pheasants are given in the Table 1 & 2. A total of 90 sightings were made from 20 transects from 2009 to 2011. Of which 41 was of RJF, 28 was of KP sightings and 21 was of GPP. A total of 111 photographs were obtained from the camera traps in which RJF was captured maximum with 51 photographs followed by KP (39 photographs) and GPP (21 photographs). The highest density (12.9 individuals/Km^2) and photographic rate was obtained for RJF (3.19/100 trap nights) followed by KP (6.7/Km^2& 2.5/100 trap nights) and GPP (4.2/ Km^2 & 1.32/100 trap nights). Average group size of the KP was 2.3/km^2 and RJF and GPP had similar group size (1.9/km^2). Density of group size was found to be high for RJF 5.9/km^2, Kalij 2.1/km^2 and lowest was GPP 41.3/km^2. Sex ratio of RJF was 1.95 (1:1.95) female per male and KP was 1.2 (1:1.2) female per male where as GPP had 1.3 /male (1:1.3).

Habitat Association

Habitat overlap was observed to be high between RJF and KP (64.5%) and almost analogous overlap obtained between KP versus GPP (40.8%) and RJF versus GPP (41.3%) (Figure 2).

The logistic regression analysis shows (Table 3, 4 & 5) that grass cover, shrub cover and tree density was significantly associated with KP detection where as litter cover, grass cover and shrub cover and tree height was associated with RJF and GPP detections. Disturbances in the form of grass cutting, animal presence in the trails, lopping and wood cuttings were negatively associated with all three pheasants. Around 25 % (n=10) of camera placed in open areas adjoining river and streams did not capture even a single photograph of pheasant.

RJF was detected mostly in moderate canopy cover (40-50%), High shrub and low tree density area. *Dillenia indica* dominated habitat was significantly correlated with all three pheasants detections (R=0.34,

Table 1. Density and group size of three sympatric pheasants in Pakke Tiger Reserve

Species	Number of observation	Model	ESW	GS±SE	Dg ±SE	% CV	Di±SE	% CV	Confidence Interval	
									Lower	Upper
Red Jungle fowl	42	HF/ Normal	6.9±0.7	1.9±0.1	5.9±1.1	17	12.9±2.1	18.1	8.1	17
Kalij Pheasant	32	HF/ Normal	8.0±1.7	2.3±0.2	2.1±0.7	34	6.7±1.7	22.2	2.3	9.6
Grey peacock Pheasant	23	HF/ Normal	7.1±1.9	1.9±0.3	1.3±0.5	41	4.2±0.7	19.2	2.8	8.9

ESW-Effective strip with, GS-Group Size, Dg-Group density, Di-Individual density

p<.0001). *Dilinia indica*, *Melia azedarach* and *Paederia scandens* are associated with RJF detection in most of the places (88%). KP detection was high in low canopy cover (20-40%), high shrub cover (60-90%) and low grass cover (20-40%) area with high tree density area. Species associated with KP detection (80%) was *Dillenia indica, Paederia scandens*, *Dysoxylum sp* and *Ailanthus integrefolia*. GPP was present in the dense primary forest with 25-30 meter height and 60-100 % canopy cover. Moderate shrub cover (40%-60%), high litter cover and species like *Dillenia indica Dysoxylum fraserianum, Pterospermum acerifoliumm, Melia azedarach and Mucuna impricata* were associated with GPP detections.

Activity patterns

In total 210 photographs were obtained from 2800 trap nights, of which 46.2% were of RJF, 34.8% were of KP and 19.0% were of GPP (Table 2). The mean activity of Grey peacock pheasant, RJF and Kalij was high at 6.30 hrs ± 3.37 hrs, 7.49 hrs ± 0.14 hrs and 8.29 hrs ± 0.18 hrs respectively (Table 6). The peak time of activity among all three pheasants was 6.00 hrs to 8.00 hrs (Figure 3). Pianka index shows that there was considerable overlap between KP and RJF (96%), followed by GPP with RJF (92%) and KP with RJF

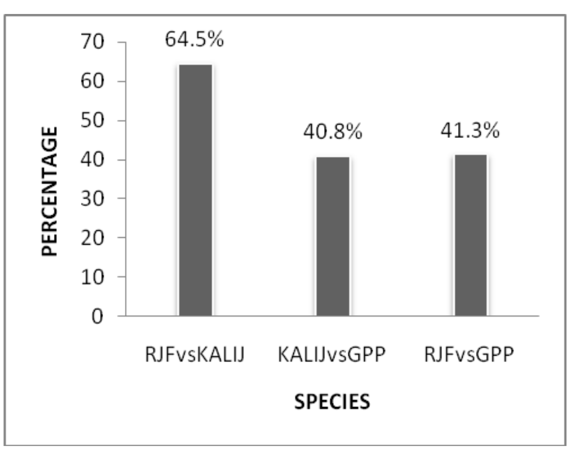

Figure 2. Pianka index shows Percentage of habitat overlap between the species.

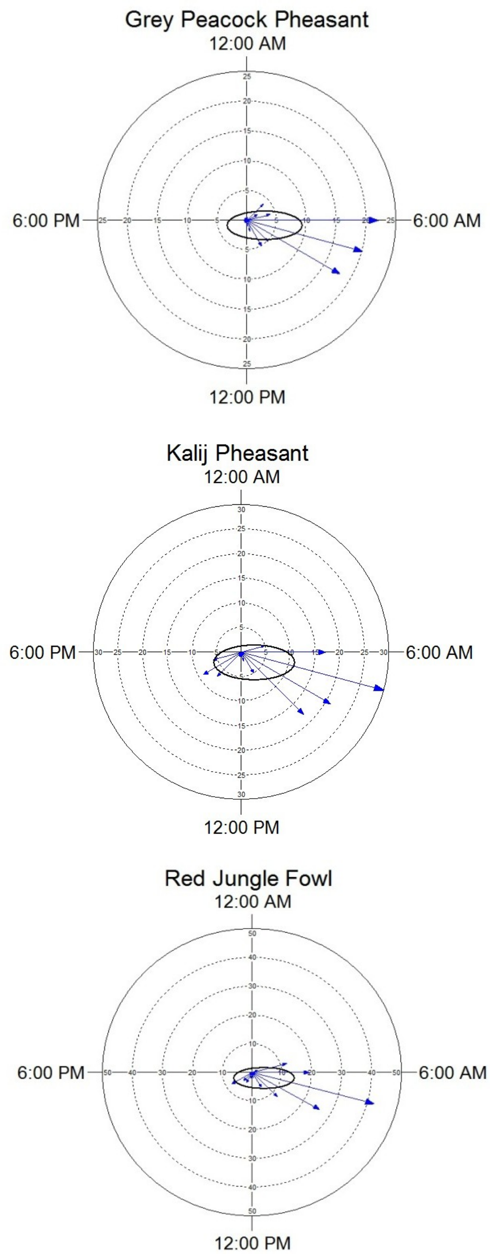

Figure 3. Activity patterns of three Galliformes species based on photograph obtained from the camera traps from 2009 to 2011.

Table 2. Photographic encounter rate of Galliformes species from 2010-2011

Species	Sampling days	Total photograph	Trap nights	Mean photograph	Photograph/100 trap nights
RJF	40	51	1800	1.2±0.1	3.19
KALIJ	40	39	1800	0.8±0.1	2.44
GPP	40	21	1800	0.4±0.2	1.32

Table 3. Habitat variables associated with Kalij Pheasant detections

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	-0.03654	0.057127	-0.64	0.52446
Canopy Cover	-0.00023	0.000588	-0.392	0.69597
Disturbance	-0.00117	0.000344	-3.397	0.00111 **
Grass Cover	0.009463	0.000742	12.747	< 2e-16 ***
Litter Cover	0.000933	0.000723	1.29	0.20133
Shrub Cover	0.002684	0.000768	3.495	0.000681 ***
Tree Density	0.585379	0.280728	2.085	0.04060 *
Tree Height	0.000488	0.001448	0.337	0.73707

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1 (Multiple R-squared: 0.5234)

Table 4. Habitat variables associated with RJF detections

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	-0.20808	0.039558	-5.26	4.81e-07 ***
Canopy Cover	0.000555	0.000362	1.533	0.1274
Disturbance	-0.000881	0.000376	-2.343	0.02042 *
Grass Cover	0.005005	0.000772	6.483	1.19e-09 ***
Litter Cover	0.006263	0.000771	8.128	1.42e-13 ***
Shrub Cover	0.003368	0.001025	3.286	0.00126 **
Tree Density	2.88E-01	2.13E-01	1.351	0.1808
Tree Height	-1.15E-03	5.15E-04	-2.235	0.0326 *

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1 (R-squared: 0.9801)

Table 5. Habitat variables associated with Grey Peacock Pheasant detections

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	4.01E-02	4.08E-02	0.983	0.3289
Canopy Cover	-6.79E-04	4.81E-04	-1.413	0.1619
Disturbance	-1.28E-03	2.47E-04	-5.169	2.02e-06 ***
Grass Cover	8.93E-03	4.86E-04	18.378	< 2e-16 ***
Litter Cover	1.34E-03	5.26E-04	2.545	0.0131 *
Shrub Cover	9.48E-03	1.12E-03	8.474	1.1e-09 ***
Tree Density	1.06E-03	1.15E-03	0.919	0.3649
Tree Height	0.404889	0.181015	2.237	0.02676 *

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1 (R-squared: 0.9859

Table 6. Circular statistics of temporal activity pattern of three pheasants in Pakke Tiger Reserve

Variable	GPP	RJF	Kalij
Number of observation	24	141	123
Mean vector	6:30	7:49	8:29
Length of Mean vector	0.638	0.752	0.669
Concentration	1.677	2.383	0.331
Circular variance	0.362	0.248	0.331
Standard error of mean	3:37	0:14	0:18
95% confidence interval	7:16	7:21	7:52

DISCUSSION

Abundance

Line transect sampling provide unbiased estimates of density and abundance (Azar, 2008) despite having limitation of usage (Burnham *et al.* 1980). By and large 111 individuals (RJF 51, Kalij 39 and GPP 24) were encountered during line transects. RJF was sighted across the park and habitats whilst GPP sighting were very low during transects as the bird was too shy to be detected, GPP was detected mostly based on their calls. RJF is found to be high in terms of density and group size which can be attributed with gregarious nature and also most adaptable species for all the habitats (Dohling and Sathyakumar, 2011). Though we identified the species by call, we did not use for counting the bird in order to minimize the error. Bamboo mixed forest had more number of KP sightings than other forest types. Photographic encounter rate was high for RJF (3.19/100 trap nights) which was abundant all over the park. Abundance varied according to habitat structure and degree of disturbances. A study from Pakke shows that unlogged forest had high pheasant's abundance than logged forest (Datta 2000). Field data was collected during winter season (October to January), hence we could not detect any seasonal changes in abundance and grouping patterns. Very few studies have determined the abundance of these species; Yu-Ren (1999) estimated the GPP density 3.75/km^2 in Hainan Island, China. Dohling and Sathyakumar (2011) estimated the density of KP to be 2.85 birds/100 in Nongkhyllem Wildlife Sanctuary, Meghalaya. RJF was estimated mainly in shivalik range accounting to 5.39 birds/km^2 (Das, 2006) and in Deva Vattala NP in Pakistan to be 7.87 birds/km^2 (Subhani *et al.,* 2010). The estimated RJF density (line transect sampling) in Carey Island west coast of Peninsular Malaysia was 0.500 ± 0.069/hectare (Azar *et al.,* 2008). Sex ratio was calculated by direct sightings in transects, oppurtunistic sightings and photographs obtained from the camera traps. Female was higher to the male for all the pheasants similar to that of Javed and Rahmani's (2000) findings.

Habitat use

Cameras and transects were placed in different types of habitats like disturbed areas, undisturbed areas, open canopy areas, bamboo forest, mixed forest to examine the habitat use of the pheasants. Litter cover, shrub cover and grass cover had positive association with pheasants detections and disturbance was negatively associated with all three pheasants detections**.** Presence of human and livestock has the negative impact on galliformes (Bhattacharya *et al.,* 2007**).** Fringe areas of the park is dotted with villages and is exposed to anthropogenic activities such as grass cutting, fodder collection, wood cutting and looping. Negative association of KP with human disturbance was correspondent to Hussain *et al.* (2001) findings that contradicted to Gaston *et al.* (1981) observations. GPP and KP was rigid to human disturbance unlike RJF, and it occurs mainly in primary forest of PTR. Whereas RJF occurred in logged forest and near by human habitation which causes them vulnerable for hunting. Pheasants were seen feeding on insects and worms from the fallen and rotten fruits of *Dillenia indica*. This might be the reason for high detection of pheasants in *Dillenia indica* dominated vegetations. High grass cover (60-90%) significantly associated with RJF that might be the cause of egg collection by grass cutters. RJF shows preference to mixed forest and in summer forest grasslands (Kalsi, 1993; Javed and Rahmani, 2000) in Dudwa National park where as present study was conducted mainly in evergreen rainforests. GPP remains in dense under growth of Pakke and it is reported to be highly elusive in other parts of Arunachal Pradesh (Datta, 2000). Distinctive call of GPP was confirmed with their presence in the dense and impenetrable vegetation. Though RJF utilizes a variety of habitats (Subani *et al.* 2010) it prefers to be occurring in undisturbed habitats for foraging and breeding (Ali and Ripley 1989). KP mostly preferred moderate grass cover, tree cover and shrub cover in western Himalayas (Sathyakumar *et al.,* 1993) which is similar to this study finding. Shrub cover was high (60-90%) with KP detection unlike in Western Himalaya (low).

Activity pattern

The Pheasants activities were observed to start before dawn (0400 hrs to 0430 hrs) and end by 1630 hrs to 1700 hrs. More than 90% of temporal overlaps occur between the species between 0600 hrs and 0800 hrs and in the evening between 1500 hrs and 1600 hrs. GPP activity was very low (5%) during the evening hours in comparission to other two species. After 1200 hrs activities slowed down for all the pheasants though call of the pheasants were heard during the day time.

Conservation problems

Male pheasant feathers are used by local tribes ornamental in headgears. Therefore male birds are vulnerable for hunting due to bright colored plumage (Ramesh *et al.,* 1999). Ground dwelling birds are easy to kill by katapult due to low flight and heavy body with higher visibility. Trapping the birds and egg collection are the major concern for the pheasants in this region. Hunting is a part of the socio culture of the indigenous communities living in the state (Kumar and Singh, 2000) and the large scale hunting and trapping is the reason for low abundance in Arunachal Pradesh (Hussain *et al.,* 2001). During our survey we removed over 50 live and dead traps in the fringe areas of the park. Though park authorities have ensured strict protection, still people frequently move to the park for grass and fodder collections and trap and hunt the pheasants. Pheasant meat have been observed to be sold openly in many market places of Arunachal Pradesh (Kaul *et al.,* 2004; Hilaluddin *et al.,* 2005). RJF is closely associated with shifting cultivation as it provides them food in the form of rice, tapioca, seeds, fruits and bamboo and grass root (Collias and Saichuae, 1966).

A monitoring programme, targeting these pheasant species throughout the year may yield insight in to seasonal changes in abundance and densities, habitat use, activity patterns and anthropogenic pressures. Information obtained during surveys to determine abundance and densities like the one derived from this study should be coupled with other methods like habitat suitability models, geographic information systems and species distribution models to determine the quality and quantity of habitats for these species.

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