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Research Article

Camera trap data reveals the habitat use and activity patterns of a secretive forest bird, Sri Lanka Spurfowl *Galloperdix bicalcarata*

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Abstract

The use of remotely triggered cameras for studies of bird ecology is uncommon. We used camera trap data from a survey conducted from January 2018 to April 2021, to analyze the habitat use and activity patterns of Sri Lanka Spurfowl *Galloperdix bicalcarata* which is known as a shy and secretive forest bird endemic to Sri Lanka. Study sites included protected areas situated in dry, wet, and montane zones of the island. Camera traps were placed representatively in the main habitat types of each study site. A total of 104 independent captures of *G. bicalcarata* were recorded during the study. The highest occupancy was recorded at Sinharaja National Heritage Wilderness Area followed by cloud forests of Horton Plains national park and dry-mixed evergreen forests of Maduru Oya National Park. The activity of *G. bicalcarata* was highly diurnal and activity levels ranged from 0.250-0.398 at the study sites. Activity peaks of *G. bicalcarata* occurred in the morning between 0700-1100h. We identified canopy cover, litter cover, litter depth, NDVI as the covariates that positively influenced the habitat occupancy of spurfowl while thick undergrowth and rocky outcrops reduced the occupancy. The findings of this study will be useful for the conservation and management decisions on Sri Lanka spurfowl and habitats that are vital for its survival.

Keywords: Ground dwelling birds, Phasianidae, habitat use, Camera trapping, Conservation, Occupancy modeling

Introduction

Conservation of rare and secretive forest species depends on accurate measurements of their microhabitat preferences. Choosing the proper approach for monitoring wildlife is always a challenge in management or conservation (Pollock et al., 2002). Camera traps have been proposed as an effective tool especially for studying and monitoring elusive species (Janecka et al., 2011). Therefore, the use of infrared-triggered camera traps has increased dramatically in recent years (Garrote et al., 2011; Niedballa et al., 2016).

Today camera traps apply active and passive sensors to detect animals passing through the field of view by their movements and by their body heat. They use auto-focus cameras that stamp each photograph with a timestamp and the ability to capture videos is also available. Since camera traps sit unobtrusively in the forest, they are very well suited for studies of animals that avoid humans, might be influenced by the presence of an observer, are nocturnal, or rare (O'Brien & Kinnaird 2008). The simplest use of camera trapping is documentation of a species' occurrence at a site. Species occurrence data is an important component of biodiversity surveys, as well as a fundamental aspect of range determination and evaluation of IUCN status.

Even though several publications of using camera traps in avian ecology studies are available elsewhere in the world (Murphy, et al., 2018, Znidersic, 2017, Luo et al., 2019), there was no such a previous research study available from Sri Lanka. With proper attention to detail, camera traps can be used profitably for inventories of terrestrial birds whenever the presence of a human observer is likely to cause a flight response or elusive response of the target species. Therefore, this is the first detailed study using this study method to study bird ecology in Sri Lanka.

Sri Lanka spurfowl *G. bicalcarata* is an appropriate species on which camera trapping technology can be used since it is a ground dwelling forest bird that we know very little about in part due to the difficulties of observing. This scarce ground bird is found in the dense forests in the wild. *G. bicalcarata* is a member of the pheasant family (Phasianidae) which is endemic to Sri Lanka. Moreover, this species is considered as a Least Concern (LC) species. However, they have a decreasing population trend (Birdlife International, 2020). *G. bicalcarata* is mostly found in the south-west lowland wet zone, being very rare in the dry zone and mountainous regions of Sri Lanka. This species is considered strictly a forest bird that can be seen occasionally in the hills up to about 2000 meters (BirdLife international, 2020).

The study was based on a camera trap survey conducted from January 2019 to April 2021 in which the primary aim was to study meso-carnivores. Due to the low height used for camera attachment, the bycatch-data generated useful and accurate capture records for ground dwelling birds as well.

Therefore, this study was conducted as an initiative of investigating the applicability of camera trapping in studying avifauna of Sri Lanka. We investigated the habitat occupancy, habitat associations and activity patterns of *G. bicalcarata* in three protected areas situated in distinct climatic zones of Sri Lanka.

Materials and methods

Study area

The study was conducted in Maduru Oya National Park (MONP), Sinharaja National Heritage Wilderness Area (SNHWA) and Horton Plains National Park (HPNP) situated respectively in dry zone, wet zone and montane zone of the island (Fig. 1). These three reserves represent three different bioclimatic regions of Sri Lanka (Wijesinghe et al., 1993).

Figure 1. Study sites are shown on the map of Sri Lanka

MONP is situated in the dry zone of Sri Lanka. The climatic conditions are dominated by the northeast monsoon, which persists from October to February. The mean annual rainfall is 1,650 mm and the mean annual temperature is about 27 °C and overall evapotranspiration rates usually exceed precipitation levels. The park lies entirely in the dry zone although the park's southern boundary is near the intermediate zone. The climax community of the area is tropical dry mixed evergreen forests. The importance of the park's fauna is its richness, which includes several endemic species (Green, 1990).

HPNP is located at an elevation range of 2,100–2,300 m and encompasses montane grassland and cloud forest (Gunatilleke & Gunatilleke, 1986). It is rich in biodiversity and many species found here are endemic to the region. The mean annual rainfall is greater than 2,000 mm. Frequent cloud cover limits the amount of sunlight that is available to plants. The mean annual temperature is 13 °C but the temperature varies considerably during the day, reaching as high as 27 °C during the daytime, and dipping as low as 5 °C at night. Although some rainfalls throughout the year, a dry season occurs from January to March. The ground frost is common in February. Mist can persist in the day during the wet season (De Silva, 2007). The main habitat types of the park can be identified as cloud forests, wet patana grasslands and cloud forest die-back/low canopy forests (Jayasekara et al. 2021). HPNP is considered as one of the Important Bird Areas (IBAs) in Sri Lanka (BirdLife International, 2009).

SNHWA, situated in the southwest lowland wet zone of Sri Lanka, is the country's last viable area of primary tropical rainforest. Covering an area of 11,187 ha and ranging from an altitude of 300 – 1,170 meters. Annual rainfall over the last 60 years has ranged from 3614 - 5006 mm with most of the precipitation during the south-west monsoon (May-July) and the north-east monsoon (November- January) (Zoysa & Raheem, 1987). More than 60% of the trees are endemic and many of them are considered rare. There is much endemic wildlife, especially birds, but the reserve is also home to over 50% of Sri Lanka's endemic species of mammals and butterflies, as well as many kinds of insects, reptiles and rare amphibians (UNESCO World Heritage Centre, 2020).

Camera trapping

Browning Dark Ops (Browning, USA) and HCO Scout guard white LED camera traps (Scout guard, USA) was used for camera trapping. Most cameras were equipped with IR motion and heat sensor triggered for low/no glow flash which generates minimal disturbance to the animals. Camera trap locations were arranged in a systematic random method using survey grids prepared on Arc Map (ESRI, USA). Sampling plots were selected to represent the main habitat types present at each study site.

Cameras were placed at 25cm (Ramesh & Downs, 2014) above the ground attached to a tree. Logs were used when large trunked trees were not available in the habitat. Camera traps were operating 24 h day^{-1} for 30 consecutive days at each station.

A total of 77 camera trap stations over 2712 camera days were placed at MONP. A total of 38 camera stations over 1845 camera days were surveyed at HPNP. Available habitat types were categorized as cloud forest, cloud forest die-back and grassland. Thirty-six camera stations over 2160 camera days were surveyed to collect data in SNHWA. Available habitat types were identified as dense wet evergreen forest, low dense wet evergreen forest, sub-montane forest, and riverine forest (Jayasekara et al., 2021).

Measuring the covariates associated with occupancy

Each camera trap location was considered as a sampling point to obtain species presence data as well as habitat/environmental variables that are associated with the particular site. These variables included a variety of biotic and abiotic factors that were considered covariates that influenced the site occupancy of *G. bicalcarata*. A total of 13 covariates were obtained. The usage of covariates differed from one study site to another, depending on the conditions available. Covariates considered and the standard methods followed to obtain them are given below (Table 01).

Table 1. Covariates used for occupancy modeling

Covariate	Abbreviation	Method
Vegetation parameters		
Stem density 1	SD1	Measured by the modified Point Centered Quarter (PCQ) method given by Chen *et al.* (2009) from the original method of Higgins (1996). Distance to the nearest woody plants (<10 cm dbh) from the camera trap in four directions was averaged. Stem density was calculated as 1/mean area $[\text{distance}]^2$
Stem density 2	SD2	Distance to the nearest woody plants (>10 cm dbh) from the camera trap in four directions was averaged. Stem density was calculated as 1/mean area $[\text{distance}]^2$
Canopy cover %	CN	Measured using photo point analysis in eCognition software as a percentage
Litter cover	LC	Percentage cover was estimated ocularly placing four quadrates of 2 x 2 m having the camera point as the center
Litter depth	LD	Measured using a metal ruler within the same four quadrates and averaged
Ground vegetation	GV	Estimated ocularly in the same quadrates used above and averaged. Ground plant cover <10 height was considered.
Normalized Difference Vegetation Index (NDVI)	NDVI	An average value was obtained for a 1 km^2 area within the plot of the camera location. Calculation methods followed Jayasekara et al. (2021)
Physical features		
Rock availability	RA	Estimated within a quadrate of 10 x 10 m having the camera point as the center. A rating of 0-10 was given.
Habitat type	Habitat type differed based on the protected area	Selected based on the categorization described in a previous section. This was the only categorical variable considered during the analysis.
Elevation	ele	The average elevation value for each plot with a camera station was extracted using the zonal statistics tool in Arc GIS. Raster elevation maps were used as a source.

Slope	slope	The percentage slope at each camera site (plot) obtained based on digital elevation model (DEM) maps
Aspect	aspect	The percentage aspect and compass direction at each camera site (plot) obtained based on digital elevation model (DEM) maps
Euclidean distance to water	edw	The average edw for each plot with a camera station was extracted using the zonal statistics tool in Arc GIS. Raster Edw maps generated using the Euclidean distance tool in Arc GIS were used as a source.

Model development

Occupancy of *G. bicalcarata* was estimated using a likelihood-based method (MacKenzie et al., 2002). Species detection history (e.g., 1100100) for each camera location, consisting of binary values with '1' indicating species detection during the sampling occasion and '0' indicating non-detection was calculated (Otis et al., 1978). It was assumed that each camera site was independent and no animal would move between sites during the survey period (Royle & Nichols, 2003). A survey duration of 30 days was divided into 10 sampling periods of 3 days to. Detection histories of each camera location were entered together as single-season models in PRESENCE v.4 (Proteus Wildlife Research Consultants, New Zealand; http://www.proteus.co.nz).

To reduce the model over-fitting by having high correlations among covariates, all the covariates were tested pair-wise for high co-linearity. Only independent variables were selected for each analysis removing covariates with *r* values <0.75. All continuous variables were standardized to z-scores before analysis (Cooch & White, 2005). Several candidate models were defined incorporating possible covariates that could influence site occupancy and the detection probability of *G. bicalcarata*. Models were run separately for the three study sites using site-specific covariates and camera trapping detection histories to investigate how habitat variables could influence species occupancy and habitat use to explore the power of covariates. The software program PRESENCE v.4 was used for the model set development.

As conceived by MacKenzie et al. (2002), psi (ψ) is interpreted as the overall proportion of a study area that is used by a given species (MacKenzie et al., 2002). A global model that contained all potential covariates for occupancy was produced and detection probability (p) was allowed to vary by all covariates. A two-step procedure was followed where 'psi' was modeled first and then p was modeled. The potential covariates for occupancy were then allowed to vary, individually or in combination, while detection was either maintained in the global model or remained constant, i.e. psi(covariate)p(covariate), or psi(covariate)p(.).

Models were ranked according to delta Akaike Information Criteria (ΔAIC). Model-averaged parameters were calculated using Akaike weights for the proportion of sites used and detection probabilities. Akaike weights are equivalent to Bayesian posterior model probabilities and indicate the relative support of a model (Wintle et al., 2003). The best-fitting models were interpreted to explain how different variables influenced species occupancy. Hence, these models provide an overall picture of the habitat associations of *G. bicalcarata*.

Activity level and activity patterns of G. bicalcarata

The timestamp data recorded on camera videos or photo records were analyzed to generate activity patterns for each focal species. To determine activity level (*a*: the proportion of the day a species is active), R package '*activity*' was used (Rowcliffe et al., 2014; Rowcliffe et al., 2016; Rowcliffe, 2019). Timestamp data of species captured on camera trap videos were converted to radian time. This was analyzed in R with 1,000 iterations. Activity graphs were generated based on non-parametric von Mises kernel density (Meredith & Ridout, 2014) using the R package '*overlap*' (Ridout & Linkie, 2009) in R version 4.0.3 (R Core Team, 2013).

Results

A total of 104 independent captures of *G. bicalcarata* were recorded during the study. The highest number of capture records were from SNHWA (45), followed by MONP (40) and HPNP (19). The naïve occupancy of G. *bicalcarata* was highest at SNHWA (0.33). The naïve occupancy at HPNP (0.11) and MONP (0.09) were lower. The model-averaged occupancy was slightly higher than the naïve occupancy values at all three sites. The highest model-averaged occupancy was recorded at SNHWA (0.43) which was significantly higher than the other two sites (Kruskal-Wallis, *z:* 8.64, *p:* <0.05). However, the detection probability at MONP (0.18) was higher than HPNP (0.16) and SNHWA (0.15).

Table 2. Camera trapping effort and habitat occupancy of *G. bicalcarata* at the three study sites (DEF: dry-mixed evergreen forest, SH: shrublands, GL: grasslands, RO: rocky outcrops, CF: cloud forest, CFD: cloud forest die-back, DWEF: dense wet evergreen forest, LDWEF: low dense wet evergreen forest, SMF: sub-montane forest, RF: riverine forest)

	Habitat			
MONP	DEF	SH	GL	RO
Camera trap days	1197	775	423	282
Occupancy	0.21±0.07	-	-	-
HPNP	CF	CFD	GL	
Camera trap days	1165	340	340	
Occupancy	0.18±0.01	0.04±0.02	0.01±0.00	
SNHWA	DWEF	LDWEF	SMF	RF
Camera traps days	540	900	420	360
Occupancy	0.41±0.02	0.46±0.03	0.49±0.02	0.27±0.05

In MONP, the only habitat occupied by *G. bicalcarata* was the dry-mixed evergreen forest (occupancy, 0.21±0.07). In HPNP, the highest occupancy was recorded from the cloud forest (0.18±0.01) and occupancy levels in cloud forest die-back and grasslands were very low. *G. bicalcarata* was highly occupying dense wet evergreen forest, low dense wet evergreen forest and sub-montane forest habitats in SNHWA. The riverine forest habitat occupancy was relatively low.

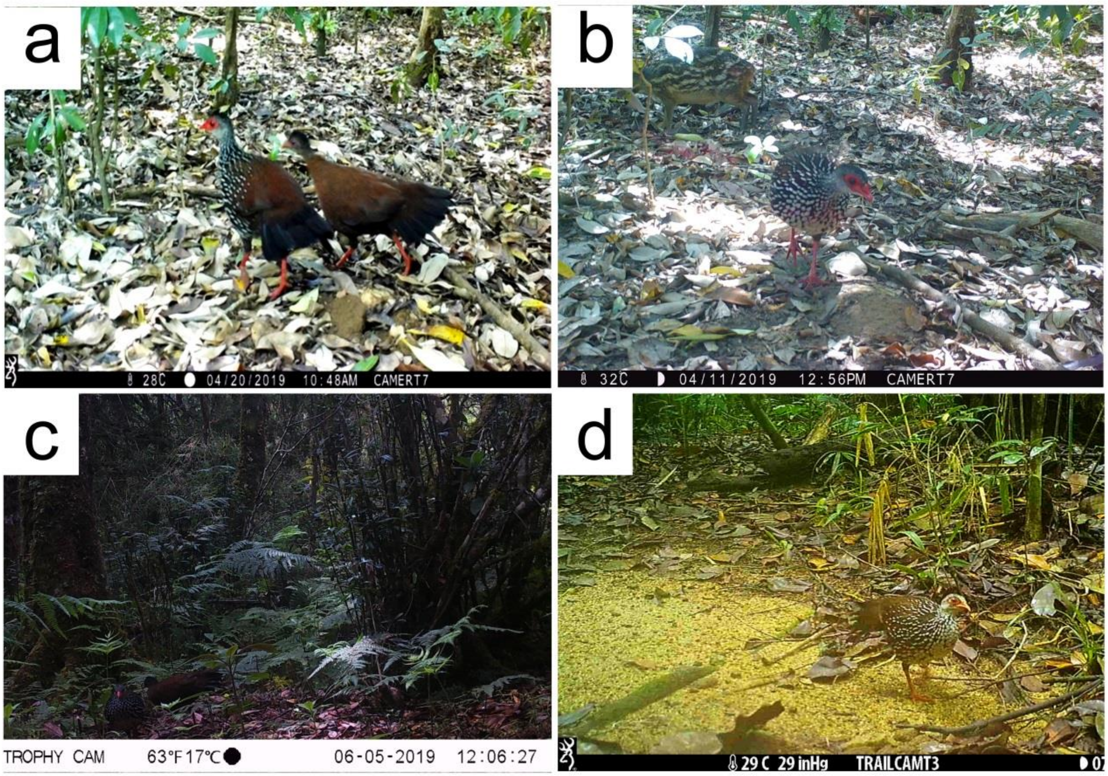

Figure 2. a) A pair of *G. bicalcarata* (adult male and female) at MONP b) *G. bicalcarata* foraging together white-spotted chevrotain at MONP c) A pair of adult *G. bicalcarata* in the cloud forests of HPNP d) An adult male *G. bicalcarata* at SNHWA

Figure 3. A group of *G. bicalcarata* (two males and one female) at MONP.

Habitat associations of G. bicalcarata

In MONP, the top-ranked occupancy model based on ΔAIC included dry-mixed evergreen forest as the most associated parameter for the occupancy of *G. bicalcarata.* Canopy cover was another covariate positively associated with *G. bicalcarata* occupancy at MONP. Canopy cover was positively associated with the *G. bicalcarata* occupancy in the top-ranked model in HPNP as well. In SNHWA, litter cover was the most associated covariate with *G. bicalcarata* occupancy whereas, canopy cover had a positive association with the detection probability (Table 3; Table 4). Meanwhile, litter cover was significantly correlated with canopy cover and litter depth at SNHWA. Additionally, NDVI was another covariate within the top-ranked models which was positively associated with *G. bicalcarata* occupancy at SNHWA. The second-ranked model included dense wet evergreen forest and sub-montane forest habitats which positively influenced the detection probability of *G. bicalcarata* (Table 3; Table 4).

Activity level and activity patterns of G. bicalcarata

The highest activity level of *G. bicalcarata* (0.398±0.06) was recorded at MONP followed by HPNP (0.283±0.06) and SNHWA (0.250±0.05). In all three study sites, a highly diurnal activity pattern was observed for the species where it was active from early morning (~ 0600). The activity peak was reached relatively faster at SNHWA where the peak activity was from 0700-0830h. Conversely, the peak activity of G. *bicalcarata* at HPNP and MONP was from 0900-1100h. We observed that *G. bicalcarata* was active in relatively extended hours at MONP where it was active from early morning past 1800h in the evening. The noon and evening activity level of *G. bicalcarata* at HPNP was moderate. Meanwhile, at SNHWA, the activity level gradually decreased towards noon and evening following the early morning activity peak (Fig. 4).

When the social organization of this species is considered a greater proportion of detections was recorded as one individual or two individuals (Male and female) respectively (Figure 2; Figure 5). There were very few incidents with three individuals where it mostly recorded as two males with one female (Fig. 3).

Indian peafowl (*Pavo cristatus*) and Sri Lanka jungle fowl (*Gallus lafayetti*) were the other bird species associated with *G. bicalcarata*. There were several incidents that our capture records indicated *G. bicalcarata* foraging in the presence of White-spotted chevrotain (*Moschiola meminna*), Red muntjak (*Muntiacus muntjak*) and Spotted deer (*Axis axis*) in the same habitat we believe that would be a community adaptation for protection against predators (Fig. 2 (b)).

Leopard (*Panthera pardus*), golden jackal (*Canis aureus*), jungle cat (*Felis chaus*), fising cat (*Prionailurus viverrinus)* common palm civet (*Paradoxurus hermaphrodites*), ring-tailed civet (*Viverricula indica*), ruddy mongoose (*Urva smithii*) and stripe-necked mongoose (*Urva vitticollis*) were the possible predators of *G. bicalcarata* recorded at MONP. Leopard, fishing cat, rusty-spotted cat (*Prionailurus rubiginosus*), ring-tailed civet, common palm civet, stripe-necked mongoose, and brown mongoose were the possible predators recorded at HPNP and SNHWA. During the study period, we observed some activities and movements of poachers inside the protected areas as well (especially at MONP).

Table 3. Highest ranking models for factors influencing the site occupancy of *G. bicalcarata* at the three study sites (ΔAIC: delta AIC; Model LL: model likelihood; K: number of parameters in the model; Naïve occ.: Naïve occupancy; psi: occupancy probability of species; SE: standard error; p: detection probability of species; "(.)" indicates constant across all camera locations)

Model	AIC	ΔAIC	AIC weight	Model LL	K	Naïve Occ.	psi(mean)	SE (psi)	p(mean)	SE (p)
MONP										
psi(DEF),p(.)	118.06	0.00	0.29	1.00	3.00	0.09	0.10	0.01	0.22	0.06
psi(.),p(DEF)	118.06	0.00	0.29	1.00	3.00		0.09	0.01	0.10	0.01
psi(CN+DEF),p(.)	119.86	1.80	0.12	0.41	4.00		0.10	0.00	0.22	0.06
Model averaged							0.10		0.18	
HPNP										
psi(CN),p(.)	67.99	0.00	0.11	1.00	3.00	0.11	0.13	0.01	0.17	0.07
psi(.),p(.)	68.50	0.51	0.09	0.77	2.00		0.13	0.06	0.17	0.07
psi(GL),p(.)	68.77	0.78	0.08	0.68	3.00		0.13	0.01	0.17	0.07
Model averaged							0.13		0.17	
SNHWA										
psi(LC),p(CN)	163.11	0.00	0.07	1.00	4.00	0.33	0.43	0.02	0.14	0.00
psi(LC),p(DWEF+SMF)	163.16	0.05	0.07	0.98	5.00		0.43	0.02	0.14	0.01
psi(LC+NDVI),p(.)	163.53	0.42	0.06	0.81	4.00		0.42	0.02	0.16	0.01
Model averaged							0.43		0.15	

Table 4. Untransformed estimates of beta coefficients and standard error (SE) for the covariates contained in the top-ranked models of *G. bicalcarata* occupancy

	Site occupancy		Detection probability		
Covariate	**Estimate**	**SE**	**Covariate**	**Estimate**	**SE**
MONP					
Intercept(psi)	-102.00	1.20	Intercept(p)	-1.25	0.32
Dense wet evergreen forest	100.68	1.20			
HPNP					
Intercept(psi)	-2.42	0.90	Intercept(p)	-1.60	0.49
Canopy cover	1.30	1.12			
SNHWA					
Intercept(psi)	-0.31	0.49	Intercept(p)	-1.89	0.35
Litter cover	0.49	0.56	Canopy cover	0.58	0.44

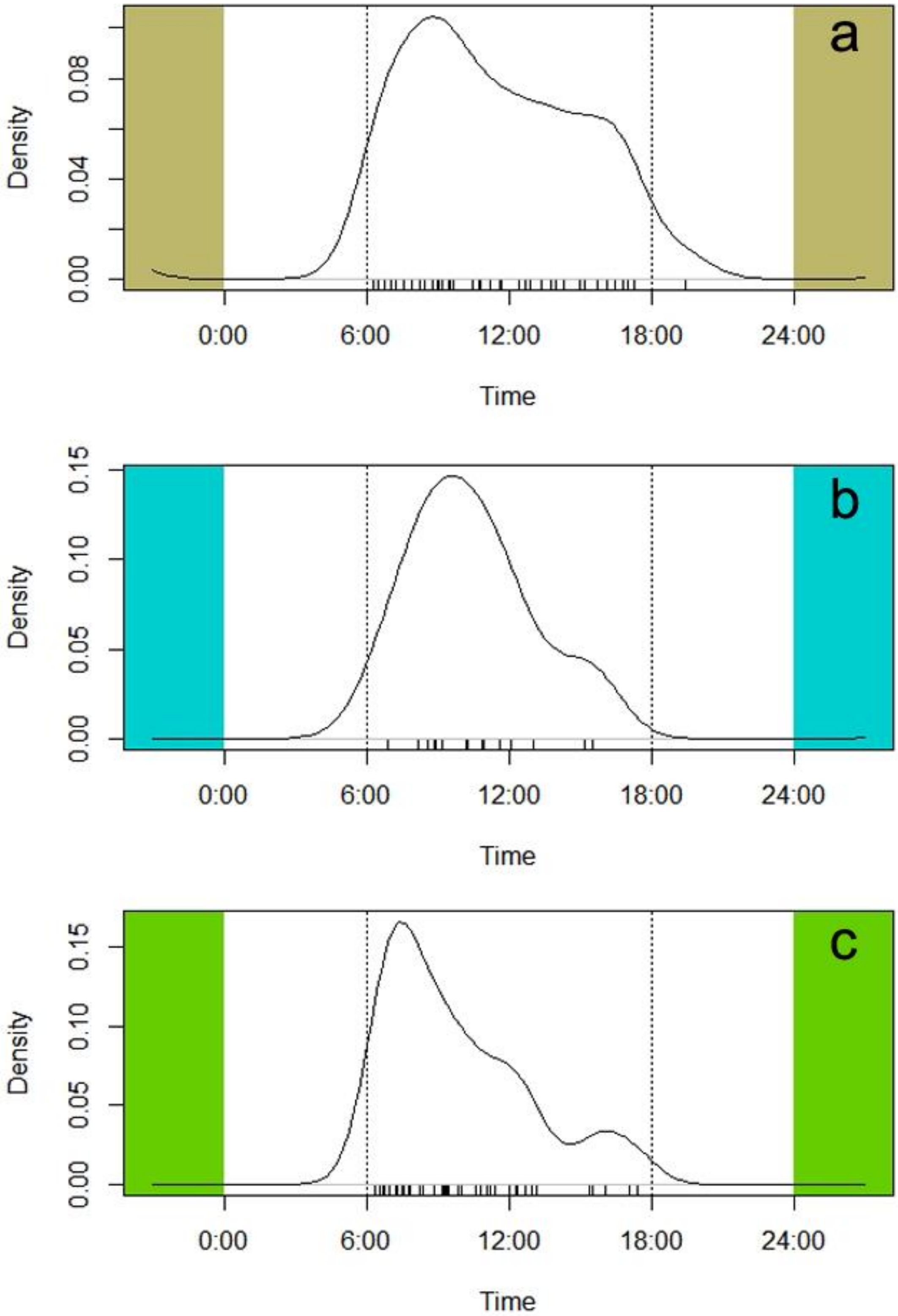

Figure 4. Activity pattern *G. bicalcarata* in the three study sites fitted with circular kernel density distributions of radian time a) MONP, b) HPNP and c) SNHWA

Figure 5. Display (Breeding behavior) of *G. bicalcarata* at MONP

Discussion

The affinity of *G. bicalcarata* for densely forested areas was visible in the results, conforming the information available in the literature (Wijeyeratne et al., 2007). Based on the occupancy models that were generated, we observed the association of this species with forest areas with thick canopy cover. In all study sites, canopy covers significantly correlated with litter cover, litter depth and sometimes with SD2 (stem density 2). We can conclude that the occupancy of *G. bicalcarata* is highly associated with densely forested areas with a thick canopy that generate a considerable amount of litter cover and litter depth to facilitate abundant prey (insects and other invertebrates, small vertebrates) to feed on. The association with high NDVI at SNHWA further confirms the impact of healthy vegetation. Another important observation was the lack of undergrowth in most of the sites occupied by *G. bicalcarata.* This was indicated in the occupancy models, where SD2 (stem density 2) did not have any positive influence on the occupancy of the species. Wijeyeratne et al. (2007) mentioned similar observations on the utilization of forest understory. These habitat requirements were fulfilled; at MONP by the climax forest of dry-mixed evergreen forest habitat, at HPNP by the dense cloud forests. At Sinharaja, the habitat types that were occupied by the species were more diverse whereas vegetation density was relatively higher in all the main habitat types.

This study indicates the importance of natural forest cover for the survival of *G. bicalcarata*. Therefore, the protection of these forest habitats is vital for the conservation of this endemic species. Pheasants and humans have long been closely associated. Due to their relatively large body size and terrestrial behavior, they are easy to trap or shoot, and their meat and eggs provide rich sources of protein for the locals (Fuller & Garson, 2000). The impact of hunting is also hard to quantify since it is illegal and, therefore, covert. Nevertheless, direct exploitation appears to be having serious negative effects on populations of several pheasant species in the world. In Sri Lankan context, the information regarding such issues is low. Alteration of native habitat could reduce avian productivity through increased rates of nest predation (Bollinger & Switzer, 2002, Haegen et al., 2000). We observed some incidents of seasonal man-made fires that occurred in MONP which destroyed considerably large forest areas with canopy cover. This would be a major threat for the survival of a forest species like *G. bicalcarata.* Areas of forested habitat may be permanently or temporarily destroyed through deforestation for other purposes such as agricultural or encroachment, including road building in sensitive ecosystems. Such anthropogenic activities may directly impact on the decline of forest specialist birds, especially in SNHWA. Therefore, it is important to consider the ecological requirements of sensitive species like *G. bicalcarata* before the implementation of any development projects.

G. bicalcarata was not recorded as much as we expected in the HPNP. Detection numbers were very low. In HPNP, the call of *G. bicalcarata* is also one of the most rarely heard bird calls. The study reveals the low abundance of this species at the site. In the present study, *G. bicalcarata* occurred more frequently in the forest interior, far from disturbed habitats since they are predominantly ground-feeding and ground-nesting birds. The distribution and abundance of animal species are sensitive to human-caused habitat changes (McIntyre & Hobbs 1999). Therefore, the increased disturbances in natural forests may affect potential nesting sites and increase the chance of nest predation rate by predators causing low recruitment rates of study species. When compared to other national parks, the presence of nature trails at HPNP and the disturbance by the visitor noise may have caused the restriction of this shy and elusive species to the inner areas of the cloud forests. We suggest detailed investigations into such impacts by focused studies.

G. bicalcarata was observed as male and female pairs in most of our capture records. There were several instances where groups were observed usually consisting of two males and one female, all individuals in adult plumage and size. Therefore, there may be some unknown social organization patterns of these secretive bird species. We recorded display behaviors of a male during July. Display behaviors were restricted to early morning (0600h-0800h).

The results revealed the highly diurnal activity pattern of the species. However, being a forest understory bird, the activity peak was reached during the morning period at all study sites. However, there were differences in the activity level. The high activity level shown at MONP could be a result of the low productivity of the dry zone forests (Dittus, 2017) where food availability is relatively low. Therefore, these birds had to forage for an extended period to fulfill their energy requirements. Conversely, at SNHWA in the low and mid-county, wet zone with high productivity (Gallery, 2014) and greater food availability, the proportion of time allocated for foraging were relatively lower (low activity level). At the cold climatic conditions of HPNP with intermediate productivity levels, the activity level was moderate. When foraging habits of the species are considered, they are known to scratch vigorously amongst the leaf litter of the forest floor for invertebrates, especially mollusks and insects. *G. bicalcarata* also consumes various seeds, fallen fruit, and spiders. The predator activity patterns at each study site could have influenced the activity of *G. bicalcarata.* We recommend further investigations into such interactions.

Our camera surveys provided baseline data on an understudied *G. bicalcarata* endemic to the island. This is the first detailed study on the habitat use and activity patterns of Sri Lanka Spurfowl. Camera traps offer considerable potential for improving our understanding of terrestrial forest birds assisting research on rare and cryptic birds from presence/absence and relative abundance surveys to behavioral and statistically sound monitoring studies. This study has shown the benefits of routine monitoring for collecting location data on difficult detect, rare, and shy bird species. Camera trapping is revolutionizing the study of elusive mammals, and we believe that there is a bright future for elusive birds as well. The camera trap method applied in this study could be used as part of a wider bird survey to assess priority areas for conservation across Sri Lanka, especially if complemented with camera trap data from other studies.

Conclusion

The present study provides the primary information on habitat use and activity patterns of *G. bicalcarata* in Sri Lanka. Our data highlights the impact of dense forest cover on the species and can be useful as a baseline for future studies and conservation planning for *G. bicalcarata*. For certain bird species, camera trapping can produce useful data and does hold the potential as a bird survey technique.

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