International Journal of Ecology and Environmental Sciences 48: 781-789, 2022
ISSN: 2320-5199 (Online); https://doi.org/10.55863/ijess.2022.6781

Impact of Anthropogenic Disturbances on Red Junglefowl *Gallus gallus* in Katerniaghat Wildlife Sanctuary, Uttar Pradesh, India

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ABSTRACT

This study revealed that the Red Junglefowl *Gallus gallus* population was threatened by anthropogenic disturbances in Katerniaghat Wildlife Sanctuary. The Red Junglefowl density in the undisturbed habitat was higher (69 individuals/km^2) than in the disturbed habitat (36 individuals/km^2). The mean group size was marginally higher in disturbed habitat (3 individuals/km^2) than in undisturbed habitat (2 individuals/km^2). The estimated sex ratio showed no major variation among disturbed and undisturbed habitats. The present study also revealed that Red Junglefowl avoided disturbed habitats, and the results provide further evidence that protection from human activities is urgently required. Unsustainable harvesting practices need to be regulated as a large number of villagers continue to exploit resources for generating income to partially support themselves. They also collect medicinal plants and other Non-Timber Forest Products in Katerniaghat Wildlife Sanctuary round the year.

Key words: Anthropogenic Disturbance, Red Junglefowl, *Gallus gallus*, Katerniaghat Wildlife Sanctuary, Impact

INTRODUCTION

Ecosystems are influenced by disturbances of several kinds, such as fires, windstorms, landslides, flooding, grazing, burrowing animals, and an outbreak of pathogens. Natural disturbances are inherent and unavoidable, affecting all levels of biological organisation. However, anthropogenic disturbance resulting due to the influence of human activities can be regulated. Due to natural and anthropogenic disturbances, ecosystems experience sudden or gradual changes, which may be intense or moderate. The presence of disturbances in ecosystems, their occurrence at a wide range of spatial and temporal scales are important drivers for their continuity (Pickett and White 1985, White and Jentsch 2001). Studies have been conducted to understand the effects of anthropogenic disturbance on birds that are often considered 'bio indicators' to infer environmental changes. (Brawn et al. 2001, Green and Baker 2003, Mallord et al. 2007, Jolli and Pandit 2011, Lin et al. 2012, Zmihorski 2012, Subasinghe et al. 2014).

The influence of human disturbance on the abundance of Himalayan pheasants in the temperate forest of Western Himalaya, India was assessed by Jolli and Pandit (2011) along a disturbance gradient defined by the human population and settlements, agricultural activities, forest wood collection, grazing, vehicle movement, use of heavy machines, dumping ground and mining. The results of the study indicated that the numbers of pheasants declined significantly with anthropogenic activities. They further inferred the response of pheasants to human disturbance and found that large-scale development can lead to the decline of pheasants in the Himalayan region.

It has been reported that sympatric detections of three pheasant species namely, Red junglefowl (*Gallus gallus murghi*), Kalij Pheasant (*Lophura leucomelanos*) and Grey Peacock-pheasant (*Polyplectron bicalcaratum*) were positively associated with microhabitat variables such as shrub cover, litter cover, and grass cover, whereas disturbance was negatively associated with the detection of all these pheasants (Selvan et al. 2013). They also examined the habitat use of Red Junglefowl and found that it occurred in logged forests and nearby human habitation, which makes them vulnerable to hunting.

In Mizoram, Lalthanzara et al. (2014) found low density of Grey Peacock-pheasant in comparison to other studies, and feared that the low density may be due to anthropogenic activities, habitat degradation, predators, low food availability or other environmental factors. They suggested taking immediate conservation measures for the survival of this important ecological indicator species in the montane broad-leaved evergreen forest of Mizoram. Threats to Red Junglefowl in Deva Vatala National Park, Pakistan, have been investigated using methods, including semi-structured interviews, participatory observations, and group discussions with the local community (Akrim et al. 2014). It was recorded that the major threats to Red Junglefowl in Deva Vatala National Park were egg picking, hunting, chick capturing, and habitat degradation.

Although few studies have been conducted on the flocking and habitat use pattern of Red Junglefowl (e.g., Javed and Rahmani 2000), not much has been explored pertaining to the impact of anthropogenic disturbances on Red Junglefowl. In this paper, the impact of anthropogenic disturbance on Red Junglefowl has been studied in Katerniaghat Wildlife Sanctuary in the context of habitat attributes. Our findings may be helpful to the Sanctuary managers for the overall management of its habitat.

STUDY AREA

The Katerniaghat Wildlife Sanctuary is located in Nanpara 'tehsil' of district Bahraich, Uttar Pradesh, India. The Indo-Nepal border constitutes the northern boundary of the Sanctuary. The entire area, totaling 400 km^2 is situated between 28°06' N and 28°24' N latitudes and 81°02' E and 81°19' E longitudes. The forest area was declared a Wildlife Sanctuary with Govt. of U.P. notification no. 388/14-3-32/1976, dated May 31, 1976. Together with adjoining 150.02 km^2 of Reserve Forest, which serves as a buffer, the Sanctuary constitutes one ecological unit. It is one of the few remnants of the rich and diverse '*Terai*' ecosystems, having connectivity with Royal Bardia National Park, Nepal, which lies to the north, and Dudhwa National Park to the west of the Sanctuary (Jha 2000). However, during the last 30 years, the connectivity of Dudhwa NP has unfortunately lost.

METHODOLOGY

Numerous methods have been described to assess anthropogenic disturbance and its impact on animal populations by different workers (Watson 1979, Gill et al. 1996, Gill 2007, Posa and Sodhi, 2006, Shahabuddin and Kumar 2006, Morris 2010, Mengesha et al. 2011, Kala and Dubey 2012). These described methods varied according to the area, species under study, and study duration. We used circular plot method (10 m radius) to collect field data on anthropogenic disturbances to envisage their impact on the abundance and distribution of the Red Junglefowl.

We selected disturbed and undisturbed habitats for extensive sampling to estimate the density of the Red Junglefowl (referred hereafter as RJF) and investigated vegetation structure. Disturbed habitat was selected based on human use, livestock movement, and human dependence on forests. The disturbed habitat was located near human habitation. For undisturbed habitat, the core area of the Sanctuary was selected that was without any anthropogenic pressures and was better managed. Permanent line transects were established in both disturbed and undisturbed habitats to estimate the bird population. Data were collected in circular plots of a 10 m radius to quantify vegetation structure. Data on the vegetation was collected in circular plots at every 200 m on the transects established to estimate the population of RJF. Data were collected on the number of tree species, their girth at breast height (GBH), tree height class, number of cut/lopped trees, shrub species, saplings, herb species, weeds and wildlife signs such as pellets, hoof marks, pugmarks, scats, etc., if any in disturbed as well as undisturbed habitats. Seedlings, grasses, and ground cover were quantified within the circular plots using four randomly selected quadrates of 50 × 50 cm each. The impact of resource use on the ground cover was also quantified within the 10 m circular plot in four 50 × 50 cm randomly placed quadrats. These quadrats were also used to quantify grazing and disturbance signs. Moreover, entry and exit points of trails used by the local people for fuelwood and Non-Timber Forest Produces (NTFPs) collection as well as for grazing of livestock in the forest were randomly monitored to assess the extent of their dependence on each habitat and quantify the resources being extracted and also to estimate livestock grazing.

The data was segregated habitat-wise - I) Disturbed habitat, and II) Undisturbed habitat. The density of the Red Junglefowl was estimated using DISTANCE 6.0 Release 2 (Thomas et al. 2009). Estimates of half strip width (ì) were expressed in metres, encounter rate (n/L) as the number of groups/ km walk, mean group size (GS) as an average of all groups sighted, sex ratio (males: 100 females) and individual density (Di) expressed as the number of individuals/km² was computed and compared for the disturbed and undisturbed habitat of RJF. Wilcoxon signed-rank test was used to assess differences in vegetation structure between undisturbed and disturbed habitats of Red Junglefowl. Principal Components Analysis (PCA) was done for variables in undisturbed habitat of Red Junglefowl comprising Sal forest, Mixed forest, Riparian forest and Teak plantations using PAST (version 3.06) software (Hammer et al. 2001).

RESULTS

As expected, Red Junglefowl density (69 individuals/km²) in undisturbed habitat was higher as compared to disturbed habitat (36 individuals/km²) (Fig. 1). The mean group size was slightly higher in disturbed habitat (2.91 individuals/km²) as compared to undisturbed habitat (2.40 individuals/km²) (Fig. 2). The encounter rate of RJF in both habitat types showed significant differences in its density that, was 0.40 individuals/km walk in disturbed habitat whereas, in undisturbed habitat, the encounter rate was more than double the disturbed habitat (i.e., 0.90 individuals/km walk) (Fig. 3). The estimated sex ratio showed no significant variation among disturbed and undisturbed habitats as the sex ratio was 0.72:1 (males: females) in disturbed habitat and 0.77:1 in undisturbed habitat (Fig. 4). The estimated effective strip width (i) was 20.30 m in disturbed habitat and 13.42 m in undisturbed habitat, as revealed by the best-selected model to fit the Red Junglefowl data for both major habitats types (Fig. 5).

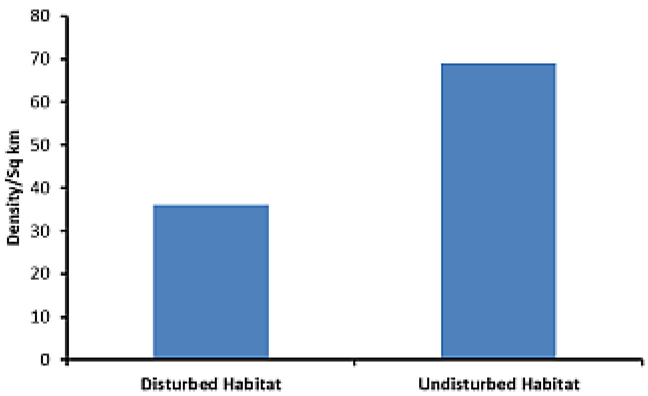

Figure 1. Density of Red Junglefowl in disturbed and undisturbed habitats of Katerniaghat Wildlife Sanctuary

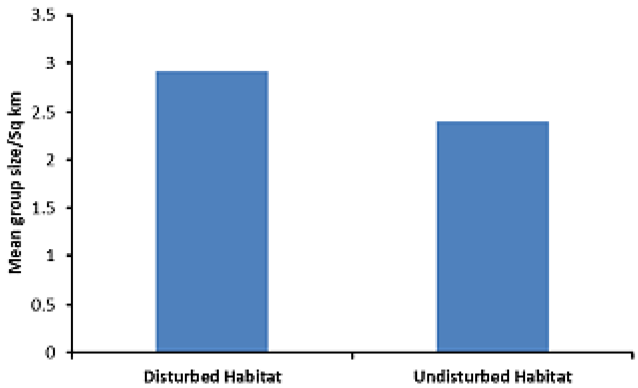

Figure 2. Mean group size of Red Junglefowl in disturbed and undisturbed habitats of Katerniaghat Wildlife Sanctuary

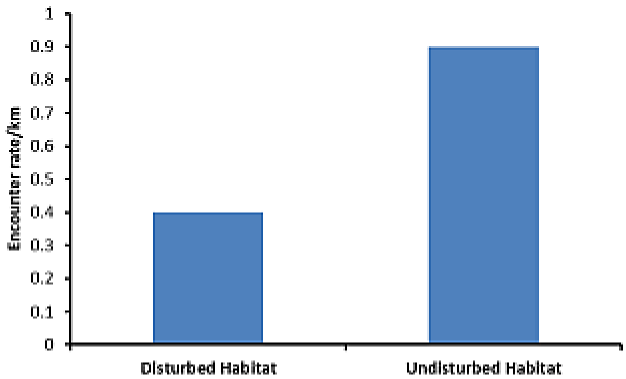

Figure 3. Encounter rate of Red Junglefowl in disturbed and undisturbed habitats of Katerniaghat Wildlife Sanctuary

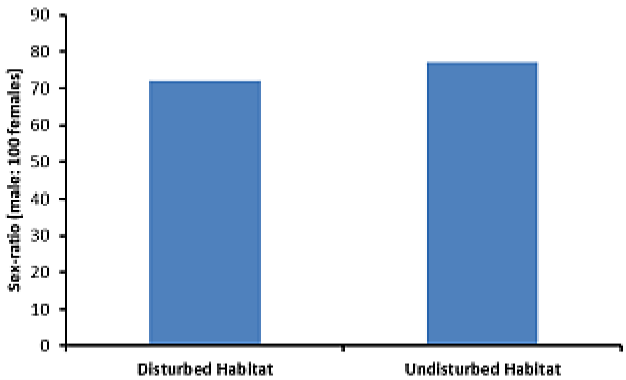

Figure 4. Sex-ratio of Red Junglefowl in disturbed and undisturbed habitats of Katerniaghat Wildlife Sanctuary

Wilcoxon signed rank test was carried out to know the effect of disturbance on vegetation structural attributes in the disturbed and undisturbed habitat (Table 1). Percentage canopy cover, tree density, sapling height, and percentage of ground cover were found to be significantly lower in disturbed habitat in comparison to undisturbed habitat (Percentage

Table 1. Wilcoxon signed rank test for knowing differences in vegetation structure between undisturbed and disturbed habitat of Red Junglefowl in Katerniaghat Wildlife Sanctuary

Habitat Variables	Undisturbed habitat	Disturbed habitat	Z-value	P value
Tree density (per ha)	507.78 ± 103.81	233.54 ± 80.72	-5.013	0.0005**
Tree height (m)	69.173 ± 14.18	87.60 ± 31.65	-1.631	0.102
Tree GBH (cm)	100.42 ± 19.62	138.59 ± 76.05	-1.559	0.118
Canopy cover (%)	57.77 ± 14.94	34.16 ± 12.21	-3.976	0.0006**
Shrub density (per ha)	4261.32 ± 2624.40	3988.85 ± 2407.70	-0.154	0.877
Shrub height (cm)	76.10 ± 22.95	50.07 ± 33.32	-2.511	0.011*
Shrub cover (%)	33.47 ± 10.26	32.91 ± 15.87	-0.695	0.486
Sapling density (per ha)	2006.37 ± 1720.78	1815.28 ± 2479.73	-1.524	0.127
Sapling height (cm)	18.06 ± 6.86	13.30 ± 19.02	-2.898	0.0037**
Grass density (m^2)	25.05 ± 17.53	75.66 ± 102.88	-1.345	0.178
Grass height (cm)	13.94 ± 2.72	13.61 ± 4.91	-0.571	0.567
Herb density (m^2)	25.91 ± 16.02	15.5 ± 18.79	-2.442	0.0145*
Herb height (cm)	12.77 ± 2.95	9.59 ± 3.86	-2.241	0.0193*
Seedling density (m^2)	12.69 ± 14.14	4.33 ± 7.19	-2.166	0.0302*
Ground cover (%)	69.72 ± 13.88	32.91 ± 11.76	-4.908	0.0009**

*P<0.05, **P<0.01, Z=Wilcoxon Rank value

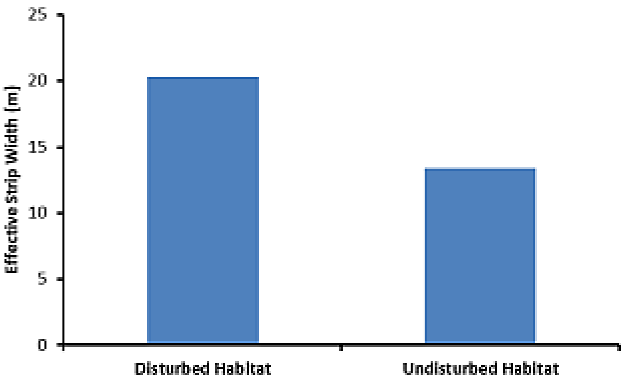

Figure 5. Effective strip width (m) of Red Junglefowl in disturbed and undisturbed habitats of Katerniaghat Wildlife Sanctuary

canopy cover Z=-3.976, P=0.0006, Tree density Z=-5.013, P=0.0005, sapling height Z=-2.898, P=0.0037 and percentage ground cover Z=-4.908, P=0.0009). Significant differences were observed between disturbed and undisturbed habitats with respect to shrub height, herb density, herb height, and seedling density (shrub height Z=-2.511, P=0.011, herb density Z=-2.442, P=0.0145, herb height Z=-2.241, P=0.0193 and seedling density Z=-2.166, P=0.0302) (Table 1). However, no significant differences were observed between disturbed and undisturbed habitat types used by Red Junglefowl in Katerniaghat Wildlife Sanctuary with respect to tree height, tree GBH, shrub density, shrub cover, sapling density, grass density and grass height (Table 1).

Principal Components Analysis (PCA) extracted four main components which accounted for 51.4% of the total variance and were considered to interpret the results of this analysis. The first component (PC-I) accounted for 15.7% of the total variance and was highly correlated with sapling density, sapling height, tree height, and tree GBH (Table 2). The second component (PC-II) accounted for 13.1% of the total variance and was correlated with grass height, grass density, sapling height, and tree density. The third component (PC-III) accounted for 12.0% of the total variance and was correlated highly with shrub cover, sapling height, herb density, and herb height. The fourth component (PC-IV) accounted for 10.6% of the total variance and was correlated with herb density, grass density, ground cover, and tree height (Table 2).

There were 64 villages within 5 km from the forest boundary and ten villages located within the Katerniaghat Wildlife Sanctuary. There were about 5,000 people residing in these villages, having a livestock population of 60,000. During random monitoring of entry points at the village boundaries, it was observed that most of the livestock population

Table 2. Principal Components Analysis of undisturbed habitat variables of Red Junglefowl in Katerniaghat Wildlife Sanctuary

Variables	Principal Components			
	PC 1	PC 2	PC 3	PC 4
Tree density	0.186	**0.343**	0.097	-0.459
Tree GBH	**0.369**	-0.265	0.142	0.252
Tree height	**0.400**	-0.014	-0.241	**0.311**
Canopy cover	0.218	-0.310	0.250	0.059
Shrub height	0.136	-0.065	-0.398	0.309
Shrub density	0.132	-0.135	-0.272	-0.115
Shrub cover	-0.122	-0.290	**0.355**	-0.145
Sapling density	**0.507**	-0.019	-0.145	-0.194
Sapling height	**0.359**	**0.338**	**0.360**	0.012
Grass density	-0.247	**0.403**	-0.240	**0.330**
Grass height	0.176	**0.522**	0.037	0.037
Herb density	-0.073	-0.059	**0.321**	**0.468**
Herb height	0.152	0.102	**0.323**	0.099
Seedling density	0.233	-0.012	-0.064	0.136
Ground cover	-0.103	0.215	0.266	**0.317**
Eigen value	2.353	1.966	1.802	1.587
Explained Variance	15.686	13.104	12.011	10.582
Cum % Variance	15.686	28.790	40.801	51.383

Table 3. Grazing pressure (per day) on the forest from villages during the peak grazing season in Katerniaghat Wildlife Sanctuary (n=8)

Village	Cow (Min-Max)	Buffalo (Min-Max)	Goat (Min-Max)
Amba	95-147	22-33	15-23
Bardia	52-125	32-67	11-31
Bishanapur	27-55	39-65	25-56
Bhawanipur	42-115	54-83	17-38
Bichhia	38-135	37-87	29-45
Tedhi	26-75	34-55	27-55
Dhakia	55-154	19-89	26-47
Bharthapur	21-49	27-68	17-52
Fakirpuri	31-67	15-35	27-44
Rampurawa	34-119	38-61	11-39

graze inside the forest throughout the year. Livestock herds enter 5-6 km deep into the forest through different entry points and graze for about 7-8 hours. The minimum and maximum livestock that enter the Sanctuary forest during the peak grazing summer season from the adjoining villages are summarised in Table 3.

The villagers carried out fuelwood collection throughout the year except for 2–3 months during the rainy season when the area becomes inaccessible due to heavy rains. People move 3 to 4 km inside the forest in the morning hours to collect fuelwood and spend about 2 to 3 hours accomplishing collection. Important fuelwood species in the study area were *Schleichera oleasa, Trewia nudiflora, Acacia catechu, Adina cardifolia, Tectona grandis, Dalbergia sissoo* etc. We observed seasonal differences in fuelwood collection by the villagers (Table 4).

The local villagers were found to collect a total of 19 Non-Timber Forest Products (NTFPs) (Table 5) from the Sanctuary. The NTFPs comprised seven species of trees, three species of shrubs, three species of climbers, three species of herbs, two species of grasses, and one epiphyte. The collection of NTFPs was carried out throughout the year by the local communities depending upon their availability in the forest (Table 5).

DISCUSSION

The study indicates that the vegetation structure is influenced by intensive biomass extraction in a disturbed habitat, which results in lower density of the Red Junglefowl. Disturbances are known to change important habitat variables, which result in changing bird species composition in the forests (Shahabuddin and Kumar 2006). Bhattacharya et al. (2009) observed that the presence of people, livestock, and shepherd dogs have a negative impact on galliformes that use predominantly the same

Table 4. Fuelwood collection in Katerniaghat Wildlife Sanctuary during summer and winter seasons

Season	No. of cycle loads	Fuelwood (kg)	No. of head loads	Fuelwood (kg)	Total collection (kg)
Winter	21	630	125	1875	2505
Summer	18	540	47	705	1245

Table 5. Non-timber forest products collected by villagers from Katerniaghat Wildlife Sanctuary

Common Name	Scientific name	Growth form	Part collected	Local uses
Shikakai	*Acacia rugata*	Shrub	Shoots	Pickle and vegetable
Bel	*Aegle marmelos*	Tree	Fruit, Entire plant	Fruits edible, fruit juice used as fish bait
Amla	*Phyllanthus emblica*	Tree	Fruit	Fruits edible, pickle
Pipla	*Piper longum*	Climber	Fruit	Fruits edible, used to treat cough and cold
Neem	*Azardirachta indica*	Tree	Leaf	Juice used in fever, as an insecticide
Barro	*Terminalia bellirica*	Tree	Fruit	Fruit powder used in treating cough
Harro	*Teminalia chebula*	Tree	Fruit	Fruit pulp used to treat constipation
Piyari	*Buchanania latifolia*	Tree	Fruit	Seeds edible
Bans	*Bambusa arundinacea*	Herb	Leaf, Young shoot	Leaf juice used to treat jaundice, vegetable
Baent	*Calamus tenuis*	Climber	Stem	Stems used to make furniture
Bankash	*Eulaliopsis binata*	Herb	Aerial part	Making cordage and ropes
Meetha neem	*Murraya koenigii*	Shrub	Leaves, twigs	Leaves used for seasoning food
Munj	*Saccharum munja*	Grass	Entire plant	Used as thatching material
Duddhi	*Ichnocarpus frutescens*	Climber	Stem	To make ropes, leaves as fodder
Arind	*Ricinus communis*	Shrub	Leaf, Fruit	Leaf juice is used to treat jaundice
Sal	*Shorea robusta*	Tree	Young shoots, bark	Fermenting material, Juice, as a fish poison
Sikhul, Khus	*Vetiveria zizanoides*	Grass	Root	To treat stomach problems
Hadjor	*Vanda* spp.	Epiphyte	Entire plant	Entire plant paste used in treating fractures
Aduwa	*Zingiber officinale*	Herb	Root	Root powder used to treat throat problems, spice

pastures and forest. Increases in livestock numbers have negatively affected the rangelands and galliformes in the Bedini Ali Region in the buffer zone of Nanda Devi Biosphere Reserve. Posa and Sodhi (2006) have examined impact of anthropogenic land use practices on forest birds with respect to canopy loss and found that canopy cover of 60% or higher was required by 24 of the 26 bird species in the native forests of Subic Bay, Philippines. Several other studies conducted on bird-habitat relationships, including those of Fernández-Juricic and Tellería (2000) also suggested that the presence of humans and disturbance caused has a negative impact on bird abundance. They have also found that the number of active birds decreased with an increase in the number of pedestrians during daytime, and the density of birds was negatively related to the number of visitors in urban parks.

The observed higher group size of Red Junglefowl in disturbed habitats could be due to availability of food such as grains in higher abundance around settlements and also the presence of thickets of *Lantana* sp. in forest edges, which were used for nesting. The higher flock size of RJF in disturbed habitat types could also be due improved vigilance by more number of birds in a flock since the area is open in comparison to undisturbed habitat. Wang et al. (2015) have also recorded that Great Bustards *Otis tarda* gained vigilance benefits from increasing group size, which showed a negative correlation between group size and the percentage of individuals scanning their surroundings, and a positive correlation between group size and the percentage of time with at least one individual scanning its vicinity.

Several factors are responsible for variation in the sex ratio of birds in different habitats (Göth and Booth 2005, Sheldon 1998, West et al. 2002). The lower sex ratio in the disturbed forest of Katerniaghat (Fig. 4) may be attributed to relatively more hunting of RJF males in the population due to their higher visibility and vocalization.

Higher effective strip width (m) in disturbed habitat (Fig. 5) may also be related to disturbance factors such as higher human movement in the area as birds maintain distance from humans where they are extensively hunted. This difference in effective strip width may also be due to the anti-predator behaviour of birds as animals do to reduce the probability of being detected, attacked, or killed by a predator (Caro 2005).

Red Junglefowl was associated with and utilising rich microhabitats in undisturbed habitat in Katerniaghat Wildlife Sanctuary. Similarly, Mallari et al. (2011) have also reported that Red Junglefowl preferred areas with a dense herb layer in Palawan forest of Philippines and had the highest density estimates in old-growth forests.

A study by Musavi and Khan (2013) on the impact of resource use by local communities on Katerniaghat Wildlife Sanctuary has revealed that local villagers are heavily dependent on the forest for their sustenance. The study revealed that villagers hold a significant number of livestock holding per family varying from 1 to 17 and more than 80 percent of the families owned livestock.

The average annual fuelwood consumption in household activities for villagers was 1263.18 ±215.82 kg whereas the annual collection of non-timber forest products (NTFPs) in sampled households in Katerniaghat Wildlife Sanctuary was 899.58±174.39 kg, which included products such as fodder for livestock, medicinal plants, vegetables and thatch grass (Musavi and Khan 2013).

Extensive collection of fuelwood and extraction of NTFPs and grazing can alter the microhabitats and their composition and eventually dynamics in a forest stand. This alteration is likely to affect the population and distribution of Red Junglefowl in the Katerniaghat Wildlife Sanctuary. Similar patterns of impacts of extraction of forest resources on birds have also been noticed by Dahal et al. (2015), who found that heavily grazed sites had signiûcantly lower species richness, indicating a strong detrimental effect of grazing practices on bird communities. According to Dennis et al. (2008), grazing indirectly affects bird communities through changes in vegetation characteristics that affect nest site suitability and food supply. Martin and McIntyre (2007) have also predicted that species that depend on understory vegetation would be most negatively affected by livestock grazing. Moreover, they also suggest that any level of excessive livestock grazing is detrimental to woodland birds, particularly the understory-dependent species. If trees are not cleared, a rich and abundant bird fauna can coexist with moderate levels of grazing.

Jolli and Pandit (2011) have recommended that the strong response of pheasants to anthropogenic disturbance has ecological applications and can be used to manage wildlife in habitat quality monitoring. In the Katerniaghat Wildlife Sanctuary, the anthropogenic pressures shall remain significant threats for the survival of the Red Junglefowl and, as such, must be dealt with accordingly. Therefore, research efforts need to be made to identify the best habitat within the current distribution of the target species and the factors that influence habitat quality.

ACKNOWLEDGEMENTS

We are thankful to the Chief Wildlife Warden, Uttar Pradesh for issuing research permit to conduct this study in Katerniaghat Wildlife Sanctuary. Also, assistance extended by the Range Forest Officer in field is greatly acknowledged. We are equally thankful to the Chairperson, Dept. of Wildlife Sciences and our colleagues for their encouragement.

Authors' contributions: Both the authors contributed equally

Conflict of interest: The authors confirm that there was no conflict of interest in this research and anything else that could be inferred as a potential conflict of interest.

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Received:20th October 2021
Accepted:30th August 2022