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ECOLOGICAL STUDY OF SATYR TRAGOPAN (*TRAGOPAN SATYRA*) IN SIKKIM-INDIA: A THREATENED BIRD SPECIES OF EASTERN HIMALAYA

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ABSTRACT

Climate change is a rapid process in Himalaya, it has significantly affected the ecological pattern of the species, however, Himalaya is considered as data deficient region which generally lacks quantitative analysis needed to impact conservation and management policies for avian species. A few phenological changes are well documented, whereas, the changes in behaviour and ecological interactions remain opaque for many higher taxa. The present paper, the first time, we detailed out ecological interaction and community-level ramifications of the Satyr Tragopan (*Tragopan Satyra*, Phasianidae) in Sikkim Eastern Himalaya especially focusing upon the Khangchendzonga Biosphere Reserve (the core zone, Khangchendzonga National Park is recently inscribed by the UNESCO as world heritage site). Overall, the results during study period quantified the overall density of the Satyr Tragopan at 0.79±0.35/sq.km and the encounter rate at 0.079±0.02 in the region, by using Distance software 0.7. The result also indicated that the species is confined in a narrow stretch of habitat range (2800 m- 3400 m asl) of the ecotone of cold temperate and subalpine regions of the Khangchendzonga Biosphere Reserve. It seemed that their habitat is under threat due to ecotone zone, where always community's succession occurs. Our analysis addresses the necessary aspects of conservation planning for long-term monitoring of the species and may guide future IUCN Red List of Threatened Species Assessments in Eastern Himalaya before plunging to extinction.

INTRODUCTION

An interaction between plants and animals is directly associated within and between the ecosystem and their external environment variables, which is a priority area of research in the current scenario for on-going biodiversity conservation assessment theme. Globally, biodiversity is under tremendous environmental and anthropogenic pressures, which applies equally to all its elements including the plant and animal species. It may increase the risk of vulnerability as some species show the extremely poor level of adaptation to altered habitats (Lovejoy, 1986, Vermeij, 1986). Therefore, habitat alternation suggests that certain habitats and species are under the risk of extinction (Terborgh and Winter, 1980, Slobodkin, 1986; Dunn *et al,* 2016). Sikkim (India) records many threatened bird species (Acharya & Vijayan, 2010) and most of them are confined to restricted elevation range (Acharya *et al,* 2011) for their possible specific ecological niche requirements. Due to anthropogenic pressures and habitat fragmentation these birds are becoming more sensitive within restricted range and hence, the immediate task is needed for their improving conservation and management practices, especially in protected areas (Basnet and Badola, 2012; Dunn *et al,* 2016). Additionally, understanding the changes in population size and distribution patterns of species including density, space and time, are equally important to plan appropriate habitat management and conservation strategies (Bibbly *et al,* 2000; Martin *et al,* 2007; Clark *et al,* 2013). Estimation of avian abundance and density provides baseline information for investigating their population size and habitat associations (Norvell *et al,* 2003; Piana, 2016) within a particular landscape. Distance sampling method applied to provide estimates of density and abundance of the species in the particular region; the method can be applied to point and line transects for any

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systems and species (Sutherland, 1996). However, a line transect has merit as it increases the detection probability (Wilson *et al,* 2000) and also the ratio of survey to transit time is increased in line transect designs (Buckland, 2006), which makes a line transect be the most efficient and least biased method for estimating density and abundance of the species. In distance method survey, if point locations are combined with distance sampling then it is possible to estimate detection probabilities and thereby the species densities (Rosenstock *et al,* 2002; Piana, 2016), because distance sampling reduces bias in estimation of the species populations (Buckland *et al,* 2001; Thomas *et al,* 2010), these data are more reliable and helpful for conservation and habitat management planning of the species which further help for IUCN assessment of threatened species. In this paper, to begin understanding the ecological interaction of a species, the first time a study was attempted on Satyr Tragopan, as a case study in the Khangchendzonga Biosphere Reserve, using line transect. The Satyr Tragopan is Himalayan Peasant; a Near Threatened species, occurs in the Himalayas of Nepal (uncommon), India (uncommon), Bhutan (fairly common) and China (local, with a limited range in the south and south-east Tibet) (BirdLife International, 2001).

MATERIALS AND METHODS

Himalaya Pheasant

Satyr Tragopan is one of the Himalayan Pheasants. The Himalayan Pheasants represent the most distinctive bird family in the Himalayas owing to their charismatic features, they act as an indicator of habitat quality and adverse human impacts in the high-altitude ecosystems and play a vital role in the food web (Ramesh *et al,* 1999; Fuller and Garson, 2000). For Satyr Tragopan, the male has red underparts with black-bordered white spots and olive-brown coloration to upper parts including rump and upper tail -coverts and facial skin is blue. Female varies from rufous-brown to ochraceous -brown in coloration; wings, tail, and under parts are generally brighter and more rufescent than on other female tragopans (Grimmett *et al,* 2011). These diagnostic characters help to identify the species in the field.

Perception-based information

The secondary information of Satyr Tragopan was gathered from all over the region, especially focusing in and around the area of Khangchendzonga Biosphere Reserve (KBR) in Sikkim through literature survey, and also through interactive meets with the local people particularly former hunter, Himal-Rakshaks (officially designated protector volunteers in KBR by the Sikkim Government) and Foresters in order to identify the potential forest areas. The historical data of the species was also collected to find out the presence or absence of pheasants in the particular area (followed by Jolli *et al,* 2011).

Field Surveys

The field surveys were conducted in two major altitudinal transects, Yuksom-Black-Kabru transect and Tholung-Kisong transect of the Khangchendzonga Biosphere Reserve (KBR, extending along 27°15'-27°57' N. lat. 88° 02'-88°40' E long, Badola and Subba, 2012), in Sikkim Eastern Himalaya, using a standardized methodology of line transect during May 2014-March 2017. The Yuksom-Black Kabru transect, a part of the southwest KBR in West Sikkim and the Thulong-Kisong transect, a part of the southeast KBR in North Sikkim were surveyed for the species especially covered the core zone, the Khangchendzonga National Park of KBR, which recently been inscribed as the World Heritage site (under mixed category) on 17.07.2016 by the UNESCO (Fig 1). The study areas covered the altitudinal gradient around c. 1760 m-4900 m asl in the KBR.

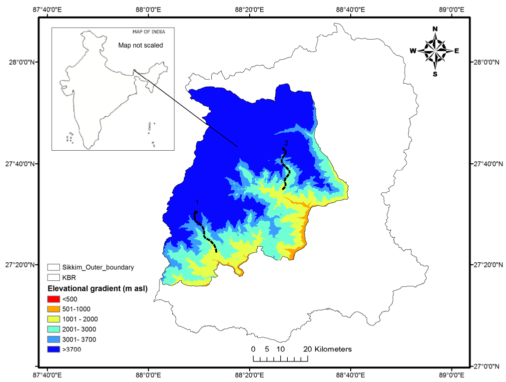

Fig 1 Location of study sites in the Khangchendzonga Biosphere Reserve (1 depicts Yuksom-Black Kabru transect and 2 depicts Tholung- Kisong transect)

Sample design

The two major transects were selected in the core zone of KBR, covering its northern and western parts to reduce the bias of availability of the species in time and space. Depending upon the accessibility in the study area, different sub-transects were laid down at different broad habitats along the elevation gradients in the two transects. Within sub-transacts, the total 680 point grids having 200 m x 200 m were laid down to detect the presence of the Satyr Tragopan at the perpendicular line based on altitude. The minimum 200 m distance between two successive points was maintained.

Distance analysis

Distance program was used (Thomas *et al,* 2005; Anderson *et al,* 2015) to estimate the Satyr Tragopan density, encounter rate, detection probability, mean cluster size and effective strip width (ESW). Distance data were analyzed using the program Distance 7.0, which has four key functions such as uniform, half-normal, hazard rate and negative exponential all with cosine series adjustment. Based on Akaike's Information Criteria (AIC), we used the chi-squared statistics to assess the 'goodness of fit' of each function (followed by the similar approach by Burnham *et al,* 1981; Buckland *et al,* 1993; Kidwai *et al,* 2011). The pooled data across years were used to increase the number of detection is recommended to estimate density with a reasonable degree of accuracy using program Distance (followed by the similar approach of Scott *et al,* 2006). For small sizes, we applied the Akaike's Information Criterion (AICc) to select the most parsimonious model from all possible combinations that are of uniform, half normal and Hazard Rate models with Cosine, Simple Polynomial and Hermite Polynomial adjustment. The Half Normal function with Cosine adjustment was fitted best in the model to achieve consistent convergence (followed by similar approach Anderson *et al,* 2015). Detection probability of Satyr Tragopan was also modeled using different models and adjustment terms and according to the AIC value, the Half-Normal model without any adjustment terms provided the best fit at the point, i.e. detection function of individuals should be 1.0.

Habitat assessment for Satyr Tragopan

For the habitat assessment of the Satyr Tragopan, we recognized area, the Yuksom- Black Kabru (Dome) or Y-BKD transact (27˚22'32.0" N latitude and 088˚13'29" E longitude to 27˚30'14.2" N latitude and 088˚09'20" Longitude) along 1780 m to 4520 m asl, lies in the Khangchendzonga Biosphere Reserve of Sikkim in its West district, as a case study. Yuksom, a place for the trekkers and trailhead, the trail goes up to Dzongri and Gochela in KBR is designated as tourism zone; the entire targeted transect is approximately a 30 km walk from Yuksom and reaching up to Black Kabru. A long walking distance across temperate to alpine zone passes through Sachen, Bakhim, Tsokha, Phitang, Dzongri and Laxmi Pokhri (lake) reaching to the base of Mt Kabru (dome). The whole transect was surveyed first to understand the habitat range of the Satyr Tragopan and also cross-checked for its presence with former hunters, Himal-Rakshaks, Foresters, Tourist Guides, and Potters, to know the exact habitat range of the species in the region. This transect offers great opportunities to visitors, scientist and nature lovers for its diverse tropical mixed broad-leaved forest, sub-alpine conifer-Rhododendron forest, alpine meadows, cascading streams, sacred lakes, a wide variety of birds, flowering plants as well as medicinal plants and scenery of the World's third highest peak Mount Khangchendzonga presents. The habitat range of the Satyr Tragopan was encountered from 2800 m asl -3400 m asl based on our primary observation in the target site and the indigenous knowledge. As a case study, for understanding the habitat requirements of the Satyr Tragopan in KBR, we focused 2600 m - 3600 m asl range of the Yuksom- Black Kabru (Dome) transect.

Field Sample collection

Woody vegetation composition structures were studied using stratified random sampling in the target site to know the habitat composition of the Satyr Tragopan. The potential transact for vegetation was laid down random stratification, and depending upon the requirements different sites were identified, based on homogeneity composition of forest and altitude. For the trees, 10 quadrates of 10 m x10 m size at each site were laid down. Within each 10 m x10 m quadrate, 5 m x5 m size was taken for the shrubs and the saplings, whereas, the seedlings were observed under 10 quadrates of 1m x1m size. Due care was taken to sample the most representative area of each site.

Data Analysis

The procured data of woody vegetation were quantitatively analyzed for density, relative density, frequency, relative frequency dominance and relative dominance using formulae given by Misra (1968). The Important vegetation Index was also quantified by summing of relative density, relative frequency and relative Dominance of the woody species in the forest. To evaluate species diversity for each site the Shannon and Wiener Index (1963) and Simpson Index (1949) were applied, which is given as,

$$H' = -\sum_{i=1} (ni/N) \log 2 (ni/N)$$

Where ni represents a total number of individuals of particular species and N represents a total number of individuals of all species.

The Index of Species Evenness was determined by Shannon Index of Evenness, which can be expressed as, E=H'/ln(S); where, H = Shannon's Index of Diversity, and S = number of species in the sample; species dominance was quantified by Simpson's Index (1949), as,

$$D = \sum_{i=1} (ni/N)^2$$

Where ni represents a total number of individuals of particular species and N represents a total number of individuals of all species.

Species richness was quantified by using Margalef's Index I= (S-1)/ ln (N); Where, S = the number of species in the sample; and N = the total number of individuals in the sample.

RESULTS

Population assessment

The Satyr Tragopan was sighted of 54 individuals on 21 occasions with aggregations ranged from 1- 5 individuals. Based on Distance 7.0, the detection probability of the Satyr Tragopan in the targeted site was estimated at 0.75 (CV% 21.9). The overall density of the Satyr Tragopan in the target landscape in the Khangchendzonga Biosphere Reserve was estimated at 0.79±0.35/sq.km with an overall encounter rate of 0.079±0.02 for the Satyr Tragopan. The probability of detecting the Satyr Tragopan first decreased initially and after certain distance then again the detection probability increased and thereafter decreased with increasing distance from the observer (Fig 2).

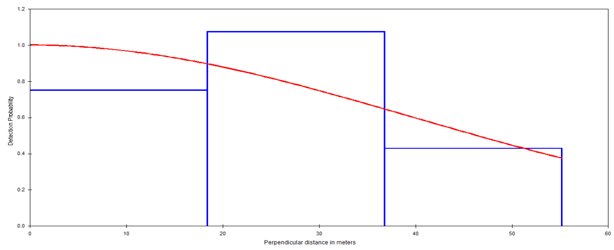

Fig 2 The best fit detection function model generated by DISTANCE analysis considering all Satyr Tragopan in the Khangchendzonga Biosphere Reserve during the study period (20014-2017).

Habitat assessment

The total 7 sites were identified as a habitat range of the Satyr Tragopan for the habitat assessment based on homogeneity of species and altitude in the cold temperate forest and subalpine region of the Yuksom-Black Kabru transect. The total 34 woody species were identified along 2600-3600 m asl range under 12 families. The Ericaceae followed by Sapindaceae and Rosaceae emerged as the most dominant family. The individuals of adult, sapling, and seedling per hectare also quantified. The maximum number of individuals of adult woody species were recorded at 3600 m asl (15200/ha) and the minimum at 2600 m asl (5400/ha). It seemed a trend that the number of individuals of adult woody species was increasing with altitude in the study sites. The maximum number of saplings of woody species was found at 3100 m asl (3000/ha) and the maximum number of seedlings was found at 3400 m asl (2100/ha) (Fig 3).

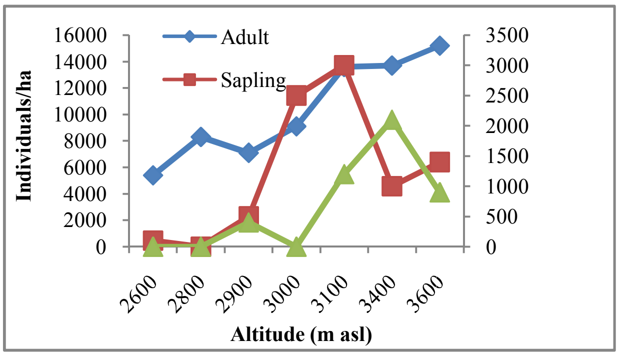

Fig 3 Abundance of woody species of the habitat of the Satyr Tragopan in the Khangchendzonga Biosphere Reserve

The basal area cover of woody species in meter per hectare of the study area was also quantified. We encountered the maximum basal area cover of adults at 3400 m asl (3386.56 sq. m/ha) and the minimum area cover of adults at 3600 m asl (562.11 sq. m/ha). The maximum basal area cover of sapling was found at 3000 m asl (5.29 sq. m/ha) and similarly, the highest basal area cover of seedling was found at 3400 m asl (0.23 sq. m/ha) (Fig 4).

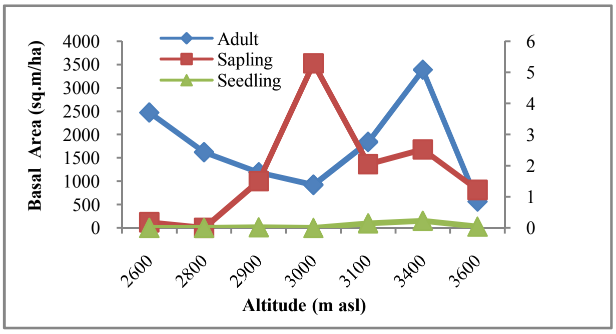

Fig 4 Basal area of woody species of the habitat of the Satyr Tragopan in the Khangchendzonga Biosphere Reserve

The ecological indices of the habitat of the Satyr Tragopan were also quantified such as Margalef's Index of Species richness (range from 5.80-10.76), Simpson's index of Dominance (range from 1.41E+00-1.67E-01), Shannon-Weiner Diversity Index (range from 2.082-1.18), and Shannon Index of Species Evenness (range from 0.87-0.64). Overall, all the ecological indices appeared to be negatively correlated with altitude using the regression line (Fig 5).

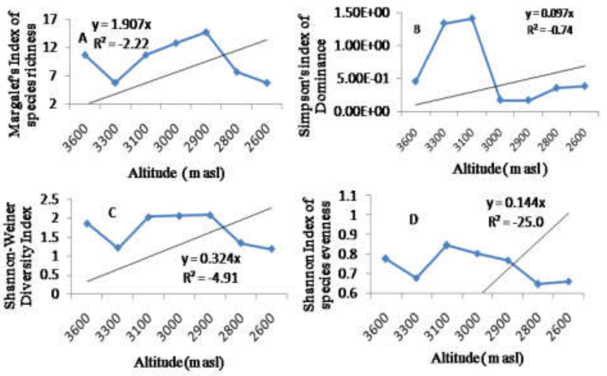

Fig 5 Ecological indices of the habitat range of the Satyr Tragopan in the Khangchendzonga Biosphere Reserve

Based on the relative density, relative frequency and relative dominance of woody species, the Important Vegetation Index (IVI) of the Satyr Tragopan's habitat range was also quantified. As per IVI, *Rhododendron hodgsonii* (Ericaceae), *Abies densa* (Pinaceae) and *Rhododendron campylocarpum* (Ericaceae) had the highest IVI at 3600 m asl. Similarly, *Abies densa, Rhododendron falconeri* (Ericaceae), *Betula alnoides* (Betulaceae) and *Rhododendron barbatum* (Ericaceae) at 3400 m asl, *Rhododendron falconeria, Rhododendron arboreum* (Ericaceae) and *Abies densa* at 3100 m asl, *Abies densa, Rhododendron falconeria, Rhododendron arboreum* at 3000 m asl, *Rhododendron arboreum* and *Magnolia campbellii* (Magnoliaceae) at 2900 m asl, *Rhododendron arboreum, Magnolia campbellii,* and *Quercus pachyphylla* (Fagaceae) at 2800 m asl, and *Quercus Pachyphylla* and *Rhododendron arboreum* in the site at 2600 m asl were the dominant species of the Satyr Tragopan habitat range. Overall, it seemed that the Satyr Tragopan habitat range was confined in a very narrow stretch of cold temperate and sub-alpine zones of the Khangchendzonga Biosphere Reserve. It was seen that the Satyr Tragopan dwelling mainly restricted in the dense undergrowth and bamboos of the ecotone of the cold temperate-subalpine forest in the Khangchendzonga Biosphere Reserve.

DISCUSSION

The results indicate that the Satyr Tragopan is confined in a narrow stretch of habitat range from 2800 m -3400 m asl of cold temperate and subalpine regions in the Khangchendzonga Biosphere Reserve. Whereas, Grimmett *et al* (1998) have reported that the Satyr Tragopan was found along 2590-3800 m asl (in winter at 2000 m asl). Similarly, studies in Annapurna Himal in Nepal (Lelliott and Yonzon 1980) and in Singhalila National Park in Darjeeling (Khaling, 1997) showed Satyr Tragopan distribution in similar habitat and elevation range. The results also indicate that the overall density of the Satyr Tragopan was at 0.79±0.35/sq.km and encounter rate was at 0.079±0.02 in the Khangchendzonga Biosphere Reserve. Although, the habitat loss and fragmentation is a profound impact on declining population of threatened and endemic birds in the Himalayas and elsewhere (Crosby, 1996; Mauro and Vercruysse, 2000; Bird International, 2001; Chettri *et al,* 2001, 2005; Pandit *et al,* 2007; Dunn *et al,* 2016). It has been reported that the endemic birds are unable to cope with non-native habitats resulting from deforestation and land use pattern (Vijayan and Gokula, 2006; Clark *et al,* 2013). The main cause of extinction of endemic species is driven by the loss of potential breeding habitat (Mauro and Vercruysse, 2000; BirdLife International, 2001). Our finding also suggests that the Satyr Tragopan is confined in the ecotone of the cold temperate forest and subalpine region of the Khangchendzonga Biosphere Reserve and their habitats are under threat due to the fragile community composition in the ecotone zone which may easily come under the impact of climate change. Further, it seemed that the species richness of woody species is higher in the ecotone zone, i.e. the middle of the altitude of the habitat range of the Satyr Tragopan and also indication that the lower region of the woody species is shifting towards the higher region. Gaire *et al* (2014) have reported that the timberline tree, *Abies spectabilis* has been shifting towards higher altitude at the rate of 2.61m/per year since 1850, and phenology shifting (Badola,

2010) is evident in Himalaya due to climate change. However, the temperature is increasing generally at 0.01 to 0.04˚C per year (Sharma *et al*., 2009); whereas, the rainfall is uncertain (Goswami *et al,* 2006) due to climate change in Himalaya. Additionally, due to anthropogenic pressures and habitat fragmentation, Himalayan birds are becoming more sensitive within restricted range and hence, the immediate task is needed for their improved conservation and management practices, especially in the protected areas (Basnet and Badola, 2012; Clark *et al,* 2013). Scientific data are required on the ecological status, distribution, diversity of bird species and associated habitats, which may offer vital clues on the disturbance level for the effective implementation of conservation management of the same (Chettri, 2000; Nawaz *et al*, 2000; Klerka *et al,* 2004; Fernández-Juricica *et al,* 2004; Basnet and Badola 2012).Therefore, the study on pheasants' diversity and abundance alone without understanding their habitat relationships would be inadequate for a complete and quality research assessment because either is ecologically inter-related. However, Mountain range of the eastern Himalayas is considered as an endemic bird area (BirdLife International, 2001), which supports 22 restricted-range bird species, out of which 22 species 19 are endemic to the Eastern Himalayas (Stattersfield *et al*, 1998; Jathar and Rahmani, 2006). The principal threat to the avian fauna of Himalaya is the loss of habitat; particularly tropical lowland, subtropical and temperate forests (Crosby, 1996). Although, monitoring the Himalayan Pheasants are largely ignored for its conservation and habitat management due to their habitats which mostly confined to sloppy mountain landscape where the climate is unbearable with difficult landscape topography to carry out the study. Therefore, conservation directives should focus on Himalayan Pheasants for their priority conservation and appropriate habitat management in the Himalayas before they are forced to go through the doors of extinction. The authors highly recommend for the long-term data and monitoring mechanism in the Himalayan landscape to allow interpretation of the changes in ecology interaction of Himalayan Pheasants along with climate change, and associated habitats to strengthen their conservation management by involving policymakers, community people, government and non-governmental organizations.

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