



**Foraging behaviour, Food resources and Habitat use by  
Rufous-necked Hornbill (*Aceros nipalensis*) in Jigme  
Singye Wangchuck National Park, Bhutan.**

**Karma Sherub**



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**“Report on Data collection for the Summer and Autumn seasons”**

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## Summary

In Bhutan, the Rufous-necked hornbill (*Aceros nipalensis*) is listed in “Schedule 1” of the Forest and Nature Conservation Act of 1995 and forest rule of 2006 as an endangered species. At the global level, it is classified as a vulnerable by the IUCN (Birdlife International, 2016). Jigme Singye Wangchuck National Park (JSWNP) in Bhutan is one of the important habitat for Rufous-necked hornbill (RNH) where it occurs below 1800m in Warm Broadleaved forests. In this paper some aspects of feeding ecology, habitat use, flock size, distribution, conservation threats and nesting of RNH in JSWNP are presented based on observations carried out from June to November 2016.

Of the total area surveyed in the park, the RNH was found between the altitude of 784m - 1608m. The maximum number of hornbills sighted in a day was 8 at Korphu village in Trongsa district. A flock comprising of two to five individuals were recorded during the non-breeding season. Once a flock of five individuals, which is the largest, was recorded during the study period.

A total of 73 tree species belonging to 29 families were identified from 125 plots (10m x 10m) laid randomly in five villages spread over JSWNP between 784m - 1608m. The diet of RNH comprised 23 species of fruits, belonging to 11 families. Fourteen of the 23 food plant species were recorded in the plots. Some invertebrate animals were also consumed as food i.e insects & crustatians. Two active nesting hole trees were also located and studied

Prevailing threats of RNH in JSWNP were also identified. Over the recent year, the over head high power transmission lines have brought immense changes to the RNH habitat. The other frequent threats are agriculture, logging, firewood collection, grazing, and extension of land for building houses in the area. For the long term conservation to save this threatened species from extinction, studies related to the hornbill behavior, food resources and their habitat use, along with conservation of habitat are important.

## **Introduction**

Bhutan is home to four species of hornbills (Bucerotidae): Wreathed Hornbill (*Aceros undulates*), Oriental Pied Hornbill (*Anthracoceros albirostris*), Rufous-necked (*Aceros nipalensis*), and Great hornbill (*Buceros bicornis*), out of which the latter two species occur in Jigme Singye Wangchuck National Park (Lepage, 2016) of Bhutan. The Rufous-necked hornbill (RNH) has been listed as ‘vulnerable’, while the Great hornbill has been listed as ‘near threatened’ by IUCN (Birdlife International, 2016).

In Jigme Singye Wangchuck National Park (JSWNP) of Bhutan, Rufous-necked hornbill is found in the lower altitude range of broadleaved forests mostly along the southern and central part of the park, especially in areas of Trong village block under Zhemgang district, Korphu and Langthel village blocks under Trongsa district and Athang village block under Wangdue district (Birdlife International, 2016; Penjore, 2010).

In this report some aspects of feeding ecology, habitat use, flock size, distribution and nesting of RNH, studied during summer and autumn season of 2016 in Jigme Singye Wangchuck National Park, are presented. The major threats to this species, due to various anthropogenic activities, are also outlined and discussed.

## **Problem statement**

In Bhutan, Rufous-necked hornbill is listed as protected species under the schedule I of the Forest and Nature Conservation Act, 1995. One of the mandates of Jigme Singye Wangchuck National Park is to conserve such a vulnerable species. However, its habitat are degrading due to various anthropogenic activities such as firewood collection, non-wood forest product utilization, illicit timber extraction, road construction, forest fire, shifting cultivation, hydro power projects and other developmental activities.

For the conservation of RNH and its habitat, a full understanding of the diet and food availability are needed (Leighton, 1982). It is very important to know what they feed on because it influences their survival. Similar study in Indian Eastern Himalaya region was recently carried out by

Shukla *et al.* (2016). The need to study their seasonal use of the various food resources and habitats are critical in light of the diminishing habitats in this Park.

Therefore, it is imperative to have enough quantitative information on the habitat requirement by the focal bird species for its conservation and management of critical habitat before it is too late. Regulation of distribution and abundance is deemed crucial to determine habitat quality and quantity for monitoring hornbill population in the protected areas as well as to enable the survival of hornbill species and sustainability of broadleaved forests of Bhutan. Successful conservation of Rufous-necked Hornbill will ensure conservation of other hornbill species in the park as well because it has more selective habitat use.

### **Scope of the present study**

The population and breeding status of hornbill make them excellent indicators of the health of the forests they inhabit (Poonswad, 1991). For a sustainable population, hornbill require sufficient food and safe nesting sites, as provided by intact forests and large tree cavities (Poonswad & Tsuji, 1994). A sustainable food supply is critical for sustainable population that determines the present and future picture of the fate of hornbill.

Understanding the basic biology of hornbills, especially those with critical population status, are a prerequisite for maintaining sustainable populations and habitat, and involve regular fieldwork for population assessment and ecosystem health. No such study was carried out in JSWNP, however, similar study was recently carried out by Shukla *et al.* (2016) in Indian Eastern Himalaya region.

### **Objectives of the present study**

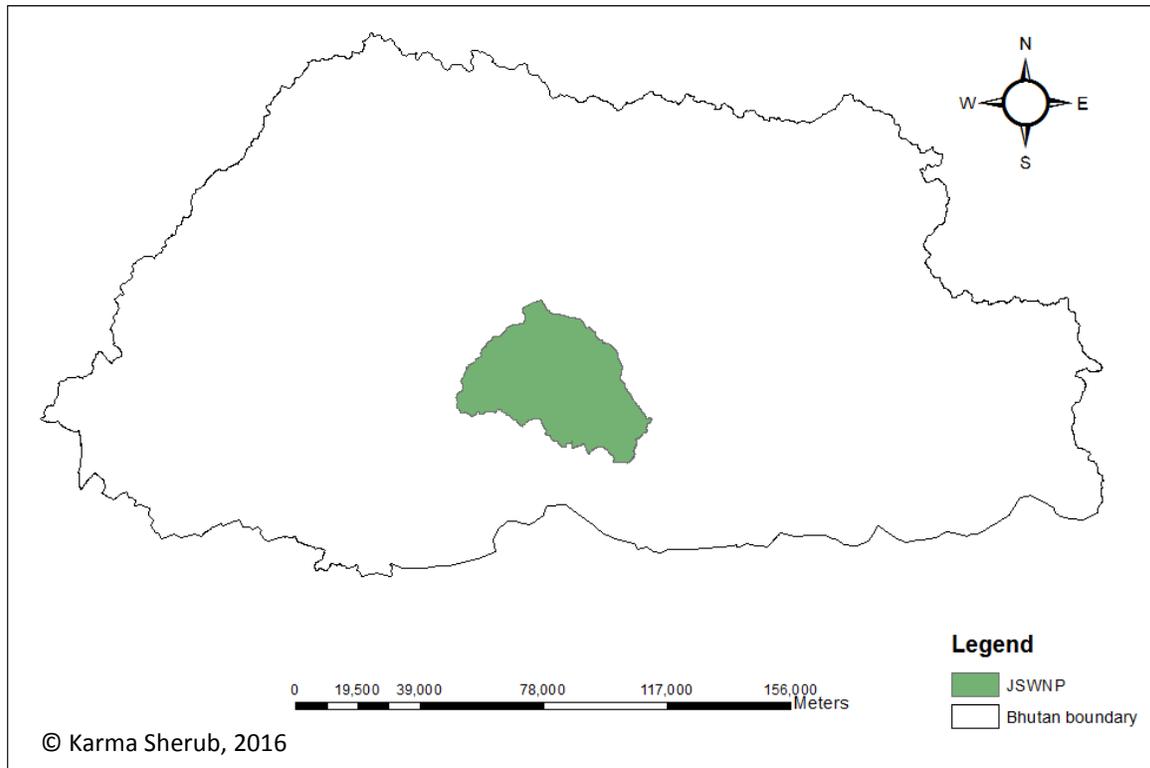
The present study was designed to understand the feeding ecology of RNH, with special reference to consumption of food resources during breeding and non-breeding season, aiming at the following objectives:

1. The determine the diet composition of Rufous-necked Hornbill during breeding and non-breeding season in Jigme Singye Wangchuck National Park, Bhutan

2. To document the habitat characteristics preferred by Rufous-necked Hornbill in the Park.
3. To identify the potential threats to Rufous-necked Hornbill in the Park.

### Study area

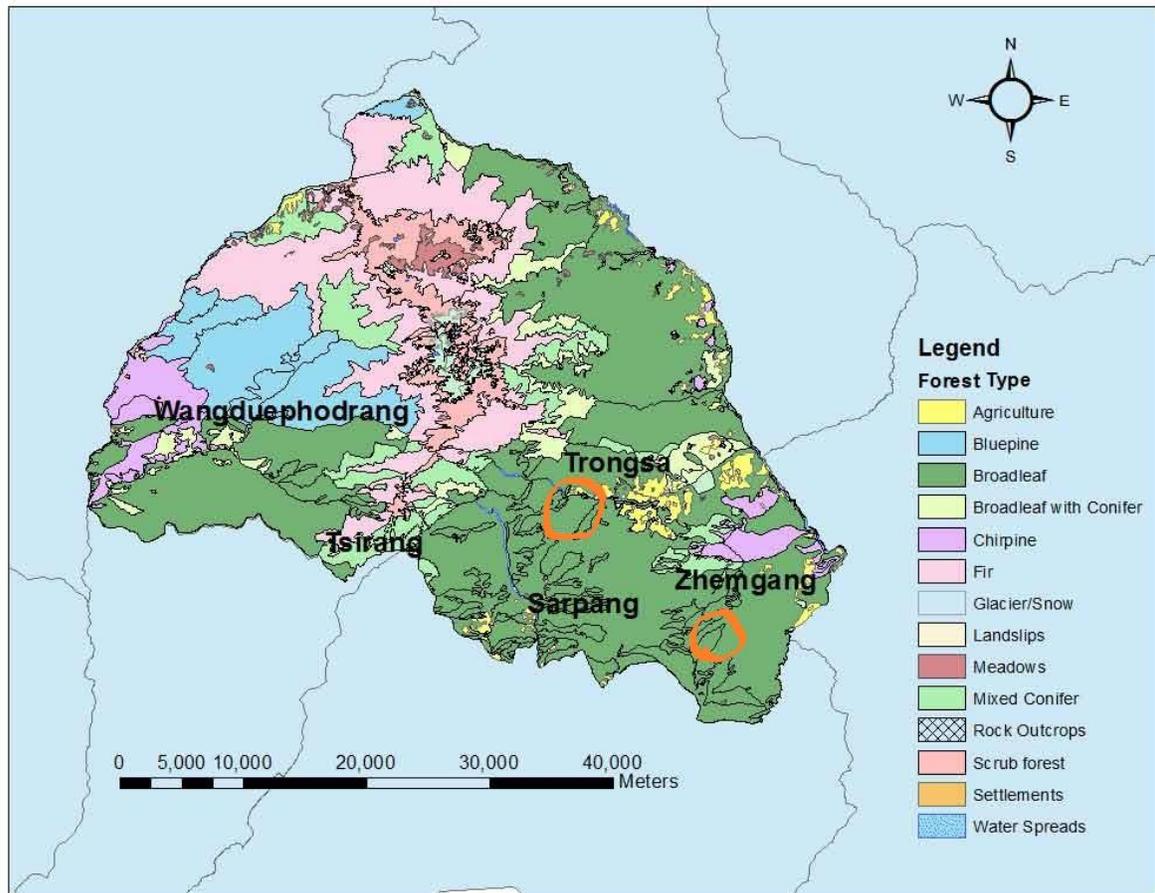
The present study was conducted in the Jigme Singye Wangchuck National Park of Bhutan which falls within the administrative jurisdiction of five districts; Wangdi, Trongsa, Zhemgang, Sarpang and Tsirang and has an area of 1730 sq km. The forest type in Jigme Singye Wangchuck is dominated by ‘Cool Broadleaved Forest’ at lower altitude and by ‘Mixed Conifer Forest’ and ‘Fir Forest’ at higher altitudes. The elevation ranges from less than 200m in south to over 4000 m in north forming the highest peak known as Black Mountain (JSWNP, 2016).



**Figure 1: Bhutan Map showing the location of the study area - Jigme Singye Wangchuck National Park.**

The park harbors wide diversity of climatic conditions, making it suitable for many different flora and fauna species. The topography of study area is mostly rugged in most areas. The rainfall in the area occurs during June-August. The climate is cold in winter and moderate in summer months (Dorji, 2013).

JSWNP has one of the highest coverage of mature conifers such as fir and pine beside other types of broadleaf forests. It is home to over 5000 species of vascular plants, more than 22 mammals' species and about 395 species of birds. The habitat of Rufous necked hornbill in this Park is at <1800 m asl in primary 'broadleaved evergreen forest' (Dorji, 2013).



**Figure 2: Jigme Singye Wangchuck National Park depicting the study area (marked in orange circles) and the Forest Type distribution in five districts.**

Other terrestrial fauna found in the park includes rare and endangered species such as musk deer, himalayan black bear, golden langur endemic to eastern Himalaya, clouded leopard, red panda and Royal Bengal tiger. Most people in the study area practice subsistence agriculture and also rear livestock. The park emphasizes research and monitoring, wildlife management, conservation education, sustainable live hoods and the improvement of social welfare of communities in and around the park (Dorji, 2013).

### **Distribution and sightings of RNH in JSWNP**

The present study revealed the altitudinal distribution of the Rufous-necked hornbill in the park between altitudes 784 - 1608m. The field survey was done at the areas where RNH occurred frequently. The transects in each area were sampled 1-4 times. The sightings of individuals on repeated transect walked were used to estimate the status of RNH.

A total of 80 individuals were sighted. The maximum number of hornbill sighted in a day was 8, recorded from Korphu village under Trongsa district. The highest mean number of RNH being sighted (Mean: 5.5; SD:  $\pm 2.1$  & 3.5) per visit were recorded from Nabay and Korphu villages respectively during the non-breedingseason (Table 1).

However, during the breeding season, the highest mean number of RNH being sighted (Mean: 4.00; SD:  $\pm 2$ ) per sampling were recorded from Nabay village, Zhemgang district (Table 1). The mean number of hornbill seen in non-breeding season (30.3) was higher than breeding season (10).

The Chakharthang and Chungzhing village under Sarpang district were visited once as the sighting frequency was very less and the effort walked to reached the area was a long distance. Therefore only the place where the sighting was maximum were visited to collect an ample data on foraging and habitat use (Table 1).



**Figure 3: (left) Preliminary survey with a local people on sighting of RNH in an area. The importance of RNH in an ecosystem were also been shared with the local people residing in important RNH habitat; (right) Recording the data on sighting of RNH with a local guide.**

**Table 1: RNH records in areas surveyed between June 2016 to October 2016 in Jigme singye Wangchuck National Park, Bhutan.**

| Area   | Season       | Month            | Effort (km walked) | Days spent | No. of Sighting | Mean no. of sighting per sampling | Max. nos. seen per day |
|--|--------------|------------------|--------------------|------------|-----------------|-----------------------------------|------------------------|
| Nabay village, Zhemgang district             | Breeding     | July             | 3.2                | 3          | 12              | 4 ± 2                             | 6                      |
|  | Non-breeding | October-November |                    | 2          | 11              | 5.5± 2.1                          | 7                      |
| Chakarhang village, Sarpang village district | Non-Breeding | July             | 1.5                | 1          | 2               | 2                                 | 2                      |
| Chungzhing village, Sarpang district         | Non-breeding | July             | 3                  | 1          | 2               | 2                                 | 2                      |
| Gonphaii village, Zhemgang district          | Breeding     | July             | 4.37               | 3          | 9               | 3± 1                              | 4                      |
|  | Non-breeding | October-November |                    | 2          | 6               | 3± 2.8                            | 5                      |
| Berti, Zhemgang                              | Breeding     | July             | 3.29               | 2          | 6               | 3±1.4                             | 4                      |
| Wangdigang village, Trongsa district         | Non-Breeding | August           | 1.2                | 4          | 13              | 3.8±1.3                           | 5                      |
| Nabji village, Tronsa district               | Non-breeding | August           | 2                  | 2          | 8               | 4±0                               | 4                      |
|  | Non-breeding | October-November |                    | 2          | 9               | 4.5±3.5                           | 7                      |
| Korphu village, Trongsa district             | Non-breeding | September        | 1.5                | 2          | 11              | 5.5±3.5                           | 8                      |

### Composition of flock size in breeding and non-breeding season

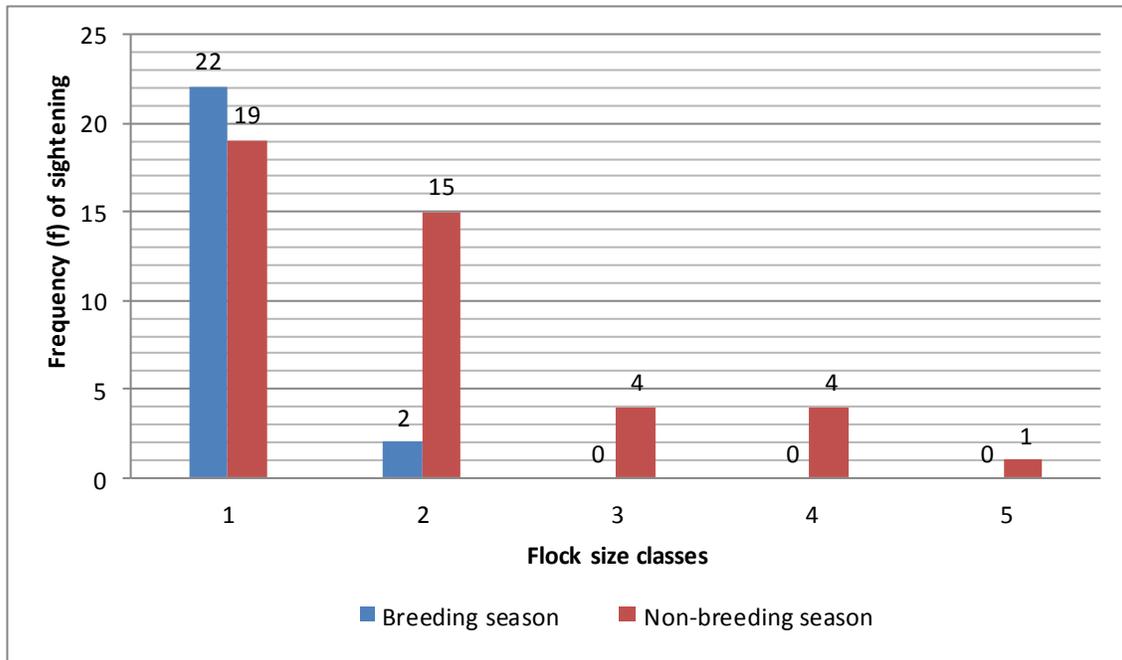
The evidences data for the female RNH first seen sealed in the nest at around mid April was retrieved from the Tingtibi Forest Range Office, Zhemgang. The end of breeding season was assumed by the sighting of juveniles in the area for the first time (26th July) with the parents RNH during the data collection. However, the exact date for the female starting to seal the nest will be monitored during the upcoming data collection for rest winter and spring season.

During the breeding season males were recorded 22 times, scanning and gathering the food material to feed the females which is enclosed in the nest. However, only two sightings of females were recorded that too in pairs, which shows that these females were not nesting (Appendix 1; Figure5).



**Figure 4: (A) The male RNH on *Alangium chinense*; (B) non-breeding pair of RNH captured during the breeding season.**

During the non-breeding season (after 26<sup>th</sup> July), the RNH were seen in flock size of two to five individuals (Appendix 1; Figure 5). The highest flock composition comprised of five individuals but in low sighting frequency ( $f=1$ ). Cody (1971) and Morse (1970) mentioned that the flocking tends to occur when food availability is low. Therefore, it was observed that the frequency of individual visiting the same fruit tree were maximum. The juveniles were also seen after the mid of July, escorted by the parents (Figure 6).



**Figure 5: Graph showing the frequency of flock size composition of RNH seen during breeding and non-breeding season in Jigme Singye Wangchuck National Park, Bhutan.**



**Figure 6: Two male juveniles RNH with their parents recorded from Jigme Singye Wangchuck National Park, Bhutan.**

### Food type and food diversity

The food eaten by the RNH was very diverse. Fruit food was classified into 11 families out of which the family Moraceae represented the highest number of food plants having 7 species (Appendix 2; Table 2). All the RNH were seen feeding on the ripened fruits during the entire study period. Gautier-Hion *et al.* (1985) commented that the colour and texture are the cues used by hornbills and other birds to determine if a fruit is ripe.

**Table 2: Total number of fruit tree species under each family used for feeding by RNH in JSWNP, Bhutan.**

| Si. No. | Family         | Number of species species |
|---------|----------------|---------------------------|
| 1       | Anacardiaceae  | 2                         |
| 2       | Burseraceae    | 1                         |
| 3       | Cornaceae      | 1                         |
| 4       | Elaeocarpaceae | 1                         |
| 5       | Flacourtiaceae | 1                         |
| 6       | Lauraceae      | 6                         |
| 7       | Magnoliaceae   | 1                         |
| 8       | Meliaceae      | 1                         |
| 9       | Moraceae       | 7                         |
| 10      | Rhamnaceae     | 1                         |
| 11      | Rosaceae       | 1                         |

Hornbills select fruits that provide superior energetic rewards and usually more protein per fruit than those eaten by other birds and mammals (Kinnaird & O'Brien, 2007). The RNH was also observed feeding on invertebrates such as crabs, caterpillar, beetle and larvae of bee.

### Diet composition during the Breeding season

A total of 14 fruiting tree species were recorded during the breeding season diet of RNH, which was comprised of twelve genera under seven families such as Meliaceae, Moraceae, Lauraceae, Flacourtiaceae, Burseraceae, Rosaceae and Manoliaceae (Appendix 2; Table 3).

**Table 3: The number of fruit food consumed by the RNH during the breeding season.**

| Si. No. | Family         | Number of tree species |
|---------|----------------|------------------------|
| 1       | Burseraceae    | 1                      |
| 2       | Flacourtiaceae | 1                      |
| 3       | Lauraceae      | 5                      |
| 4       | Manoliaceae    | 1                      |
| 5       | Meliaceae      | 1                      |
| 6       | Moraceae       | 4                      |
| 7       | Rosaceae       | 1                      |

The family Lauraceae represents the highest species that were consumed during the breeding season which shows the food preferences during breeding season. The species recorded under this family are *Beilschimidia grammiena*, *Cryptocarya amygdalina*, *Litsea sericea*, *Persea odoratissima*, and *Phoebe lanceolata*.

A male RNH was followed to locate the nesting tree. Two active nest trees were located from Gonphaii and Nabay villages respectively under Zhemgang district and the regurgitated fruits under the nest tree were collected for the identification.

A total of five fruit food species were recorded below nest tree such as *Aphanamixis polystachya*, *Beilschimidia grammiena*, *Canarium strictum*, *Ficus roxburghii* and *Eleocarpus lanceifolius*. Animal matter such as the remnant of crabs, beetles and the larva of bees were also recorded below the nesting tree (Figure 7; the food items collected from 20<sup>th</sup> to 30<sup>th</sup> June, 2016).



**Figure 7: Regurgitated invertebrate matter under the nesting tree species, (A) Beetle; (B) Crab, and (C) Larvae of the bee.**

The maximum number of food items delivered to the nest by a male to feed the female was the fruits of *Beilschimidia grammiena* in the nest located at Nabay village and the *Aphanamixis polystachya* from the nest located at Gonphaii village. It was observed that the male RNH carry the mixture of fruits items and feeds the female at the maximum of 5 times in a day and minimum of 4 times in a day while observing from 6h - 18h. The presence of any disturbances and the whether condition like presence of fog and rain were affected the scheduled feeding behavior and the arrival timing of male at RNH to the nest hole.

The recording of RNH diet of the breeding pair which falls under the nestig tree is the most quantitative way of describing hornbills diet, which allows detection of many more species, that could be missed from a reliance on only transect walks or fruits tree watches. However, it was very difficult to locate the nesting tree due to the hilly terrain and thick undergrowth of the study area. The difficulties were also faced while observing hornbills on fruiting tress as they are shy and fly away on detecting human presence.

#### **Diet composition during the Non-Breeding season**

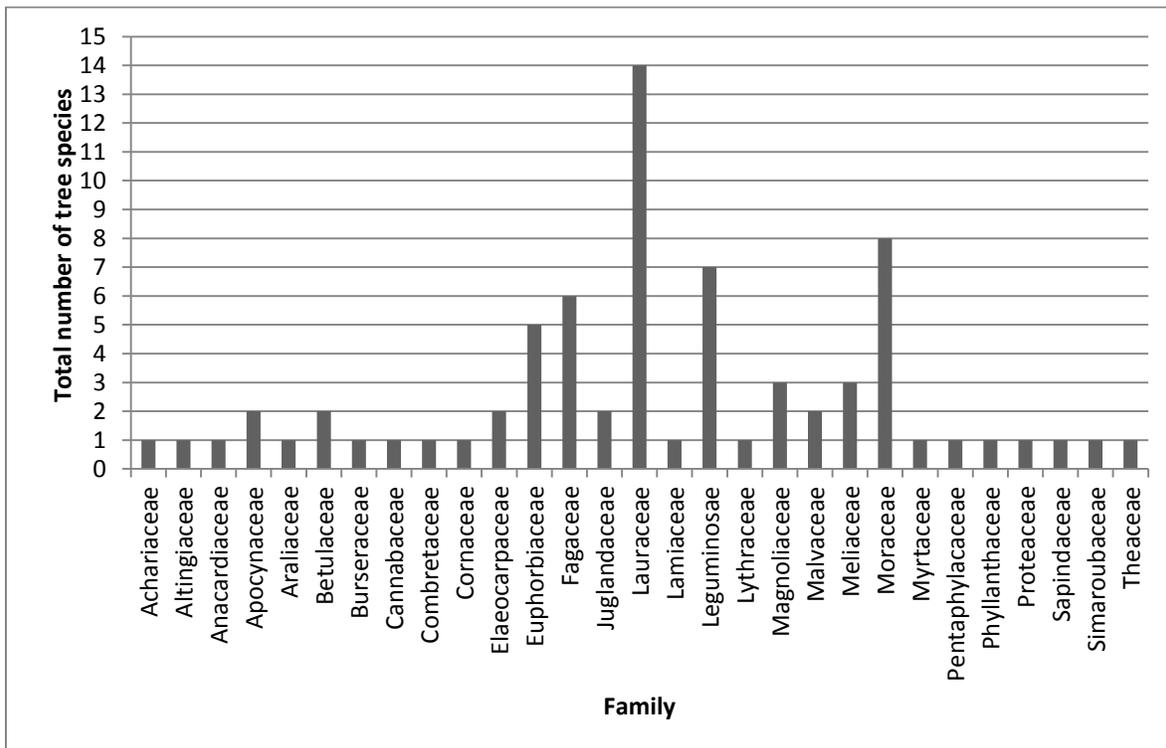
During the non-breeding season, the RNH were found consuming the fruits of up to 11 species of trees, comprising of seven genera under six families such as Cornaceae, Lauraceae, Anacardiaceae, Rhamnaceae, Elaeocarpaceae, and Moraceae. The highest number of tree species, whose fruits are consumed during this period was from the family Moraceae. The fruits species under this family were *Ficus hederacea*, *Ficus hirta*, *Ficus hispida* and *Ficus semicordata*. Some caterpillars was also consumed during this period (Appendix 2; Table 4).

**Table 4: The number of fruit bearing families consumed by the RNH during the non-breeding season in JSWNP, Bhutan.**

| <b>Si. No.</b> | <b>Family</b>  | <b>Number of tree species</b> |
|----------------|----------------|-------------------------------|
| 1              | Anacardiaceae  | 2                             |
| 2              | Cornaceae      | 1                             |
| 3              | Elaeocarpaceae | 1                             |
| 4              | Lauraceae      | 2                             |
| 5              | Moraceae       | 4                             |
| 6              | Rhamnaceae     | 1                             |

### Vegetation composition of RNH habitat

The Rufous-necked hornbill in JSWNP was seen occurring in Warm Broadleaf forest, which consists of various tree species. A total of 73 tree species were identified from the entire study sites of RNH habitat belonging to 29 families. The Lauraceae family comprised the highest tree species (14 nos.) compared to all other families (Figure 8; Appendix 3 & 4). The density of fruits and trees are not yet analyzed because the plant species are still under process of identification.



**Figure 8: Total tree species under each family in JSWNP, Bhutan**

### Status and characteristics of nesting hole trees

In breeding season of 2016, a total of 2 active nest hole trees were located in the park. Both the nest hole trees were occupied on large size trees and the cavities were located on the trunk of the tree. The nesting hole located on *Engelhardia spicata* in Gonphaii village was just 4 m above the ground level. Therefore, dimensions of nest holes were taken during the non-breeding season when it was not occupied as it was easy to reach (Table 6). The plots were laid surrounding the nest tree to find the density of nesting tree species in the locality. The density of *Engelhardia*

*spicata* at Gonphaii village was 0.05 trees/ha and the density of second nesting tree *Altingia excelsa* at Nabay village was 0.3 trees/ha.

**Table 8: Nest site characteristics of RNH**

| Si No. | Parameters                                     | Gonphaii village           | Nabay village          |
|--------|--|----------------------------|------------------------|
| 1      | Nesting tree species                           | <i>Engelhardia spicata</i> | <i>Altingia excels</i> |
| 2      | Tree density (per ha) (trees $\geq$ 10 cm GBH. | 0.05                       | 0.3                    |
| 3      | Nesting tree height                            | 23                         | 33                     |
| 4      | Nesting tree GBH (cm)                          | 108                        | 109                    |
| 5      | Height of cavity from ground level             | 4                          | 21                     |
| 6      | Girth at tree (cm)                             | 98                         | -                      |
| 7      | Nest opening orientation                       | NW                         | NW                     |
| 8      | Cavity length (cm)                             | 45                         | -                      |
| 9      | Cavity width                                   | 36                         | -                      |
| 10     | Cavity depth                                   | 42                         | -                      |
| 10     | Altitude(m)                                    | 1549                       | 924                    |



**Figure 9: Location of nesting site of RNH in Zhemgang district**



**Figure 10: (A) The nest hole tree at Gonphaii Village; (B) The nest tree hole at Nabay village**

## Conservation threats

The RNH in most of the countries are hunted for meat, feathers and beak (Vidhidharm *et al.*, 1995). In Bhutan, hunting is very rare as per the survey done within the entire study period. The threats that were seen in the RNH habitat in JSWNP were agriculture, logging, firewood collection, grazing, and extension of land for building houses. However, Datta (2009) commented that the forest loss has a lesser threat for this species, because the condition and extent of forests at higher elevations are relatively better than in the foothills.

Over a recent years, a high power transmission line has been erected (fig) has brought an immense change in the RNH habitat. Many trees were cut for the construction of route to carry the materials for building the transmission tower. There is a probability that the nest and fruit trees being felled and the population decreased compared to previous year. Besides, the transmission wires affect the flight path of hornbills. However, there is no previous data on the status of hornbill in JSWNP for comparison.



**Figure 11: The transmission lines in the habitat of Rufous-necked Hornbill in JSWNP, Bhutan**

One other potential threats hornbill in the study area is the grazing. During the summer, almost all cattle from the central part of Bhutan are migrated to the JSWNP for fodder and grazing. Many important hornbill tree species are lopped and grazed and hamper the growth and regeneration. So it is important to carry out studies on the threats to hornbill habitats for longterm conservation in Bhutan.

## Conclusion

The present study was designed to understand the feeding habit of RNH, with special reference to consumption of food resources during breeding and non-breeding season. The habitat characteristics and the potential threats on conservation of Rufous-necked Hornbill in the Jigme Singye Wangchuck National Park of Bhutan are highlighted.

The study was carried out for the two seasons. The field work was carried out from middle of June to middle of July (summer) during the second term semester break and the second field survey was carried out from the middle of September to the middle of October during the time of divisional attachment period. During the first term data collection, female RNH was seen sealed in the nest, which showed an active breeding season and the second term data collection was during the non-breeding season.

A lot of difficulties were faced during the data collection due to hilly geographical terrain and thick undergrowth in the park. Clear visibility of RNH was very difficult due to thick vegetation cover.

The difficulties were also faced while observing hornbill's behaviour because they were shy and often flew away due to observer presence. Locating the active nesting site was less chance because while following the male RNH during the breeding season, we always lost our track of visibility due to thick forest. However, two active nests were located.

The study is proposed to continue in following two seasons, i.e. winter and spring of 2016-2017. During this time, new sites will be explored. The conservation awareness campaign will be launched amongst the rural people residing in proximity of RNH habitat in JSWNP. I hope that this study would help in better understanding of the ecology, behavior and habitat use of RNH and lead to its long term conservation in foothills of Bhutan.

## Appendices

### Appendix 1: Frequency of flock size composition of RNH seen during breeding and non-breeding season in Jigme Singye Wangchuck National Park, Bhutan.

| Flock size classes | Frequency (f) of sighting |                     |
|--------------------|---------------------------|---------------------|
|                    | Breeding season           | Non-breeding season |
| 1                  | 22                        | 19                  |
| 2                  | 2                         | 15                  |
| 3                  | 0                         | 4                   |
| 4                  | 0                         | 4                   |
| 5                  | 0                         | 1                   |

### Appendix 2: Fruit bearing tree species consumed by RNH in Jigme Singye Wangchuck National Park, Bhutan.

| Si. No. | Plant species                  | Famiy     | Season                  |
|---------|--------------------------------|-----------|-------------------------|
| 1       | <i>Aphanamixis polystachya</i> | Meliaceae | Breeding                |
| 2       | <i>Arthocarpus lakoocha</i>    | Moraceae  | Breeding                |
| 3       | <i>Alangium chinense</i>       | Cornaceae | Non-breeding            |
| 4       | <i>Beilschimidia assamica</i>  | Lauraceae | Non-breeding            |
| 5       | <i>Beilschimidia grammiena</i> | Lauraceae | Breeding & Non0breeding |

|    |                                 |                |                         |
|----|---------------------------------|----------------|-------------------------|
| 6  | <i>Casearia glomerata</i>       | Flacourtiaceae | Breeding                |
| 7  | <i>Canarium strictum</i>        | Burseraceae    | Breeding                |
| 8  | <i>Choerospondias axillaris</i> | Anacardiaceae  | Non-breeding            |
| 9  | <i>Cryptocarya amygdalina</i>   | Lauraceae      | Breeding                |
| 10 | <i>Eleocarpus lanceifolius</i>  | Elaeocarpaceae | Non-breeding            |
| 11 | <i>Ficus hederacea</i>          | Moraceae       | Non-breeding            |
| 12 | <i>Ficus benjamina</i>          | Moraceae       | Breeding                |
| 13 | <i>Ficus hirta</i>              | Moraceae       | Non-breeding            |
| 14 | <i>Ficus hispida</i>            | Moraceae       | Non-breeding            |
| 15 | <i>Ficus roxburghii</i>         | Moraceae       | Breeding                |
| 16 | <i>Ficus semicordata</i>        | Moraceae       | Breeding & non-breeding |
| 17 | <i>Hovenia acerba</i>           | Rhamnaceae     | Non-breeding            |
| 18 | <i>Litsea sericea</i>           | Lauraceae      | Breeding                |
| 19 | <i>Mangifera sylvatica</i>      | Anacardiaceae  | Non-breeding            |
| 20 | <i>Persea odoratissima</i>      | Lauraceae      | Breeding                |
| 21 | <i>Phoebe lanceolata</i>        | Lauraceae      | Breeding                |
| 22 | <i>Prunus cornuta</i>           | Rosaceae       | Breeding                |
| 23 | <i>Taluama hodgsonii</i>        | Magnoliaceae   | Breeding                |

**Appendix 3: List of identified tree species sampled in RNH habitat in Jigme Singye Wangchuck National Park, Bhuta**

| <b>Sl. No</b> | <b>Tree species</b>               | <b>Family</b>   |
|---------------|-----------------------------------|-----------------|
| 1             | <i>Acrocarpus fraxinifolius</i>   | Leguminosae     |
| 2             | <i>Aesculus assamica</i>          | Sapindaceae     |
| 3             | <i>Aglaia lawii</i>               | Meliaceae       |
| 4             | <i>Ailanthus integrifolia</i>     | Simaroubaceae   |
| 5             | <i>Alangium chinense</i>          | Cornaceae       |
| 6             | <i>Albizia chinensis</i>          | Leguminosae     |
| 7             | <i>Albizia gamblei</i>            | Leguminosae     |
| 8             | <i>Albizia lebbeck</i>            | Leguminosae     |
| 9             | <i>Alnus nepalensis</i>           | Betulaceae      |
| 10            | <i>Alstonia scholaris</i>         | Apocynaceae     |
| 11            | <i>Altingia excelsa</i>           | Altingiaceae    |
| 12            | <i>Aphanamixis polystachya</i>    | Meliaceae       |
| 13            | <i>Bauhinia purpurea</i>          | Leguminosae     |
| 14            | <i>Beilschmiedia gammeieana</i>   | Lauraceae       |
| 15            | <i>Beilschmiedia assamica</i>     | Lauraceae       |
| 16            | <i>Betula alnoides</i>            | Betulaceae      |
| 17            | <i>Bischofia javanica</i>         | Phyllanthaceae  |
| 18            | <i>Bombax ceiba</i>               | Malvaceae       |
| 19            | <i>Callicarpa arborea</i>         | Lamiaceae       |
| 20            | <i>Canarium strictum</i>          | Burseraceae     |
| 21            | <i>Casearia glomerata</i>         | Salicaceae      |
| 22            | <i>Castanopsis hystrix</i>        | Fagaceae        |
| 23            | <i>Castanopsis tribuloides</i>    | Fagaceae        |
| 24            | <i>Celtis tetrandra</i>           | Cannabaceae     |
| 25            | <i>Choerospondias axillaris</i>   | Anacardiaceae   |
| 26            | <i>Cinnamomum bejolghota</i>      | Lauraceae       |
| 27            | <i>Cinnamomum impressinervium</i> | Lauraceae       |
| 28            | <i>Duabanga grandiflora</i>       | Lythraceae      |
| 29            | <i>Elaeocarpus lanceofolius</i>   | Elaeocarpaceae  |
| 30            | <i>Engelhardie spicata</i>        | Juglandaceae    |
| 31            | <i>Erythrina arborescens</i>      | Leguminosae     |
| 32            | <i>Eurya acuminata</i>            | Pentaphragaceae |
| 33            | <i>Ficus benjamina</i>            | Moraceae        |
| 34            | <i>Ficus elastica</i>             | Moraceae        |
| 35            | <i>Ficus hispida</i>              | Moraceae        |
| 36            | <i>Gynocardia odorata</i>         | Achariaceae     |
| 37            | <i>Helicia nilagrica</i>          | Proteaceae      |
| 38            | <i>Hovienia acerba</i>            | Rhamnaceae      |

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|----|--------------------------------|---------------|
| 39 | <i>Juglans regia</i>           | Juglandaceae  |
| 40 | <i>Kydia calycina</i>          | Malvaceae     |
| 41 | <i>Lithocarpus elegens</i>     | Fagaceae      |
| 42 | <i>Lithocarpus fenestratus</i> | Fagaceae      |
| 43 | <i>Lithocarpus listeri</i>     | Fagaceae      |
| 44 | <i>Litsea cubeba</i>           | Lauraceae     |
| 45 | <i>Litsea glutinosa</i>        | Lauraceae     |
| 46 | <i>Litsea sericea</i>          | Lauraceae     |
| 47 | <i>Macaranga denticulata</i>   | Euphorbiaceae |
| 48 | <i>Macaranga peltata</i>       | Euphorbiaceae |
| 49 | <i>Mallotus nepalensis</i>     | Euphorbiaceae |
| 50 | <i>Mangifera sylvatica</i>     | Anacardiaceae |
| 51 | <i>Michelia champaca</i>       | Magnoliaceae  |
| 52 | <i>Michelia doltsopa</i>       | Magnoliaceae  |
| 53 | <i>Morus australis</i>         | Moraceae      |
| 54 | <i>Morus laevigata</i>         | Moraceae      |
| 55 | <i>Morus macroura</i>          | Moraceae      |
| 56 | <i>Neocinnamomum caudatum</i>  | Lauraceae     |
| 57 | <i>Ostodes paniculata</i>      | Euphorbiaceae |
| 58 | <i>Peltophorum pterocarpum</i> | Leguminosae.  |
| 59 | <i>Persea duthiei</i>          | Lauraceae     |
| 60 | <i>Persea charkeana</i>        | Lauraceae     |
| 61 | <i>Persea fructifera</i>       | Lauraceae     |
| 62 | <i>Phoebe attenuata</i>        | Lauraceae     |
| 63 | <i>Phoebe lanceolata</i>       | Lauraceae     |
| 64 | <i>Phoebe sp.</i>              | Lauraceae     |
| 65 | <i>Quercus acutissima</i>      | Fagaceae      |
| 66 | <i>Sapium insigne</i>          | Euphorbiaceae |
| 67 | <i>Schefflera tenuis</i>       | Araliaceae    |
| 68 | <i>Schima wallichii</i>        | Theaceae      |
| 69 | <i>Syzygium cumuni</i>         | Myrtaceae     |
| 70 | <i>Talauma hodgsonii</i>       | Magnoliaceae  |
| 71 | <i>Terminalia myriocarpa</i>   | Combretaceae  |
| 72 | <i>Toona ciliata</i>           | Meliaceae     |
| 73 | <i>Wrightia religiosa</i>      | Apocynaceae   |

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**Appendix 4: Total number of tree species under each family in Jigme Singye Wangchuck National Park, Bhutan.**

| <b>Si. No.</b> | <b>Family</b>           | <b>Number of tree species</b> |
|----------------|-------------------------|-------------------------------|
| 1              | <i>Achariaceae</i>      | 1                             |
| 2              | <i>Altingiaceae</i>     | 1                             |
| 3              | <i>Anacardiaceae</i>    | 1                             |
| 4              | <i>Apocynaceae</i>      | 2                             |
| 5              | <i>Araliaceae</i>       | 1                             |
| 6              | <i>Betulaceae</i>       | 2                             |
| 7              | <i>Burseraceae</i>      | 1                             |
| 8              | <i>Cannabaceae</i>      | 1                             |
| 9              | <i>Combretaceae</i>     | 1                             |
| 10             | <i>Cornaceae</i>        | 1                             |
| 11             | <i>Elaeocarpaceae</i>   | 2                             |
| 12             | <i>Euphorbiaceae</i>    | 5                             |
| 13             | <i>Fagaceae</i>         | 6                             |
| 14             | <i>Juglandaceae</i>     | 2                             |
| 15             | <i>Lauraceae</i>        | 14                            |
| 16             | <i>Lamiaceae</i>        | 1                             |
| 17             | <i>Leguminosae</i>      | 7                             |
| 18             | <i>Lythraceae</i>       | 1                             |
| 19             | <i>Magnoliaceae</i>     | 3                             |
| 20             | <i>Malvaceae</i>        | 2                             |
| 21             | <i>Meliaceae</i>        | 3                             |
| 22             | <i>Moraceae</i>         | 8                             |
| 23             | <i>Myrtaceae</i>        | 1                             |
| 24             | <i>Pentaphylacaceae</i> | 1                             |
| 25             | <i>Phyllanthaceae</i>   | 1                             |
| 26             | <i>Proteaceae</i>       | 1                             |
| 27             | <i>Sapindaceae</i>      | 1                             |
| 28             | <i>Simaroubaceae</i>    | 1                             |
| 29             | <i>Theaceae</i>         | 1                             |

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