NESTING ECOLOGY and DIET SOURCES OF RUFOUS-NECKED HORNBILL
(*Aceros nipalensis*)

East and South-east buffer zone of Phrumsengla National Park (Lhuentse & Mongar) with intensive study at Tsanzabi, Saling geog in Mongar

CLP Project ID: *03158213*

HORNBILLS: Connecting Environment, Economy and Culture in Bhutan

Rinchen Wangchuk, Dr.Sherub, Dr.Nawang Norbu
Ugyen Wangchuck Institute for Conservation and Environmental Research
Lamai Goempa, Bumthang

With funding support from Conservation Leadership Programme, USA

Prepared by:

Rinchen Wangchuk, Ugyen Wangchuck Institute for Conservation and Environmental Research
Dr.Sherub, Ugyen Wangchuck Institute for Conservation and Environmental Research
Dr.Nawang Norbu, School for Field Studies
Dr.Davide Dominoni, Max Planx Institute of Ornithology, Glassgaw, UK (Team member)

Field work supported by:

Kinley Choden, Ugyen Wangchuck Institute for Conservation and Environmental Research
Ugyen Tenzin, Ugyen Wangchuck Institute for Conservation and Environmental Research
Tshethup Tshering, Ugyen Wangchuck Institute for Conservation and Environmental Research
Rinchen Drakpa, Ugyen Wangchuck Institute for Conservation and Environmental Research
Rinchen Singye, Ugyen Wangchuck Institute for Conservation and Environmental Research
Pema Khandu, In-Charge, Park Sub-Range Office, Tsamang, CPRO, PNP
Wangda Jatsho, Central Range, Linemthang, CPRO, PNP,
Sangayla, Park Sub-Range Office, Zangkhar, EPRO, PNP

Field Guides:

Ap Tegpo, Tsanzabi village
Ap Sither Thinley, Saling village
Ap Leki Tshering, Broksar village
Ap Sangpo, Thridingbi village

Citation:

Ugyen Wangchuck Institute for Conservation and Environmental Research, 2017. *Report on* HORNBILLS: Connecting Environment, Economy and Culture in Bhutan *(Case study on Nesting Ecology and Diet Sources of Rufous-necked hornbill in the east and south-east buffer zone of Phrumsengla National Park under Lhuentse and Mongar),* Department of Forests and Park Services, Ministry of Agriculture and Forests. Royal Government of Bhutan. Lamai Goempa: Bumthang.

Executive Summary

The Hornbill project on trying to assess the connectivity of the ecological services of the vulnerable Rufous-necked hornbill with the possibility of economic gains for the local communities and preservation of the believed local cultures was implemented over a period of more than one year. The project was proposed and funded through Conservation Leadership Programme grants since the year 2013. The project period was deferred to one year beyond due to some logistics and suitable time not coinciding with the hornbill breeding specially to study the movement ecology through tagging.

The Rufous-necked hornbill (RNH) being one of the vulnerable species found only in South Asia amongst the other three species found in Bhutan suffered the drastic population decline due to habitat degradation and fragmentation. On the other hand, the species showed some shift in its viable habitat towards the higher elevation during the 21st century. Bhutan being one of the safe refuges for the hornbill species proposed to start studies on its habitat use, movement ecology and diet during the last few years.

The current habitat sites are found to be encroached with developmental activities like road construction, power transmission line installation, forest timber logging leading towards less food and space for the hornbills. However, the study revealed that RNH breeds almost 80% successfully within the matured broadleaved natural forest under Saling geog but infested with developmental activities destroying the natural habitat sites. The local people residing in and around the hornbill habitat areas truly believe Hornbills as majestic birds that doesn't destroy agriculture crops or attack livestock. So, it is protected with various cultural believes and therefore retains marked house construction trees for the hornbill nesting as it has used for yearly nesting. Hornbills also play a vital role in the lives of the local people as they depend on variety of forest fruits and eats so many insects that infest their cereal crops that contributes in maintaining the forest health through seed dispersing actions. Series of competitions and eco- guided walk related to hornbill conservation carried out in three community primary schools falling within the hornbill habitat range benefited to some extent especially the participating students.

Assisting the communities in developing eco-tourism services like eco-trails and homestays in the hornbill habitat areas and attract birding tourists and many others soon could be a "win win" situation for the livelihoods of the local people. The hornbill breeding, phenology of the fruit trees, movement ecology needs to be studied further for better understanding of the RN hornbill providing a harmonious coexistence with the communities in the long run.

Table of Contents

Part 1. Introduction

Hornbills are the most conspicuous birds dwelling the warm broadleaved and old world tropical forests. Their large horn like beaks and audible call makes researchers easy to identify and survey (Chimchome *et al*. 1993; Kinnaird and O'Brien, 2007; and Poonswad 2012).

Rufous-necked Hornbill – RNH (*Aceros nipalensis* – Hodgson, 1829) is recognized as an omnivorous and monogamous by its feeding and breeding characteristic among the 32-hornbill species found in the South Asian region out of 54 species recorded worldwide under the Bucerotidae family as per Poonswad and friends (2013) and Jinamoy *et al*, (2013). Rufous-necked hornbill is native to and currently found in Bhutan, China, India, Laos, Myanmar, Thailand and Vietnam (IUCN, 2012 and Jinamoy *et al*, 2013) (Figure 1). Bhutan provides a safe home for four hornbill species in its sub-tropical evergreen forests along the southern belts and few parts in the highest northern forest areas like in Gasa, Lhuentse and Tashi Yangtse districts (Figure 1). Among the 10 declared Protected areas (PAs) Phrumsengla Natioanal Park is one of the safe homes for the two sympatric hornbill species such as the Great (*Buceros bicornis*) and Rufous-necked hornbill inhabiting along the southern and eastern belt of the park area reaching as high as 2300 m above sea level in the cool broad-leaved forest.

Hornbills are regarded as one of the key components of ecosystem resilience brought through natural forest restocking being fruit eaters, seed dispersal agents and predators for forest insect pests as Kinnaird and O'Brien rightly referred Hornbills as "Farmers of the Forest" for their ecological services in the community wherever they dwell. So, Hornbills like the Rufous-necked plays an important role for the sustainability of the broadleaved forest (Poonswad, 2012).

Rufous-necked Hornbill is assessed as Vulnerable species due to drastic decline in its population purely due to habitat destruction as per the Threatened Species Red list of International Union for Conservation of Nature and natural resources (IUCN, 2012) and listed under Appendices I & II of Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). In Bhutan, Rufous-necked hornbill is considered as endangered species and protected under the Forest and Nature Conservation Act (FNCA, 1995) and Forest and Nature Conservation Rules and regulations (FNCRR, 2017) listed as a totally protected species under Schedule I with heavy fines and penalties for defaulters.

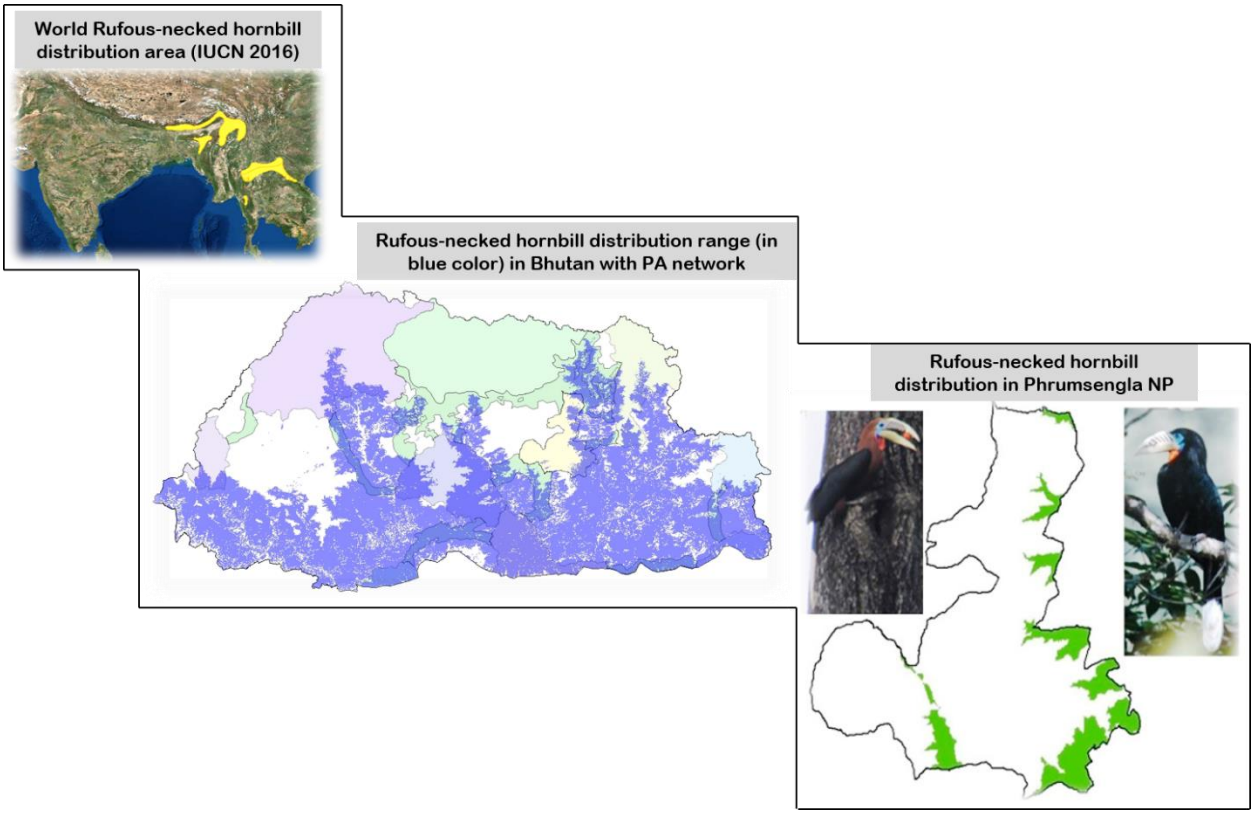


Figure 1. Distribution of Rufous-necked hornbill around the world, in Bhutan and vicinity of Phrumsengla National Park

RNH is believed to be regionally extinct in Nepal as of 1846 and locally extinct in the northern parts of Thailand due to habitat loss, habitat fragmentation and hunting (SHRESTHA, (1993) in Poonswad: Editor, (1998) and Jinamoy *et al*. (2013)).

The project funded by Conservation Leadership Programme (CLP) was proposed and implemented to achieve the following objectives that can contribute towards the viable conservation of Rufous-necked hornbill in the long run.

1. To understand the habitat preference and nesting characteristics of RNH in PNP and its bufferzone area.
2. To study the nesting and the breeding success of the RNH breeding
3. Inventory of the diet composition and food sources prefred by RNH
4. Determine the feeding behaviours of the male RNH during the breeding season.

Part 2. Materials and Methods

2.1 Study Area

Hornbills are mostly seen breeding and transiting in the extreme southern and eastern part of PNP within the warm broad-leaved and sub-tropcial forest areas. The areas fall under Mongar and Lhuentse districts with more developmental works advancing like road construction and power transmission lines. In the areas under Mongar logging under the adminstration of Lingmethang Forest Management Unit (LFMU) of Mongar Forest Division (MFD) office was started a decade ago extracting broadleaved timber and still going deeper into the Mongar Kheng an area of undisturbed vegetation. The area is further connected with the Biological corridor connecting PNP and Royal Manas National Park (RMNP) in the broadleaf forest. The hornbill present areas has an increasing number of human population where people depend on livestock rearing and agriculture farming growing crops like maize (staple crop) and paddy with some off-farm activities to sustain livelihhod. Number of active Rufous-necked and Great hornbill nest are found more in these area suitable for hornbill studies.

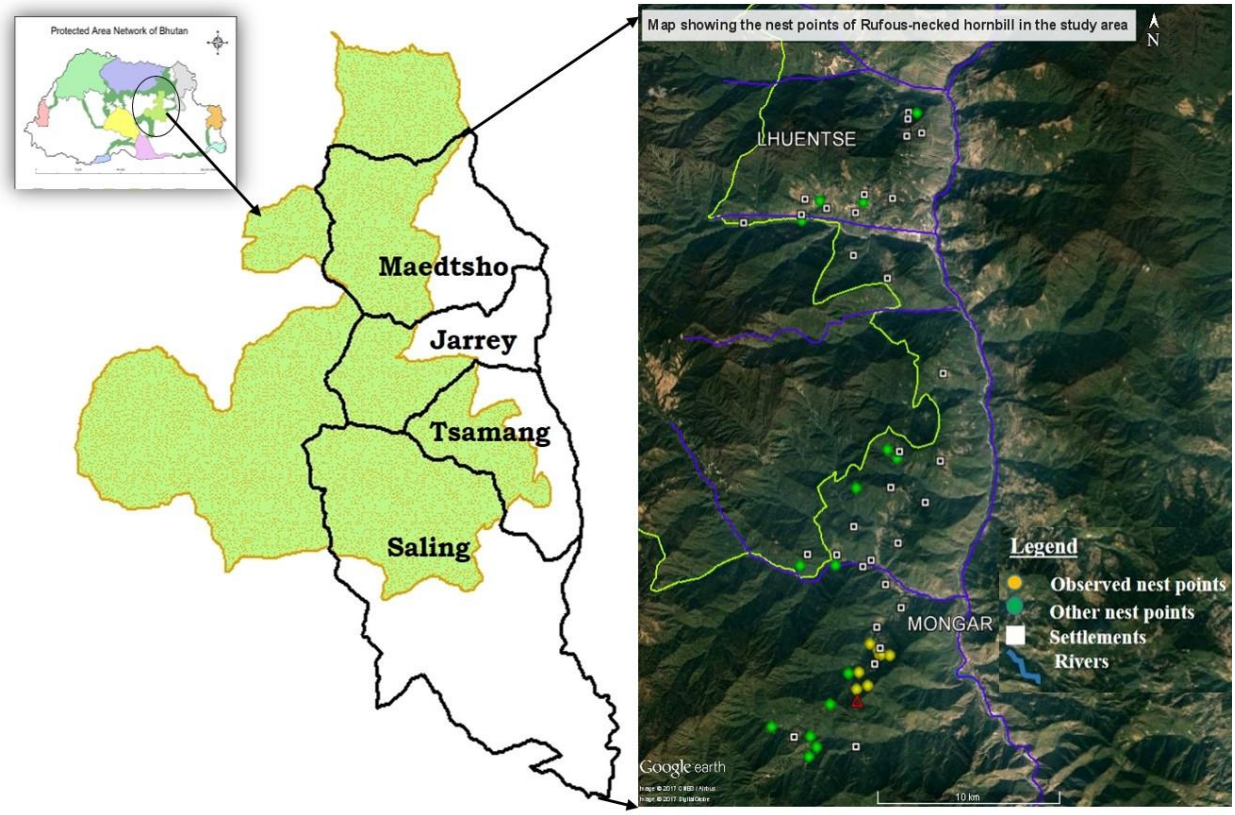


Figure 2. Maps showing the study sites of Rufous-necked hornbill

2.2 The field work process

The hornbill nest verification and identification was carried out in all four sub-district areas. Site visit to the nest locations were based on the local information and confirm the use of the nest holes inspecting around and observing the feeding visit of the male hornbills during the onset of the breeding season. The detail information on the habitat variables such as altitude, aspect, slope gradient, forest types, species composition, Global Positioning System (GPS) coordinates, etc. on nest site location were recorded for habitat preference assessment. In addition information on the actual nest host tree, nest hole aspects, shapes of nest hole, tree height, diameter at breast height (dbh) and tree species were recorded. The field information was collected using Garmin eTrex 20, diameter tape and Sunto compass.

The active confirmed nests were monitored for collecting information on feeding by male hornbills. The regurgitated seeds and other dropped food items were collected in colletion trays made of green color cloth pieces installed at the base of the nest trees. Feeding observation and regurgitated seed collection was done twice a week at the breeding confirmed nest locations using datasheets. The collected regurgitated materials were dried and stored in perforated plastic containers. Accordingly the details of the seeds were enumerated for assessing the type, quantity and quality of food sources and requirement of the diets at different stages during the nesting time.

Part 3. Results

3.1 Ecology of Rufous-necked hornbill

3.1.1 Habitat preference

Rufous-necked hornbills in the study are mostly found breeding in the sub-tropical, warm-broadleaved and cool broadleaved forests (600 - 1000 masl) having an annual rainfall amount of 1000-1500 mm. Hornbill flocks are observed within the cool-broadleaved forest (<2600 masl) and dry Chirpine forests (1000 -1800 masl) during the pre and post breeding season for foraging with the newly fledged young ones. The field information was gathered before and during the breeding season period which starts by end of March or beginning of April month and lasted till end of July which sometimes carries over till mid of August. Nestings were found inside matured tree holes located besides footrails and unpaved roads, grazing camps with more than 50 percent located nearby a water source indicating a necessity of water for the life of a hornbill.

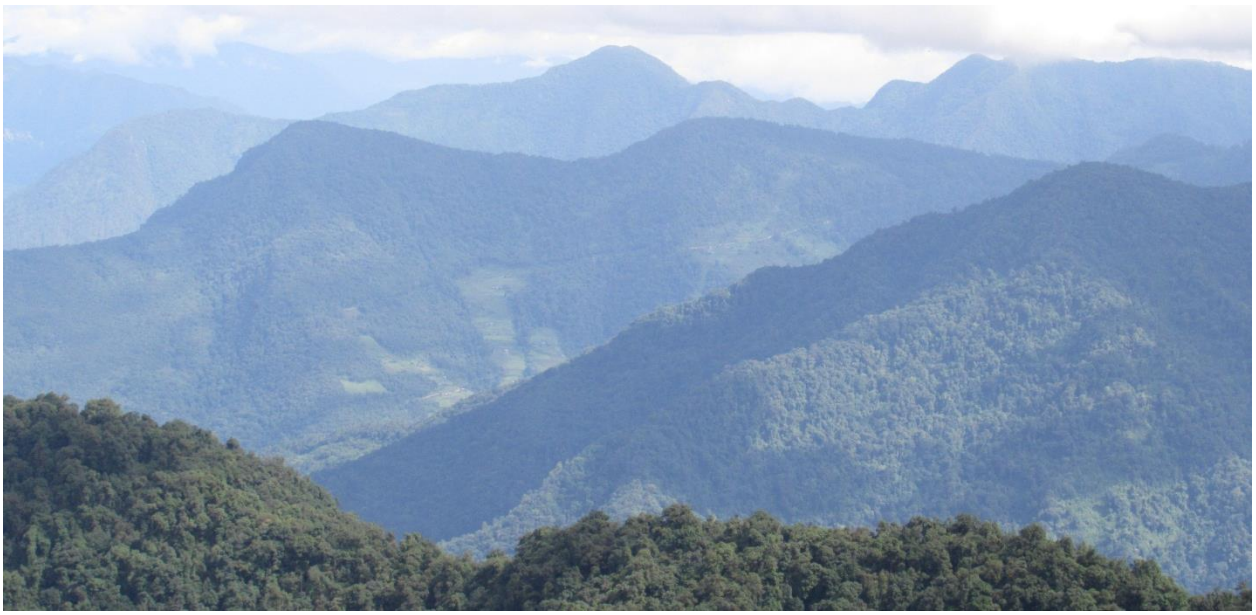


Figure 3. Rufous-necked hornbill habitat areas under Mongar district area

3.1.1.1 Altitude, Slope, Aspect of the Rufous-necked hornbill habitat

Most of the nesting sites were found between an altitude range of 1035 - 1881 masl with an average of 1527 masl in the study area. Among the four hornbill species found in Bhutan Rufous-necked is sighted at the highest elevation record of 2294 masl in the study area used as foraging site locally called as "*Sising prey"* dominated with *Quercus, Michelia, Persea, Ilex,*

Rhododendron etc. species in *Ungar* under *Maedtsho* geog (sub-district) of *Lhuentse* district. The gradient of the nesting sites had mostly gradual slope that ranged from 5-60 percent facing north and east with 41% (n=17) frequently facing towards north east.

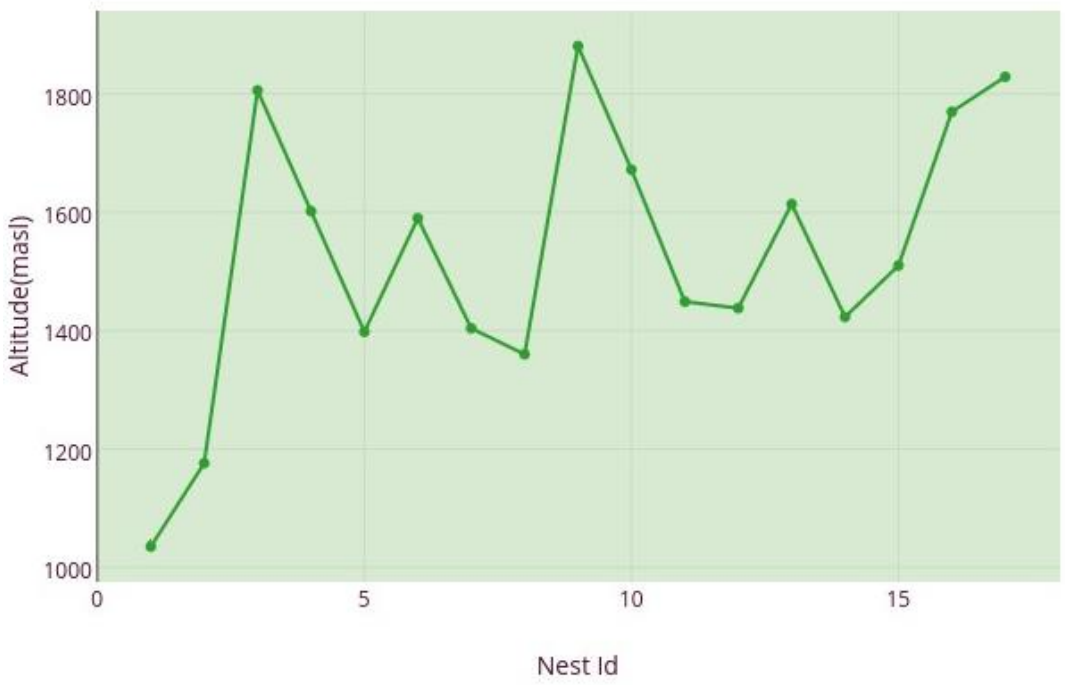


Figure 4. Elevation of RNH nest sites from the entire study area

3.1.2 Nest site and nesting characteristics

The nest observation was done during the breeding and non-breeding season in the study area. Nesting cavities looks like holes created by other associatiate species like birds (woodpeckers) or cavities created due to fungal rotting or insect attacks on the tree trunk. The nest openings that are orbicular and oval in shape are found mostly facing north, east or west directions in the study area and we didn't come across even a single hornbill nest facing south in our study.

Figure 5. Picture displaying various shapes of nest cavity entrances with number of grooves indicating hornbill age.

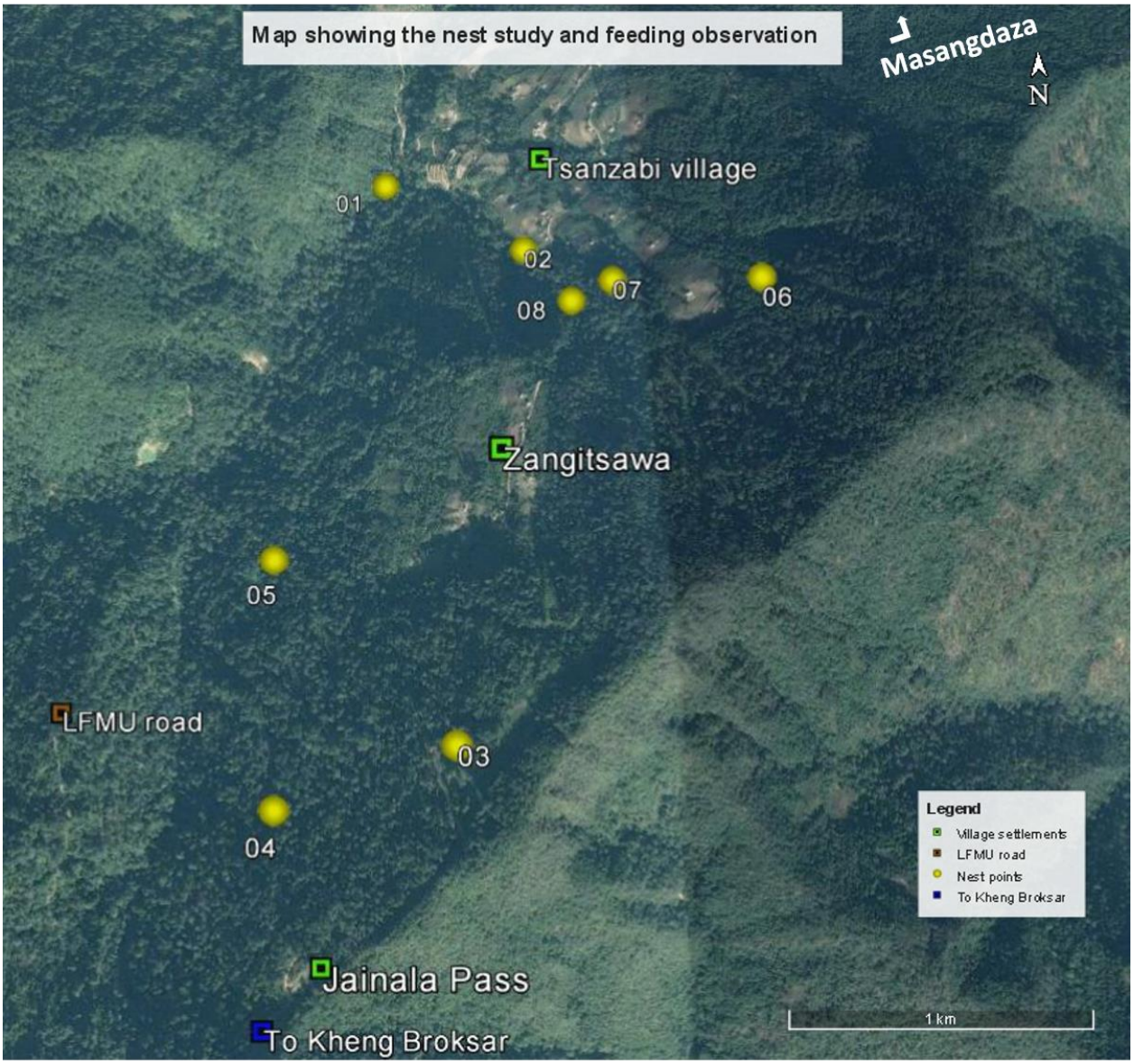
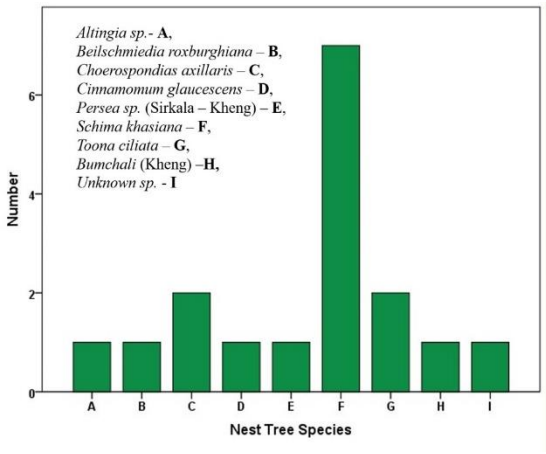


Figure 6. Map showing the nesting and feeding observation sites

3.1.2.1 Nest tree and its characteristics

The predominant trees used by Rufous-necked hornbill for nesting are mostly *Schima khasiana* a hardwood and tall broadleaved tree species classified under Theaceae family which accounts for 41.18% (n=7) of the 17 nesting trees (Table 1). The other common tree species used for nesting was *Toona cilliata* a good timber tree. The height of the nest trees ranged from 9 – 30 meters from which the nest height were found between 7 – 22 meters high from the ground level. The diameter at breast height (dbh) of the nesting trees measured higher (an average of 100.59 cm

with arnage of 25-211 cm) than the tree height which indicates hornbills prefere large sized trees for nesting.



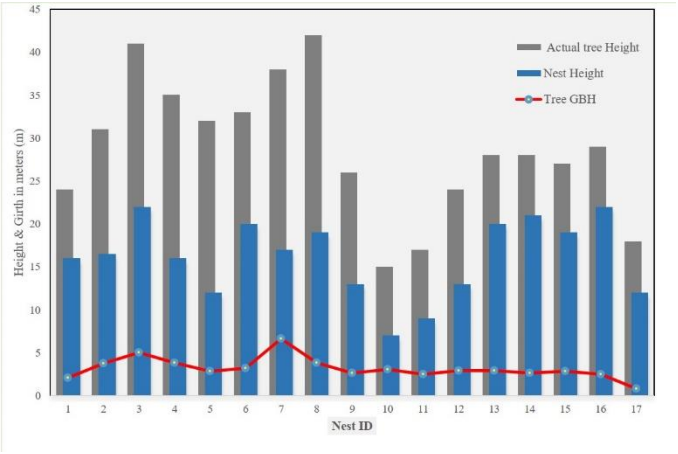


Figure 7. Tree species used for nesting by RNH

Actual tree Height and nest height with Girth (GBH)

3.1.2.2 Nesting successs

The Rufous-necked hornbill in the study area is found to be one of the widely adapted hornbill species that breeds annually in both sub-tropical and temperate forest. In regards to the breeding observation it accounts to the narrowed down study area covering eight verified active nest sites confined within the warm broadleaved forest located nearby the settlement areas under Saling in Mongar. Two nestings were unsuccessful being abandoned and disturbed by flash flooding respectively located along side of a foot trail and a steep stream inside the forest that was alive for about 30 days since the sealing of the female hornbill inside the nest cavity.

3.1.2.3 Courtship and nest site selection

Pairs of Rufous-necked hornbills are observed displaying their courtship rituals in and around the nesting habitat that commences by February and March coinciding the first and second Bhutanese lunar month (Personcom. Tegpo (45) from Tsanzabi under Saling and Thinley (39) from Tsamang under Tsamang block in Mongar and Samten (71), from Yabee village in Lhuentse) in the study area. Hornbills are also found in many numbers during this time. Most of the hornbill pairs are said to be observed nearby the past used nest trees and females are sometimes seen inside the nest throwing the unwanted materials out of the hole which indicates cleaning the cavity that will be used for a successful nesting.

Table 1. Nest tree characteristics

Nest ID	Locality	Host tree species	Tree DBH (cm)	Tree GBH (cm)	Tree Height (m)	Nest Height (m)	Altitude (m)
1	Shongjagang	*Choerospondia axillaris*	65	204	24	16	1035
2	Namling	*Altingia sp.*	120	377	31	16.5	1176
3	Gulibee	*Schima khasiana*	159	499	48	22	1806
4	Chatong nyelsa	*Schima khasiana*	122	383	35	16	1602
5	Klunmachi	*Cinamomum glauscense*	90	283	32	12	1398
6	Jachugongma	*Schima khasiana*	102	320	33	20	1590
7	Paimala	*Schima khasiana*	211	663	38	17	1404
8	Namlingyungma	*Schima khasiana*	121	380	42	19	1360
9	Mongleng	*Persea sp.*	83	261	26	13	1881
10	Ligsarbi	*Schima khasiana*	97	305	15	7	1672
11	Meralung	Unknown broad leaf tree sp.	78	245	17	9	1449
12	Manzela	*Choerospondia axillaris*	93	292	24	13	1438
13	Tsoipong	*Toona cilliata*	92	289	28	20	1614
14	Gangsengmai-nang	*Toona cilliata*	84	264	28	21	1423
15	Luchuidhur	Unknown sp. (*Bumchali*)	90	283	27	19	1510
16	Chudhigang	*Schima khasiana*	78	245	29	22	1770
17	Dochur, Yabee	*Beilschmiedia roxburghiana*	25	79	18	12	1829
		mean	100.59	3.16	29.12	16.15	1526.88
		s.d.	38.96	1.22	8.41	17.65	222.50
		range	25-211	0.8-6.63	15-48	7-22	1035-1881

3.1.2.4 Nest sealing

Right after the copulation and nest preparation the female hornbill seals herself inside the nest keeping just a narrow slit and rarely orbicular openings. The sealing starts within few days or a week after the courtship rituals. The sealing is done using local materials like *"Sakar"* (limestone soils), *"Bragtsi"*also called as *"Silajit"* in Hindi which means the black exudation extracts collected from the rocky cliffs which becomes sticky while boiled with water and filtered that is used by the herbal pharmaceuticals. As narrated by Mr.Sangay Wangchuk (38) from Tsanzabi village a local resident in the hornbill habitat resin exudations from Chirpine (*Pinus roxburghii*)

mixed with pine needle and Sakar were seen at the base of the nest tree during the nest preparation. In Lhuentse area people said that they have seen cow dungs were also used may be due to its plasticity property although we didn't have any pictorial evidences as of now (Personcom. with Mrs.Samten, 71). We could see mostly mud with plant root hairs in the plastering seal which we found last year at one of the successful nest site (Figure 8) in the intensive study area. The nesting successfully completes coinciding the month end of July and sometimes beginning of August (end of fifth or beginning of sixth Bhutanese lunar months) in the study area.

Figure 8. Nest plaster or seal dropped after the completing breeding

3.1.2.5 Breeding success

As Rufous-necked hornbill is one of the raptor like birds that make nest in the higher tree canopy with tall trees breeding successful should not be a question unless they face natural disturbances from flash flooding, windstrom, landslide, forest fire, etc. and also depends on the condition of the nest trees like we lost 3 RNH (1 mother with 2 male fledglings in Lhuentse area that died last year in July'2016 due to heavy windstorm) From observations in the study area 6 pairs could successfully complete their breeding adding about 16 individuals to the overall local population of the study area (includes the 2 pairs of unsuccessful couple and taking 2 fledglings on average from the successful nests).

Normally two chicks fledge out from every successful nests during a successful breeding period in a year as said by the local residents inhabiting the hornbill range in the study area (Result from Nest ID 17). The sex ratio of hornbill progenies may depend on many factors both biologically and physically that is not included in the current study.

3.1.3 Rufous-necked hornbill Diet Composition

The study revealed that Rufous-necked hornbills feeds on both fruits and animals but the quantity of animals eaten is more at the post breeding period which is said to be taken as a nutrient supplement for growth the young ones.

3.1.3.1 Fruit diets of Rufous-necked hornbill

We were able to record about 38 species of fruits known to be eaten by RNH including three unknown from the study area during and after the breeding season comprising of 35 species and rest that needs further confirmation (Annexure 1A) which is accounted for the entire study area. Among the fruits species recorded, 37 identified species falls under 31 Genere, 20 plant families dominated by Lauraceae with 30 percent followed by Anacardiaceae. The hornbill fruit families included Meliaceae, Moraceae, Burseraceae, Myrtaceae, Vitaceae, Santalaceae and Gutiferae with Lauraceae and Anacardiaceae. The fruit tree species includes *Beilschmedia roxyburghiana*, *Beilschmedia clarkei*, *Phoebe sp.*, *Parassasafrass confertiflora*, *Drimycarpous racemosus*, *Aglaia cucullata*, *Caserea glomerata*, *Pyrularia edulis*, *Ficus auriculata*, etc.

During the post breeding period the RNH prefered fruits that are availably growing in and around the hornbill habitat area was collected and assessed. From the fruit collection activity it was found that hornbills mostly choose to feed on larger sized fruits which has more quantity of mesocarp (pulp) like that of *Beilschmedia roxburghiana*, *Pyrularia edulis* that contains more lipid (Figure 9). *Aglaia cucullata* is one kind of subtropical fruit loved by RNH a autumn lipid rich fruit which is bigger in size with a strong garlic scent and fed at the later stage of breeding period that coincides fruit ripening. Although we tried, the nutritional analysis of the fruits was not done due to lack of equipments in hand. So, we look forward in future to do some indept studies on nutrition contents of fruits eaten by hornbills. It is felt improtant to understand the complete phenological process of the important fruit tree species and other foods eaten by RNH and also assess the sustainability in the long run and see the possibility of propagation.

The hornbills found in Lhuentse area is said to be feeding on the *Pyrus pyrifolia* locally called as *"Leetong"* in Tshochen village area under Maedthso geog as per Kinga Thinley (29) and also another loved fruit species i.e. *Elaeagnus sp.* confirmed through regurgitated seed collected from the Dochur nest in Yabee in Jarrey geog of Lhuentse. In Tsamang area RNH are found feeding on tree tomato (*Cyphomandra betacea*) fruits locally called as *"Shingi Lambendha"*.

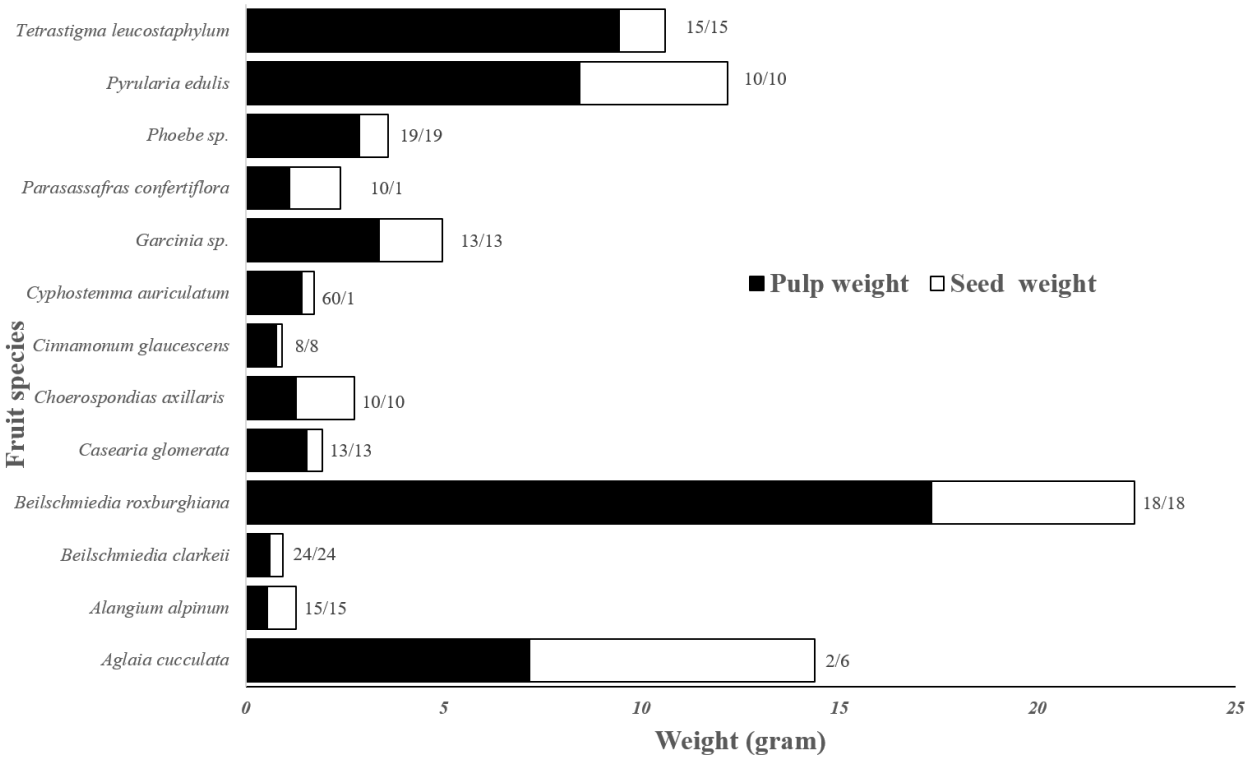


Figure 9. Weights of the fruits eaten by RNH (numbers indicating the numbers of fruit samples taken)

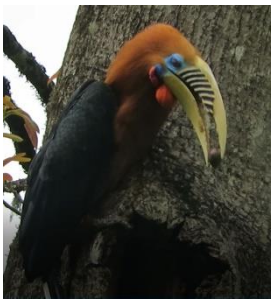
3.1.3.2 Animal matter diets

On the other hand it is also known that RNH feeds on both vertebrates and invertebrate aniaml species that includes a record of 13 animal species such as crabs, bird chicks, bettles, caterpillars and even small mammls lile squirrels, rats, as recorded at the nesting sites, information gathered through the questionnaire survey with the local people and feeding observation data and regurgitated seed collected samples (Annexure 1B). Fruit species were eaten throughout the year based on availability while animal matter foods are eaten usually after the hatching period to supplement the dietary requirement of the chicks for growth and the mother for her rejuvenation of her health.

3.1.4 Feeding observation

Feeding by male Rufous-necked hornbill was observed during the nesting period (April/May – July/August) that was conducted at the 8 identified and verified nest sites. Two nest was unsuccessul after completing about 30 days incubation inside the nest.

3.1.4.1 Feeding Bouts



From the feeding observation during the nesting season male Rufous-necked hornbill brings food to his mate or his family at about 0742 – 0800 hours in the morning, between noon and 1300 hours in the afternoon and 1609 hours in the late afternoon. It is found that the feeding male hornbills are predicted to be aged between 7 – 10 based on the number of black grooves counted on their beak (Figure 10). The predicted age of the hornbill doesn't have much impact on the feeding rate as per the current study information (Figure 10). In general an average a 8 year (n=8) old male hornbill feeds about 2.24 – 5.95 times per minute of food on average while observing for two weeks during the breeding period.

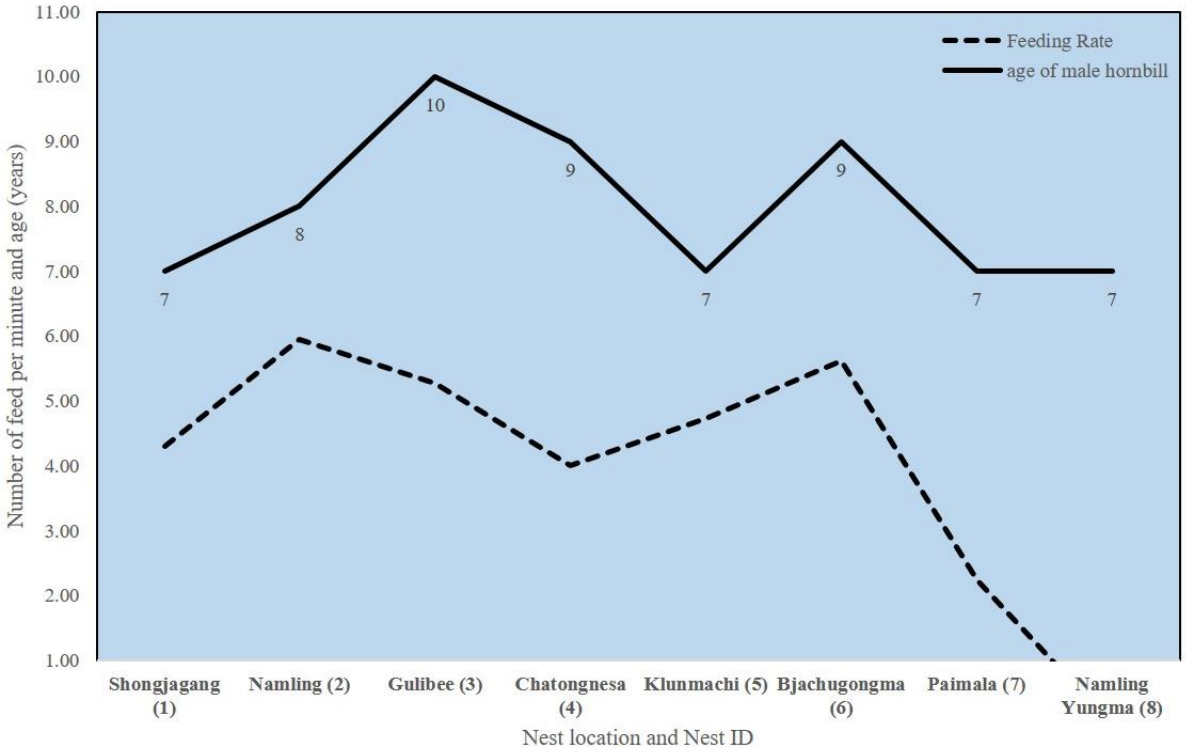


Figure 10. Feeding rate and predicted age of the male hornbills

3.1.4.2 Per Day Feeding

The male hornbill visited three to four times a day to the nest to feed his mate and the chicks right after sealing of the female hornbill inside the nest. It is observed that five out of eight male bird doesn't directly fly or perch on the nest entrance rather the male hornbill inspects the nest surrounding for sometime by making calls where the female and its chicks grumbles responding to their father's arrival (Figure 11). The frequency of visit increases and the type of food also changes with more of fleshy and lipid rich fruits in addition to food rich in protein like animal matters at the later stage of the breeding as required by the chicks when they grow.

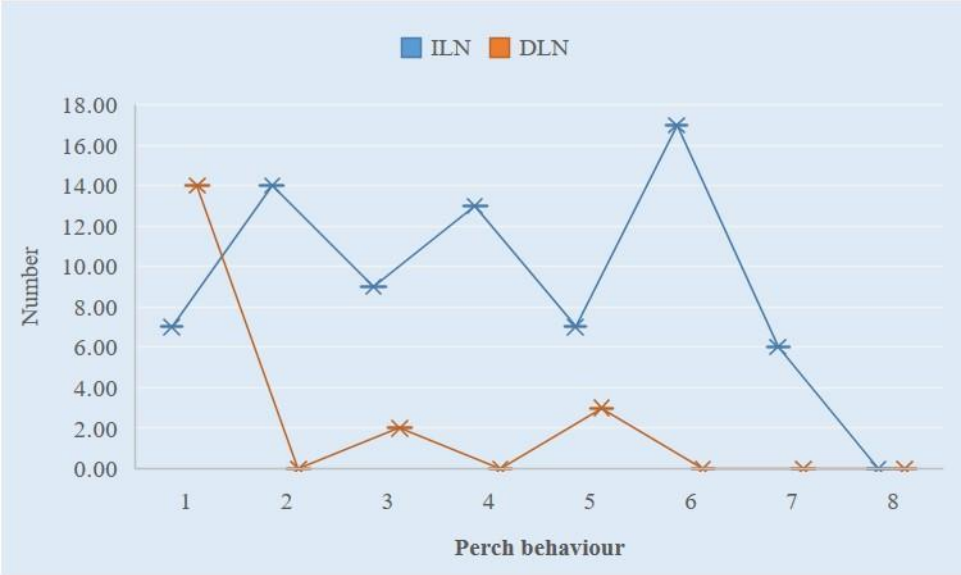


Figure 11.Figure 11.Type of landing behavior of the male hornbills while visiting for feeding its nesting female and chicks

The regurgitated seeds and other foods which are dropped were collected and measured. 15 different fruit species including 4 unidentified were collected from eight studied nests which are mostly of Laurel species (Figure 12). RNH was found feeding on a diverse fruit species with variable dimensions where we could identify and collect only few that also excludes the off breeding period food which is collected by the male hornbill only.

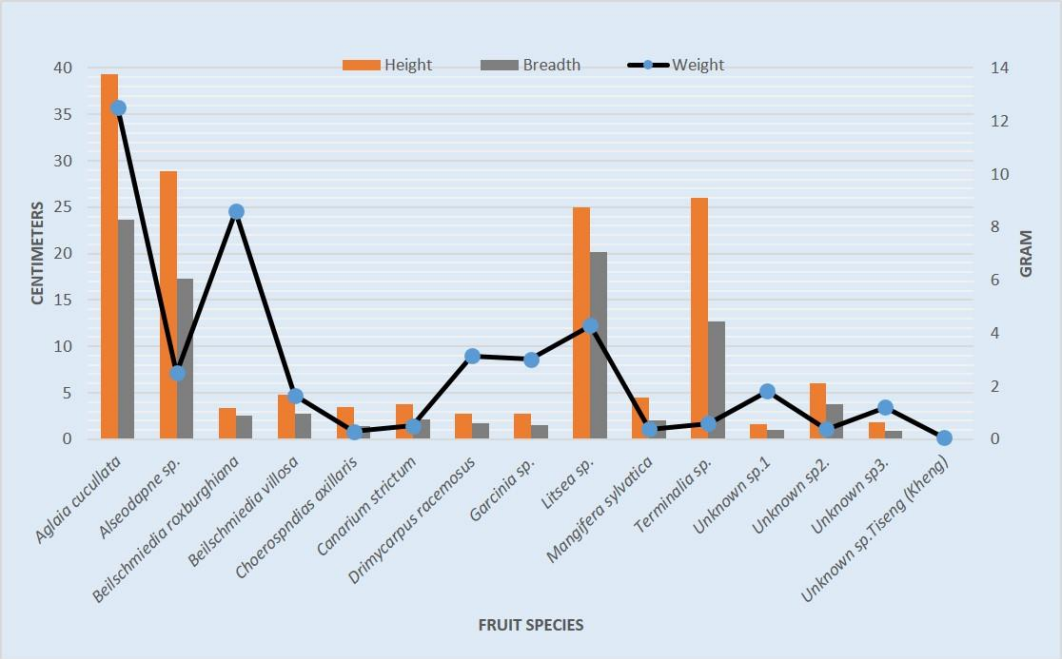


Figure 12.Measurement of the regurgitated seeds from the preferred fruits collected and fed by male hornbill

3.2 Mist netting and hornbill tagging

3.2.1 Mist netting

Mist netting is mostly deployed by Ornithologists and bat biologists for studies on species diversity, population, relative abundance, etc. In order to understand how hornbills move during its breeding stage tagging of hornbill was carried out using mist nets. Generally the nets differs in size based on the intended species. The mist net used for the current hornbill tagging was procured from Germany having a size of 12 m by 4 m with a mesh size of 150 mm.

Although the data retrieval got failed due to malfunctioning of Tag devices used with the Subscriber Identity Module (SIM) a German made developed with Global System for Mobile Communications (GSM) we could successfully tag two male hornbills at the nest site. This targetted netting activity is a first time experience for allmost all participants that was found really an ardous but a wonderful experience with lots of practical knowledge gained. The radio-telemetry technique practised by hornbill reserachers of Thailand is adopted in preparing the mist net and installation at the nest site (Manual for conservation of Asian hornbills, edited by Poonswad. P. and Kemp. C., 1993). The following tabulated data is the information enumerated from the two tagged male hornbills (Table 2).

Table 2. Information record of the tagged male hornbills

Tag No.	SIM No.	Number of grooves on the bill (predicted age)	Body Weight (Kg.) & Length (Cm.)		Wing (Cm.)		Primary wing (Cm.)	Mandible length (Cm.)			Tail length (Cm.)	Thigh length (Cm.)	Tarsus length (Cm.)	Neck length (Cm.)	Head length (Cm.)
			Kg.	Cm.	Length	Width		Upper	Lower	Width					
IMEI: 863071010582267	4	7	2.8	29.5	48	47	34	25	22	9.5	49	15.2	13.5	14.4	6
IMEI: 863071010577937	5	8	2.65	42	66	38.5	48	25.6	21.2	9.6	50.5	14.7	9.5	19.7	11.3

3.3 Cultural and economic aspects of hornbill conservation

3.3.1 Hornbills and People: *an experience of a harmonious coexistence of human and nature*

Most of the animal species inhabiting anywhere on the earth has got a cultural story or belief expressed by people staying around their natural habitat that mostly links to bonism.

Like the zomi society in India, Burma and Bangladesh in Asia, Bhutan too has many stories to tell about hornbills. Ap Tegpo (44) a local hornbill caretaker cum informant from Tsanzabi in Mongar Dzongkhag says number of hornbills have increased in his village area over the past 3-5 years may be due to favourable habitat with foods available. Ap Tegpo creates a joke with his village commrades saying *"don't act like a hornbill"* meaning his friend is jealous with his neighbhour gentlemen where female hornbills during nursing time doesnot receive the food brought and feed by the male hornbill if she sees any other birds or animals nearby (person com. with Ap Tegpo 2015). Hornbills are respected and honored by their human neighbors where they consider them as secret and noble birds why because they are recognized to live a simple life with love and faithfulness with their partners displaying the monogamous nature of relationship. The hornbills are said to be displaying majestic characteristics like when they eat, flock, sleep, etc.,**.** People love hornbills as they doesn't destroy agricultural crops except feeding on some fruits like that of *Pyrus pyrifolia* (commonly called as Asian Pear and locally *leetong*) observed at Tshochen under Lhuentse district and tree tomato (*Solanum betaceum* synm: *Cyphomandra betaceum* at Ligsarbee in Tsamang under Mongar districts which are also eaten by local people that indicates a sign of resource competition but manageable. The active nests of hornbills in the study site were found nearby the human settlements if not in and around the cattle grazing camp areas within the matured broad-leaved forest.

How a *"Luchu"* got its smuggy call: *"It is said that hornbills have a peculiar song or call different from other bird species. Lord Buddha is said to have given a peculiar voice call each to every living organism at an auspicious event during the time of the flourishment of Mahayana Buddhism in South Asia. Unfortunately, Rufous-necked hornbill was absent on the occasion. So, when other animals and bird species communicated proudly within their forest community hornbills felt ashamed and couldn't communicate among their group. So, they were unhappy and flew from tree to tree enjoying the juicy fruits. Suddenly one of the hornbill father heard a peculiar*

sound like that of a wood cutter "chopping wood" that produced a sound of kuuk…kuuk…kuuk… which pleased his ear. Then they discussed over within their group and finally the Rufous-necked hornbills decided to use it as their call for communication among themselves", verbal abstract of story as told by Sangay Tenzin (38, Lay monk at Kadam Goenpa, Mongar).

3.3.2 Benefits of hornbill existence to the resident community

3.3.2.1 Creating worthwhile ecotourism destinations through hornbill conservation

Beside the critical role as a keystone species of the broadleaf forest ecosystem hornbills display an iconic place among the birds of a locality because of their large colorful body with a large and majestic beak and peculiar type of calls (Angay Sonam Choden, 78 at Tsanzabi village). So, tourist mostly bird watchers and hornbill researchers visit those villages located within the hornbill habitat range areas whereby people are benefited from eco-tourism activities such as being a local guide and sharing about their local culture and traditions, jokes about hornbills and man, etc. A twelve-member group tourist assisted by Ap Tegpo (45, Local guide) visited and enjoyed the RNH male hornbill feeding at one of the study nest sites in Tsanzabi in the year 2015.

Developing the local area as a Hornbill Village with eco-trail services in the hornbill habitat range would benefit the local community as we can see an astounding potentiality with present status of hornbill presence and good bird diversity for Bird watching tourists and hornbill researchers. Locals can reinstate their age-old practice of handicrafts development for their own household use and as well for selling to outside visitors as we can see many beautiful cane and bamboo products.

3.3.2.2 Sustainable forest management

On the other hand, the health of local forest area can also be sustained as hornbills feed on lots of forest fruits and again helps in forest regeneration acting as natural seed dispersing agents where people use timber and other NWPF products for their home consumption and sometimes even for sale to generate minimal incomes to meet household requirements. On the contrary the local people also practice the culture of caring for others where people retains active hornbill nesting trees from cutting for construction purposes by taking alternative options (Person com. with Tegpo, 45 and Sangay Wangchuk, 38). The local people take up tree plantation and tree care in

the logged forest areas as reforestation activities supported by the NRDCL that would help in restocking the forest for the benefit of both people and hornbill although it takes time.

One of the critical locations for hornbill conservation is Broksar village where the community desires to establish a community forest management group like other villages prospecting that will help in sustainable resource utilization and to protect the resources of their area with the advantage to manage their local forest for their future generations.

3.3.2.3 Partnering conservation at the grassroot level to offset rural poverty

With most of the basic amenities of rural developmental supports are put in place now the second priority comes the capacity enhancement of the rural people to maximize rural products and preserve their pristine environment for the future. The existing community groups such as Organic Farm Products and its market possibilities, trapping to use the renewable natural resources which they have already started with support from district administration and research office in Mongar, such as essential oils from *Artemisia vulgaris* localy called as Khempa shing and *Canavis sativa* locally called as Bhang. These programs need to be strengthened that creates employment opportunities for the local youths with abilities to develop leadership and rural entrepreneurial capacities.

Similar community management programs can be initiated which has scopes of balancing the community requirement and the conservation needs such as NWFP management groups which can be nestled either under community forestry groups if possible that can encourage and support ecotourism services, preservation of spiritual, historical and religious values that is indispensable to foster community vitality.

3.3.2.4 Conservation for recreation and education

As part of the outreach activity of the hornbill project three community schools located within the hornbill habitat were included in the program and conservation related educational activities were convened for educating the local youth about the hornbills and conservation in general in close collaboration with field project partners represented by the park range, Forest Management Unit (FMU) and Natural Resources Development Corporation Ltd. (NRDCL) offices. The school participating students led by their teachers and field forestry staffs was coordinated to teach about wildlife and its conservation focused on hornbills of their surrounding environment through

education skills of competitions like essay writing, drawing and arts, group debates and poem writing activities. An eco-guide walk was also organized for the participants in each of the three school areas with the conservation related theme of *"know the common biodiversity resources of your locality"* through hornbill trekking day chattering along the traditional trails teaching them about the common animals, plants and birds, also about best practices of waste management and collecting waste rewarded with cash incentives for winning group quiz and quantities of waste collected. Students could extract lots of local stories about the hornbills from their parents and relatives which they further shared among the school friends through storytelling, poem writing, drawings and arts and debates could share amongst their school peers. The school children are expected to share their understanding about hornbill conservation from the school programs to their parents back home after their everyday schooling.

3.4 Conservation Threats

The safe existence of Rufous-necked hornbill in the study area purely depends on the state of the surrounding forest which is directly related to the attitutes of the local people residing in the hornbill habitat vicinity.

3.4.1 Deforestation to degradation of the hornbill habitat

The inception of Lingmethang Forest Management Unit (LFMU) through Natural Rescourse Development Corporation Ltd. (NRDCL) has led to deforestation and extract million quantity of timber resourcse since two decades ago that is said to have operated more than 2000 ha consisting of both hardwood and chirpine forest areas (Operation Management Plan - February' 2008 – January' 2018 of LFMU, Mongar Forest Division) beside the construction of forest roads destroying the pristine nature and fragmenting wildlife habitats. Still the current plan is under review for further operation into the remote Silambi geog area that will cause a great negative impact on the existence of the hornbills. Also, most of the timber extracted are stacked and deteriorating inside the NRDCL DEPOTS due to ban on timber export and loans freezed for construction works.

In addition large tracts of pristine forest are cleared to construct farm roads and cleared for electric transmission lines that has detrimental effects on shrinking of the viable hornbill habitat in the long run. With the advent of these basic modern falities and the policy to provide subsidized timber resources has encouraged people to use more trees for construction purposes, for firewood, fodder for cattle, non-wood forest products (NWFP) and handicraft development besides the illegal stuff started building better homes ultimately posing greater threats in addition to the larger menace created through logging on the limitted resources left in the wild. But there are still some good stories to tell that is, we saw three of the past used nest trees (2 in Tsanzabi village and one in Broksar) has got the formal hammer marking impression allowed for use as rural house constrcution timber were said to be retained by the local people themselves after seeing the hornbills using the trees for nesting that indicates a positive human

interest and support towards conservation (Sangay Wangchuk, 38 from Tsanzabi).

3.4.2 Food resource competition

Although hornbills play a vital role as seed dispersers all those seeds dispersed will not regenerate 100 percent that depends on various factors such as climatic elements, ground substrate, seed

viability, numbers of hornbills feeding and dispersing, etc. seen as some natural threats. Importantly the age old cattle herding system still practiced by the local communities to substantiate their livelihood may reduce food sources as trees are lopped for cattle fooder, wild fruits are collected for home consumption and sell for income generation, trees are cut down for handicraft making and collection of some important NWFPs as local herbal medicines poses additional threats to the survival of the hornbills due to competetion for food resources. On the other hand there are competitions from the associated species in the wild which can be either intraspecies or interspceies. But an interesting symbiotic case that we can observe is at the hornbill nest site where an active male hornbill feeds more than three individuals during its entire breeding period such as; his own family, a barking deer and a squirrel that feeds on the dropped fruits and regurgitated seed at the base of the tree. As such the seed dispersal chain goes on extending till a seedling emerges.

3.4.3 Mortality due to natural calamities

There are many evidential incidences besides many of the un-noticed and anthropogenic pressures that poses a detrimental affect on the overall breeding success and safe existence of hornbills. Land slips during the summer, accidental forest fires, disaese out breaks, femines and conditions of the nesting trees are some of the evident catastrophies endangering the peacefull life of hornbills. For instance nest ID 01 and 08 located at Namling Yungma and Paimey la respectively was badly disturbed at the final stage of breeding by a landslip in August' 2014 at Tsanzabi, Saling and the other was a tragic loss of three numbers of hornbills; a mother with two male fledglings in a nest tree break down due to strong storm at Dochur (nest ID 17) in Lhuentse in the year 2016. Several incidences of either a accidental death were reported in the past that poses threats to whole population in the long run. For instance, a female rufous-necked hornbill was rescued succeefully by the staffs of park range office in Lingmethang during May 2007 and a year later a hornbill family was crushed to death while feeling trees something to mention few and many others pass beyond the notice of concerned authorities.

No cases related to hunting and poaching against Rufous-necked hornbills are reported or documented in Bhutan although we find hornbill beaks in some rural houses kept as trophies which is said to be collected from the forest. But still it requires some form of monitoring of the unknown.

Part 4. Discussion

4.1 Habitat preference

Rufous-necked hornbill displays a wider ecological adptation where it inhabits right from the lowest reaches of sub-tropical and warm broad-leaved forest (600 - 1500 masl) mostly used for breeding and foraging, in the higher altitude areas it reaches as high as 2300 mals (but even higher at 2400 m in Bhutan as said by Sherub, 2016) in the cool broad-leaved forest of the higher Himalayan ridges and valleys for foraging and as well for breeding and rarely in the dry chirpine forest during transit observed in the study area.

The ecological habitat required by RNH in Bhutan is the highest in altitude compared to what Poonswad reported in Hornbills: A Thai heritage – A World heritage (2012) and Poonswad et al (2013) but similar in behaviour of frequent foraging along water courses during the breeding season. All the nestings were found inside live matured tree holes (Figure 6) while accounting for 17 nest sites which is located on the tree trunks and more than 50% of the nest site is located nearby a water source. The gradient of the nesting surrounding are gradual slopes facing north and east but frequently facing towards north east. About 14 nest sites are located nearby either a human settlement or a grazing camp or a foot trail/ farm road in the study area which shows a harmonious co-existence of hornbills and humans.

4.2 Nest and nesting characteristics

The findings in this study about suitable nesting trees are similar to that reported by Poonswad (1993a) in Poonswad *editor* (1998). In the study carried out by her in Khao Yai National Park in Thailand, it is found that hornbills have limitted choice in the selection of suitable nest sites owing to their inability to excavate their own nest cavities. All the nest cavities in our study are re-used over and again in all the three sub-district areas and all are made inside live matured tree trunks may be created by other birds like wood peckers. Rufous-necked hornbill nested mostly in the trees of *Syzygium sp.* at Khao Yai and *Cleistocalyx nervosum* in other parts of Thailand while in our study *Schima khasiana* was the most used tree species with *Toona ciliata* and *Choreospondias axillaris* having tall, huge girth and common broad-leaved tree species in the study area (Figure 7). In the nest tree selection in our study area it contradicts the information reported by KEMP (1976), POONSWAD (1993a) and HUSSIAN (1984) in Poonswad *editor* (1998) as we have recorded more than 41% the same tree species used as nest trees but this needs further studies

covering a larger area over the country. The trees measured 7-22 meters in its nest height above the ground level with an average of 100.59 cm dbh that correlates the requirement of large sized trees for hornbill nesting (Figure 8 & Table 1). In the study area the requirement of big sized trees for construction timber posses a serious threat to the sustainability of the successful hornbill nesting and breeding. The shape of the nest openings are orbicular while unsealed and vertical oval slit while sealed (Figure 6).

4.2.1 Nesting success; nest site selection and courtship, and nest sealing

Hornbills are mostly monogamous by their breeding behaviour, pairing for life as "one husband one wife" an outstanding behaviour even for birds (Ponswad 2012). The nesting success depends on various extraneous factors, such as availability of a suitable nest cavity and optimum weather conditions which consequently affect food supplies (KEMP, 1973, 1976; Poonswad et al 1987 in Poonswad 1998). In the study area the onset of the spring with another time of flowering of plants and available food sources stimulates the hornbills to start nesting.

In the study area Rufous-necked hornbills starts selecting suitable nests and displays courtship rituals by the end of February or beginning of March coinciding the first and second Bhutanese calender months which happens side by side nearby the nest cavities in pairs (Personcom with Tegpo, 45; Tsanzabi, Thinley, 39; Tsamang in Mongar and Samten, 71; Yabee in Lhuentse). The docile female hornbill follows the male while in search of the suitale nests where the couple flies back and forth and checks at most of the empty nests. In the study area it is said that Great hornbill competes with RNH for the nest.

The unique nesting rituals effectively differentiate hornbills from all other families of birds anywhere in the world where the entire process of nest preparation and raising of chicks takes 14-18 weeks, depending on species and size of hornbills (Poonswad 2012). The female hornbill becomes active when she investigates and trys to select the suitable nest and start to clean the cavity. Accordingly by first and second week of April the concepted female finally enters their prepared nest and starts sealing herself while the male outside assists her in getting plastering materials. Wherein Thailand female seals by Jan-Feb. and in Arunachal Pradhesh, India it happenes by third week of April (Poonswad et al 2013; Personcom. with Apparijitta, 2017) where Indian and Bhutanese share almost same sealing time in the higher altitude which happens later than the Tropical Thai RNH. The plastering materials used in the study area are Limestone soil

(Sakar), Black rock exudation (Bragtsi), Resin from chiprine, chirpine needles and cow dung (Personcom. with Tegpo, 44 and Sangay Wangchuk, 38 from Tsanzabi and Samten, 71 from Yabee). In Thailand it is seen that droppings and food pulp are used as reported by Poonswad 2013. But when we saw at the nest site in the study we could see mud with plant root hairs with some different colors mud. This need to be further examined well in the furture studies (Figure 9).

4.2.2 Breeding success

Hornbill breeding is a very individualized process that involves not only entering the nest, laying eggs, incubating the eggs, and then taking care of the chicks after closing the cavity entrance leaving a narrow oval slit just wide enough to pass food by the male and squirting faeces and other waste materials (Poonswad et al 2013). The study accounts for 75% of breeding success from the intensive observation of eight nest sites for about a month. The unsuccessful nesting pertains to natural disturbances like flash flooding that occurred in the area located nearby one of the unsuccessful nest sites.

As reflected by Poonswad et al (2013) normally one - two chicks fledge out from every 1-2 laid eggs from the successful nests during a successful breeding period in a year. The sex ratio of hornbill progenies may depend on many factors both biologically and physically that is not included in the current study which may be tried in the near future. Through the study we came to know the breeding success are affected by some factors such as landslides, flash flooding, forest fires, windstorms and weak conditions of the nest trees otherwise it will not be a question as hornbills make nests in the higher canopy of the forest stand. For instance, we had a bad experince from one of our active nest located in the east where we lost 3 RNH (one female/mother with 2 male fledglings) due to heavy windstorm at the extreme breeding completion time (July 2016, Dochur nest ID17).

The breeding period in the study area completed by the first week of August coinicding the 6^{th} – 7^{th} Bhutanese calender months taking about 5 months (150 days) that is similar to that of Indian species that is said to complete by August (Personcom. with Apparajitta, 2017) which is about two month later cpmpared to Thai species where chicks fledge during May-June in Thailand taking 105-152 days time (Ponswad et al 2013).

4.3 Diet Composition

The diversity of food eaten by Rufous-necked hornbill indicates that their foraging niches are wide, ranging from forest floor to streams, and upto the forest canopy (Poonswad editor 1998).

4.3.1 Fruit Diets

Kinnaired and O'Brien has found fruits as the major souce of hornbill food with 63% - 98% of its diet from 18 different studies. Rufous-necked hornbill in is found to be an omnivorous by food habit as per Chimchome et al. 1998 where it is found that 83 percent of fruit and 17 percent animal matters in the hornbill diet during the breeding season in Thailand. So, likewise in our present study while accounting the records taken during breeding and post breeding period we could record about 38 fruit speices including one unknown and two other requireing further confirmation through fruit sample collection and measurements taken (Annexure 1a). It consists of 37 identified species under 31 Genere, 20 plant families dominated by Lauraceae with 30 percent followed by Anacardiaceae. The hornbill fruit families included Meliaceae, Moraceae, Burseraceae, Myrtaceae, Vitaceae, Santalaceae and Gutiferae with Lauraceae and Anacardiaceae. The fruit tree species includes *Beilschmedia roxyburghiana, Beilschmedia clarkei, Phoebe sp., Parassasafrass confertiflora, Drimycarpous racemosus, Aglaia cucullata, Casearia glomerata, Pyrularia edulis, Ficus auriculata,* etc.

RNH mostly choose to feed on larger sized fruits which has more quantity of mesocarp (pulp) like that of *Beilschmedia roxburghiana, Pyrularia edulis* that contains more lipid. *Aglaia cucullata* is one kind of sub-tropical fruit loved by RNH which is an autumn lipid rich fruit bigger in size with a strong garlic scent and fed at the later stage of breeding period that coincides fruit ripening. The study found that hornbills depend on fruits available in the local surrounding that differed from place to place within the study area.

So, we look forward in future to do some indept studies on nutrition contents of fruits eaten by hornbills. Its also felt improtant to understand the complete phenological process of the important fruit tree species and other foods eaten by RNH and also assess the sustainability in the long run and see the possibility of propagation.

4.3.2 Animal matter

As Kemp (1995) in Poonswad *editor* 1998, mentioned the honbills of the genus *Aceros* are known to drop down on the forest floor along the streamsides is not just for qunenching its thirst but apparently to catch crabs, small fish and others. The present study revealed that the Rufous-necked hornbill is known to eat both vertebrates and invertebrate aniaml species that includes a record of 13 animal species such as crabs, bird chicks, bettles, caterpillars and even small mammls lile squirrels, rats, etc. However, still we see lots of things needs to be studied further especially the foraging niches of the RNH into detail.

4.4 Feeding Observation

Hornbills have a fascinating feeding behaviour. They directly swallow foods as they cannot maneuver the collected food due to their short tongue. They toss the fruits back and forth between the bill tips to soften and then jerk back to the throat for swallowing which allows researchers to count the food taken in one by one (Poonswad 2012). While feeding the female and its chicks by the male they preform the "bill-to-bill" pass of food.

4.4.1 Feeding Bouts

The feeding observation is made during the mid nesting season where the male Rufous-necked hornbill brings food to his mate or his family at about 0742 – 0800 hours in the morning, between noon and 1300 hours in the afternoon and 1609 hours in the late afternoon. In general the male hornbill feeds about 2.24 – 5.95 times per minute on average while observation done for two weeks during the breeding period.

4.4.2 Feed per day

The male hornbill visited three to four times a day and the frequency of visit increased with the closure of breeding period. The type of food also changed with more of fleshey and lipid rich fruits in addition to foods rich in protein like animal matters at the later stage of the breeding as required by the chicks as they grow (Poonswad 2012 and Ponswad et al 2013). We are able to collect about 15 different regurgitated seeds of fruits including 4 unidentified from eight studied nest sites which are mostly of Laurel species dominated by *Beilschmedia villosa, Litsea sp., Phoebe sp.,* of Lauraceae and *Aglaia cucullata* (Meliaceae) but it was so difficult in identifying

the naked seeds without having a whole fruit morphological understanding and experience of the field reality.

On the other hand five out of eight male hornbill doesn't fly directly and perch on the nest entrance but it perches on the nearby tree branches by inspecting around making calls where the female and its chicks grumbles responding to their father's arrival (Figure 12).

Part 5. Study findings and future scope of research works

With the experiences learnt from our study the following points are felt important for a better conservation of rufous-necked hornbills in Lhuentse and Mongar areas.

1. Incorporation of a separate hornbill protection and management plan specifying the need of retaining the potential and used nesting trees with a funding provision for supporting the development of ecotourism destination in some strategic areas in the hornbill habitat taking the advantage of payment for ecosystem services (PES) with the LFMU in view of the scarce fund sources.

2. Reforestation or restocking of extracted coupes or open areas with fruit trees and timber trees using hornbill preferred fruit seeds. Involve local communities in raising nurseries or collect the seedlings grown in and around the hornbill nest sites. Phenology of the important fruit trees can be started for monitoring changes and adaptation measures developed against the evident adverse impacts.

3. Encourage in retaining potential hornbill nesting trees from marking for the rural house construction or otherwise identified hornbill nest improvement needs to be conducted.

4. Time to identify the keystone species like hornbills in the conservation of the biodiversity resources through community based conservation programs through actively involvement of rural communities to manage their resources.

5. Carry out timely research on hornbill population, hornbill ecology to understand their movement, breeding, foraging, ecosystem services and their resilient capacity to adapt to changes in their habitat conditions and climate changes effects.

   Th research works needs to be done for the preparation of the next **8th International Hornbill Conference 2021 will be held in Bhutan** as it was bid and approved during the 7th IHC held in Kuching, Sarawak, Malaysia May 2017.

Part 6. References

Chimchome, V. *et al.* (1995). Comparative study of the Breeding Biology and Ecology of Two Endangered Hornbill Species in Huai Kha Khaeng Wildlife Sanctauary, Thailand.

Jinamoy, S. et al. (2013). Estimating Density of Rufous-necked hornbill (Aceros nipalensis) Using
Distance Sampling in Thung Yai Naresuan (East) Wildlife Sanctuary. *Journal of Wildlife in Thailand, 20*(No.1).

Kinnaird, M. F. & O'Brien, T.G. (2007). The Ecology and Conservation of Asian Hornbills*: Farmers of the Forest.* The University of Chicago Press.

Poonswad, P., Editor. (1998). The Asian Hornbills: Ecology and Conservation. *Thai Studies in Biodiversity* No.2: 1-336

Poonswad, P. *et al* (2012). Hornbills of The World: A Photographic Guide. The Draco Publishing and Distribution Pte. Ltd., Singapore.

Poonswad P, Kemp A. C & Strange M, (2013). Hornbills of the World a Photographic Guide. Draco Publishing and Distribution Pte. Ltd and Hornbill Research Foundation.

Appendices

Annexure 1. Diet sources of Rufous-necked hornbill

A) A glance of list of fruit species with information gathered on flowering, fruiting as per local people and reference books, types of fruits, eaten by hornbills or not, status of species as per IUCN criterion, etc.
B) Nutrient supplementary food sources esp. include animal matters

Annexure 2: Pictorial images collected on Fruits plant species and animal matter diets

A) Fruit Diets of Rufous-necked hornbills
B) Animal matter diets of Rufous-necked hornbill

Annexure 3: Glimpses of the Hornbill Project field work and other activities funded by Conservation Leadership Programme.

Annexure 1. **Diet sources of Rufous-necked hornbill. A) List of fruit plants species with detail information.**

Sl .#	Family and Common Names	Species	Habit	Flowering Time	Fruiting Time	IUCN status	Importance	Type of fruit
	Alangiaceae							
1	Mountain Alangium, Domseng (Kheng), Akhane/ Galasune (Nep)	*Alangium alpinum* (Clarke) W.W.Sm & Cave	Small tree		Aug. - Sept.	LC	Hornbill Fruit, Insect food	Drupe
	Anacardiaceae							
2	Nepali Hog Plum, Thrungchung shing (Sha), Lapsi (Nep), Klunmachi (Kheng), Nying Zhosha (Med)	*Choerospondias axillaris* (Roxb.) B.L.Burtt & A.W.Hill	Evergreen Tree, 10 m	April	June - July	LC	Hornbill Fruit, Fruit pickled, Timber, Medicinal value	Drupe
3	Pungent Fruit, Kadarmey (Kheng), Chemeyla (Saling), Khak Balaiyo (Nep)	*Drimycarpus racemosus* (Roxb.) Hook. f.	Evergreen Tree, 30 m	March - April	May - June	LC	Hornbill Fruit	Drupe
4	Himalayan Mango/ Pickling Mango, Chuche Anp (Nep), Shutale (Kheng)	*Mangifera sylvatica* Roxb.	Evergreen Tree, 10-30 m	April - May	July	LC	Hornbill Fruit, Fruit edible (pickled)	Drupe
5	Amaroo (Nep), Amber shing/ Bochong shing (Sha)	*Spondias pinnata* (L.f.) Kurz	Deciduous Tree up to 40 m.	March - May	July – Aug.	LC	Hornbill fruit (need to confirm), Fruits edible.	Drupe
	Boraginaceae							
6	Jagpaseng (Kheng)	*Ehretia sp.* P.Browne	Tree	March - May	July – Aug.	LC	Non-hornbill Fruit	Berry
	Burseraceae							
7	Poikar (Dzo/Med), Poikarshing (Sha), Gokuldhup (Nep)	*Canarium strictum* Roxb.	Evergreen Tree, up to 50 m	Feb-April	Sept. - Oct.	LC	Hornbill Fruit, Medicinal value, Incense	Drupe
	Clausiaceae/ Gutiferae							
8	Luchuito/ Lati	*Garcinia sp.?* L.	Tree		July	LC	Hornbill Fruit	Drupe
	Elaeocarpaceae							
9	Himalayan Olive, Khasha kokpa (Kheng/ Kurtoed), Khashatarka	*Elaeocarpus lanceifolius* Roxb.	Evergreen Tree 12 – 20 m.	Aug. – Sept.	Oct. - Dec.	LC	Hornbill Fruit, Timber, Tea box,	Drupe

	(Tsamang), Gasha Thung shing (Sha), Bhadrasey (Nep)						Charcoal, Fruits edible	
	Flacourtiaceae							
10	Phangla seng (kheng), Barkaunle (Nep)	*Casearia glomerata* Roxb.	Shrub or Tree, 10m	April-May	Jul-August	LC	Hornbill Fruit	Capsule
	Lauraceae							
11	Thrulo Tarsing (Nep), Praguli/ Brangkhala (Kheng)	*Beilschmiedia roxburghiana?* (Big leaf) Nees	Evergreen Tree, 25 m	March	August	DD	Hornbill Fruit, timber and tea boxes.	Drupe
12	Sanu Tarsing (Nep) Brangkhala (Kheng)	*Beilscmedia clarkei?* (Small leaf) Hook. f.	Evergreen Tree, 20 m	May	July	DD	Hornbill Fruit, Fruits edible, Timber	Drupe
13	Krupti (Kheng Broksar)	*Beilschmiedia villosa* Kostermans	Tree	April - July	July – Aug.	DD	Hornbill Fruit	Drupe
14	False Camphor tree, Kipchushing (Dzo), Kawla/Malagiri (Nep), Wamchagpa (Kheng)	*Cinnamomum glaucescens* (Nees) Hand. – Mazz.	Shrub or small Tree, 15 m	May - June	July-September	LC	Hornbill Fruit, Medicinal value, perfume making	Drupe
15	Throkthrrokla/ Zapale	*Cinnamomum bejolghota* (Buch-Ham) Sweet	Evergreen Tree up to 15 m	March - April	July - Aug.	LC	Hornbill fruit	Drupe
16	Shingmar/ Singsii (Sha), Kalo bori (Nep)	*Parasassafras confertiflora* (Meisner) D. G. Long	Small Tree, 4-6 m	Nov - January	June-Oct.	LC	Hornbill Fruit, Edible Oil,	Drupe
17	Chogsengma (Kheng)	*Phoebe sp.* Nees	Evergreen Tree	June	Aug. - Sept.	LC	Hornbill Fruit, Timber	Drupe
18	Serkala (Kheng), Guliser (Saling)	*Alseodaphne sp.*Nees ? *Or Persea sp.* Mill. *Need to confirm*	Evergreen Tree, 15 - 30 m	March - April	May/June	Need to con-firm	Hornbill Fruit	Drupe
19	Bragshing (Saling)	*Alseodaphne sp.* Nees? Need to confirm	Evergreen Tree	Feb. - April	May		Hornbill Fruit	Drupe
20	Praguli (Kheng/ Kheng)	*Persea sp. (*Hook.f.) Kostermans		May - June	Oct. - Dec.	LC	Hornbill Fruit, Firewood	Drupe
21	Shjaguli (Kurtoed)	*Persea odoratissima (*Nees) Kostermans	Small Tree up to 10 m	March - May	Oct. - Nov.	LC	Hornbill Fruit, firewood	Drupe
	Meliaceae							
22	Pacific Apple, Khwelaiseng (Kheng)	*Aglaia cucullata* (Roxb.) Pellegr.	Evergreen Tree	May	July – Aug.	Need to confirm	Hornbill Fruit, Timber	Capsule

23	Yamphai sey (Sha)	*Aglaia edulis* (Roxb.) Wallich	Deciduous Tree	May - June	July - Aug.		Non-hornbill Fruit, Boat, Cart, Furniture	Capsule
	Moraceae							
24	Roxburgh Fig, Chongma (Sha), Nebaro (Nep), Khomdhang (Kheng)	*Ficus auriculata* Loureiro	Tree 3-10 m		July – Sept.	NE	Hornbill Fruit, Important Fodder, Fruit edible	Syconia
25	Cockspur Thorn, Maidal Kanra (Nep)	*Maclura cochinchinensis* (Loureiro) Corner	Climbing shrub	April - June	July – Sept.	NE	Hornbill Fruit, Dye (wood), Fruit edible, Bio-fence	Berry
	Myrtaceae							
26	Phui Pamneyla/ Pompeyri (Kheng)	*Syzygium sp.* R.Br. ex.Gaertn.	Tree	Dec. – Jan.	March - April	Need to con-firm	Hornbill Fruit, Timber	Berry
	Proteaceae							
27	Potorshing (Sha), Bandre (Nep)	*Helicia nilgirica* Byeddome	Small Tree up to 10 m	May - July	Aug. – Sept.	LC	Hornbill Fruit (Need to confirm), Dye (Leaves)	Drupe
	Santalaceae							
28	Amphi (Nep), Tan li (Chinese)	*Pyrularia edulis* (Wallich) A. Candolle	Small Tree up to 10 m	March - April	Aug. - Nov.	LC	Hornbill Fruit, Fruit edible, Implements	Drupe
	Vitaceae							
29	Indian Chestnut Vine Crenpashui (Kheng), Bherseri (Nep.)	*Tetrastigma leucostaphylum* (Dennstedt) Mabberley	Large climbing shrub	March - May	July – Sept.	LC	Hornbill Fruit, Fruit edible	Berry
30	Eared cyphostemma, Zezeymai ruu (Kheng)	*Cyphostemma auriculatum* (Roxb.) P.B.Singh & B.V.Shetty	Climbing shrub	June - July	Aug. – Sept.	Informa -tion nil	Hornbill Fruit, Fruit edible.	Berry
	Solanaceae							
31	Tree Tomato, Tamarillo, Shing Lambendha (Kurtoed/ Kheng)	*Cyphomandra betacea* (Cavanilles) Sendtner	Small tree/ Shrub	Aug. – Feb.	Aug. onwards	NE	Hornbill fruit, Fruit edible	Berry
	Rosaceae							
32	Strawberry, Marib (Kheng)	*Fragaria nubicola* (Hook.f.) Lacaita	Stoloni-ferous herb	April - May	June - July	LC	Hornbill fruit, Fruit edible (Jam)	Berry

33	Mehel, Monkey apple, Tong (Dzo), Thungkakpa/ Thungchurpu (Sha), Mel (Nep)	*Docynia indica* (Wall.) Decaisne	Deciduous Tree up to 10 m.	March - May	May -Oct.	LC	Hornbill fruit, Fruit edible, Medicinal value	Pome
	Phyllanthaceae							
34	Churu (Dzo/ Med) Kudth (Kheng), Amala (Nep)	*Emblica officinalis* Gaertner	Deciduous shrub 1-3 m or up to 10 m		March - April	LC	Hornbill fruit, Fruit edible (Pickle), Medicinal value	Capsule
	Fagaceae							
35	Shakhoi (Kheng)	*Castanopsis or Lithocarpus*						Acorn
	Magnoliaceae							
36	Kharshing (Kheng)	*Michelia sp.* L.	Evergreen Tree	Feb. - March	Oct. - Nov.	LC	Hornbill fruit, Timber, furniture	
	Unknown species							
37	Nyeclodth (Kheng)	*Unknown sp.*	Tree	Jan. – Feb.	May - June	Need to con-firm	Hornbill Fruit	Drupe

B) Nutrient supplementary food sources esp. include animal matters

Vertebrates	**Local name (Kheng)**	**Remarks**
Bird Chick	Bjai bjew (Kheng)	Feeding data collection
Snake	Poo (Kheng/Bumthang)	Questionnaire survey
Frog	Baipola (Kheng)	Questionnaire survey
Squirrels	Tortola (Kheng)	Excreta from Dochur nest
Rats	Ngewa (Kheng)	Questionnaire survey
Lizards	Kaelangmo (Kheng)	Questionnaire survey
Invertebrates		
Chirpine caterpillar	Reypuen/ Reybektang (Kheng)	Questionnaire survey
Wild bees	Sibrang (Kheng)	Questionnaire survey
Cikada	Gonjongma (Bumthang)	Questionnaire survey
Bettles	Bainang toka (Sha)	Excreta
Snails	Bali rhroong (Kheng/ Bumthang)	Feeding data collection
Crab	Kangkarey (Kheng)	Feeding data collection & Questionnaire survey
Caterpillar	Padmalong (Kheng)	Questionnaire survey

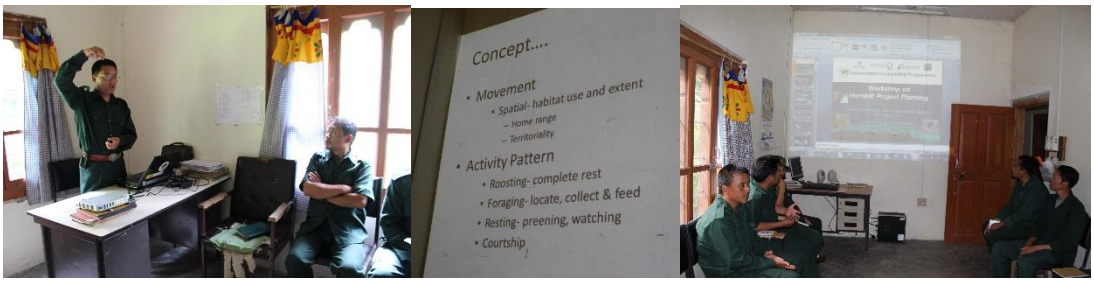
Annexure 2: Pictorial images collected on Fruits plant species and animal matter diets

A) Fruit Diets of Rufous-necked hornbills (Plant family name, species name and local names)

B) Animal matter diets of Rufous-necked hornbill

Annexure 3: Glimpses of the Hornbill Project activities funded by Conservation Leadership Programme.

1. One-day workshop



2. *Conservation awareness and education conducted as part of the outreach activities*

a. Series of competitions related to hornbill conservation

i. Best drawings selected

ii. Debate in groups, poem writing and recitation, storytelling and drawing.

b. Eco-Guided Walk teaching about common plants, animals and birds over a walk picking up waste along the traditional foot trails. Quiz competitions among the student groups.

3. Fieldwork for hornbill tagging and data collection on feeding and foraging

a. Nest verification, diet data collection, monitoring and observation of Hornbill feeding behaviors, collection of droppings (regurgitated seeds/fruits or any food parts) and gathering of information.

b. Mist netting for hornbill catching and tagging activity

c. Fruit sample collection, monitoring of tagged hornbills and data collection/questionnaire survey for gathering social views on conservation of hornbills

Acknowledgement

This study on nesting ecology and diet composition would not have materialized without the generous funding support awarded by the Conservation Leadership Programme (CLP) in the first place. So, I would like to take this opportunity to extend our sincere gratitude of thanks to all working at CLP who helped the project team in many ways for our study work.

The team would like to thank the management of Ugyen Wangchuk Institute for Conservation and Environmental Research (UWICER) for their great support and critical comments for the overall project and for the whole report structure.

The most important task was the field work wherein we would like to thank our field supporting staff friends like Mrs.Kinley Choden, Environmental Officer, Mr.Ugyen Tenzin, Forester, Mr.Tshethup Tshering, Forester all from UWICE and Mr.Wangda Jatsho, Forester, Mr.Pema Khandu, In-Charge Tsamang Sub-Range Office and all other friends working with Central Park Range in Lingmethang, Mongar and Mr.Sangayla, In-Charge Zangkhar Sub-Range Office under Phrumsengla National Park including the Park Manager Mr.Ugyen Namgyel for their wonderful support in carrying out of the field works especially in collecting data during field visits.

Besides we are also thankful to our field guide Mr.Tegpo from Tsanzabi, Mr.Leki Tshering from Broksar, Mr.Tsangpo from Thridhangbi, Mr.Sither Thinley from Saling for their great support during the field visit and data collection works. We are thankful to Mr.Ngawang Jamtsho, Unit In-Charge of Lingmethang FMU and NRDCL friends especially Kezang Tobgay for sparing Ata Ugyen who helped us physically during the hornbill tagging exercise with his lifelong experience and Lokesh Dhai for his kind assistance during the initial field work.

At the outset, we will not forget to thank the principals, participating teachers and students of Tsamang, Thridangbi and Saling primary schools for their great enthusiasm and support in making the programs fruitful and an enduring memory.

Lastly but not the least we would sincerely thank Mrs.Bee Choo for helping us in the process of arranging preparations to attend the 7th International Hornbill Conference 2017 in Malaysia. Our sincere gratitude of thanks to Dr,Pillai and team, Dr. Vijack and hornbill training team for imparting great knowledge at KhaoYai and Huwai Kha Kheng in 2016. With this we are also deeply grateful to all the organizing committee members of the 7th IHC for giving us the opportunity to participate the important event and accepting our papers to be presented during the international conference with fund supports.