Population Status and Diet of Sympatric Hornbills in Jomotsangkha Wildlife Sanctuary (JWS), Bhutan

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Presentation outline

Introduction

- ➢ Background
- ➢ Problem statement
- ➢ Scope and contribution of study
- ➢ Objectives

Literature review

- ✓ Role of hornbills in the Ecology; Seed dispersal
- ✓ Dietary habits of Asian hornbills
- ✓ Hornbills; Breeding biology

Materials and methods

- ❖ Location of the study area

Presentation outline

- **Methods**

i. Study on population status of sympatric hornbills
ii. Dietary study
iii. Study of nesting site
iv. Study of roosting site

Result and discussion

- Population status
- Diets of hornbills
- Nesting site
- Roosting site

Conclusion and recommendation
Acknowledgement
Bibliography

Introduction (Background)

- Large and charismatic birds
- Order Bucerotiformes (Family Bucorvidae and Bucerotidae)
- Tropical forest of Asia and Africa
- 15 genera, 57 species (25 species in Africa and 32 in Asia)
- Large bill surmounted with casque
- Primarily feed on fruits but also on insects and small mammals
- Seed dispersal agent-'Farmers of the forest' (Naish, 2011)

Introduction

Problem statement

- Specialized requirement
- Threats from hunting
- Habitat destruction
- Scanty study in Bhutan

Scope and contribution of study

- Pilot study in the area
- Conservation impact to all biodiversity
- Study replication

Introduction - Objectives

1) To assess the population status of hornbills in JWS.
2) To study the diets for hornbills in JWS.
3) To study the nesting site and roosting site of hornbills in JWS.
4) To make general public aware about hornbill conservation.

Literature review-Dietary habit of hornbills

- Primarily frugivory- considered omnivorous
- Fig species are keystone resource (Mudappa, 2000; O'Brien, 2007)
- 75-100% of their diet is comprise of fruits (Rohit, 2014)
- 748 plant species (163 in Africa and 589 species in Asia) in 242 genera of 79 families (Kitamura, 2011)
- Figs, lipid-rich berries/drupes and capsular fruits
- Annonaceae, Lauraceae, Miliaceae, Moraceae and Myristicaceae (Corlett, 2017)

Roles of hornbills in ecology--Seed dispersal

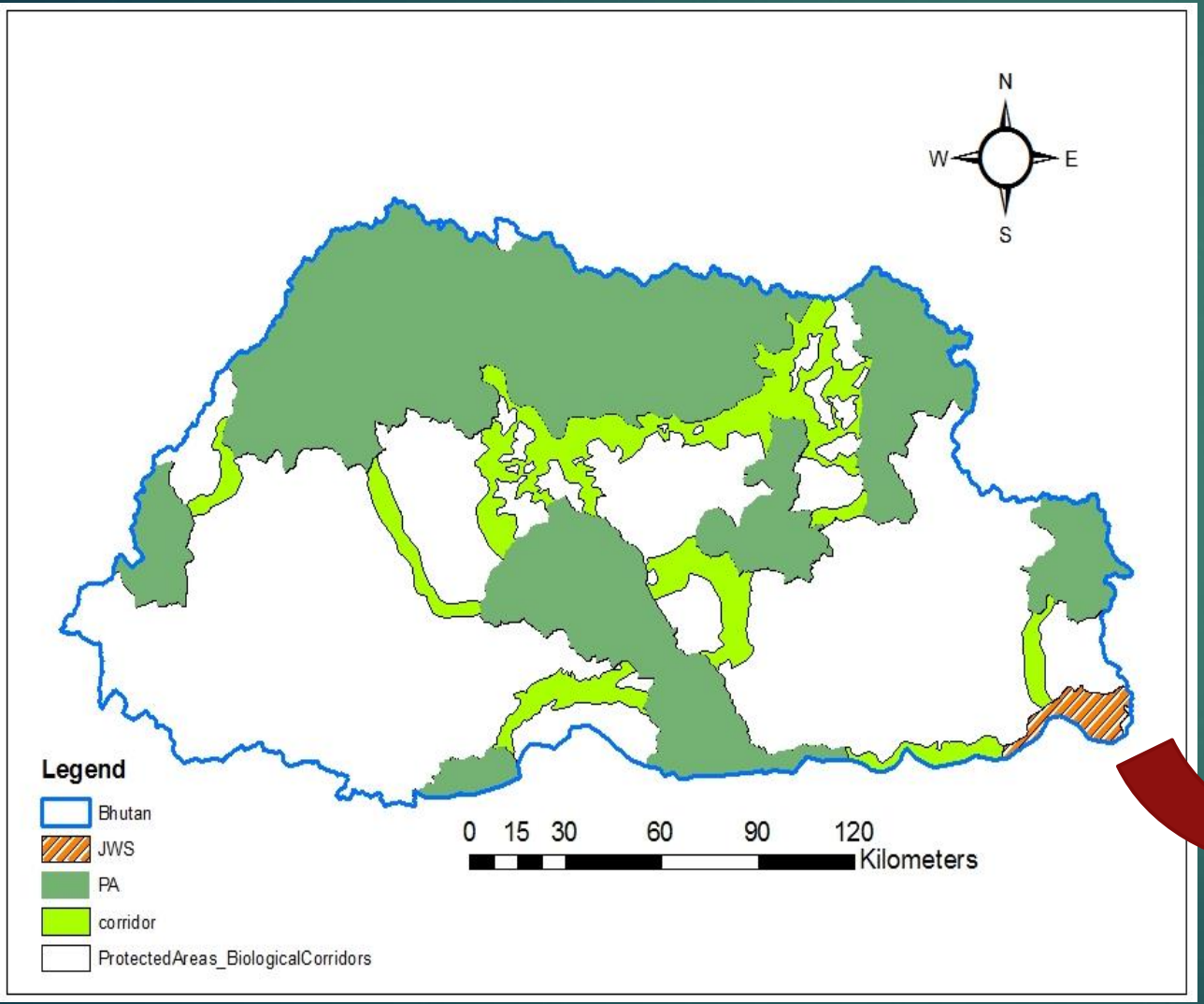
- Consume 60–600 g of fruits per day, equivalent to 20–33% of their body weight (O'Brien, 2007)
- Digest fleshy part of fruits and regurgitate/defecate the seeds intact (Kitamura, 2011)
- Carry single fruit in the bill tip but transport fruits mostly in expandable gular pouch, esophagus and stomach (Kitamura, 2011)
- Large rang species-GH fly >10km a day (Range 50sq.km – 100sq.km)

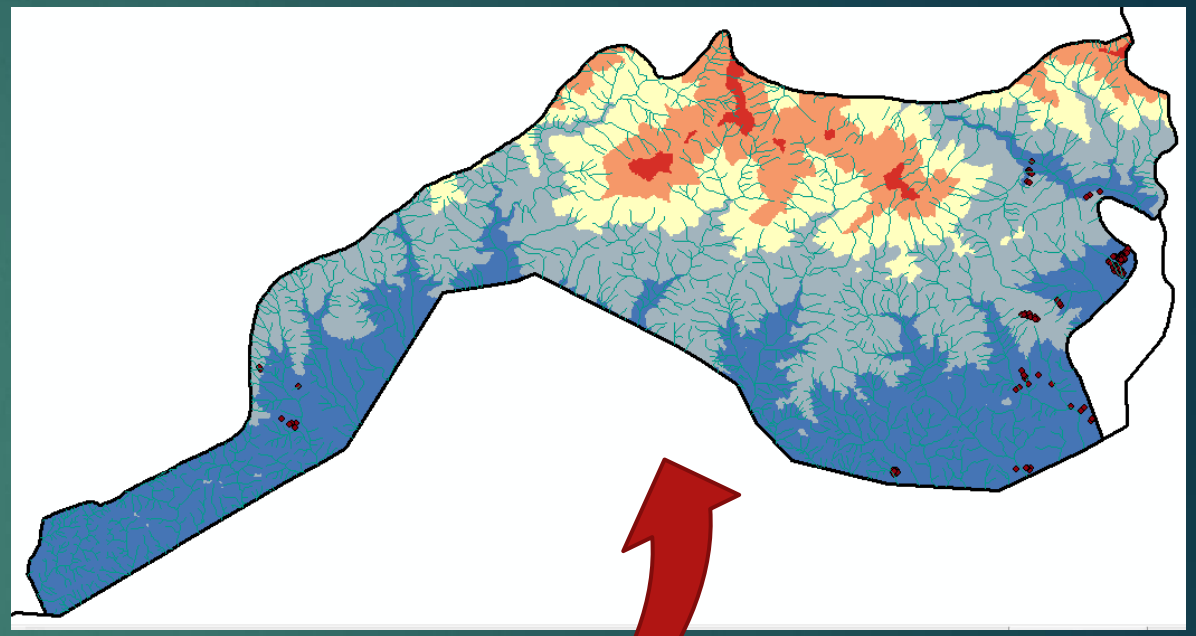
Literature review-Breeding biology

- Monogamous
- Seasonal breeder (March-August)
- Pre-breeding activity-Courtship and nest inspection
- Secondary cavity nester
- Female incarceration and nest sealing
- Breeding success-Average 1-2 chicks (Wee, 2008; Datta, 2001)

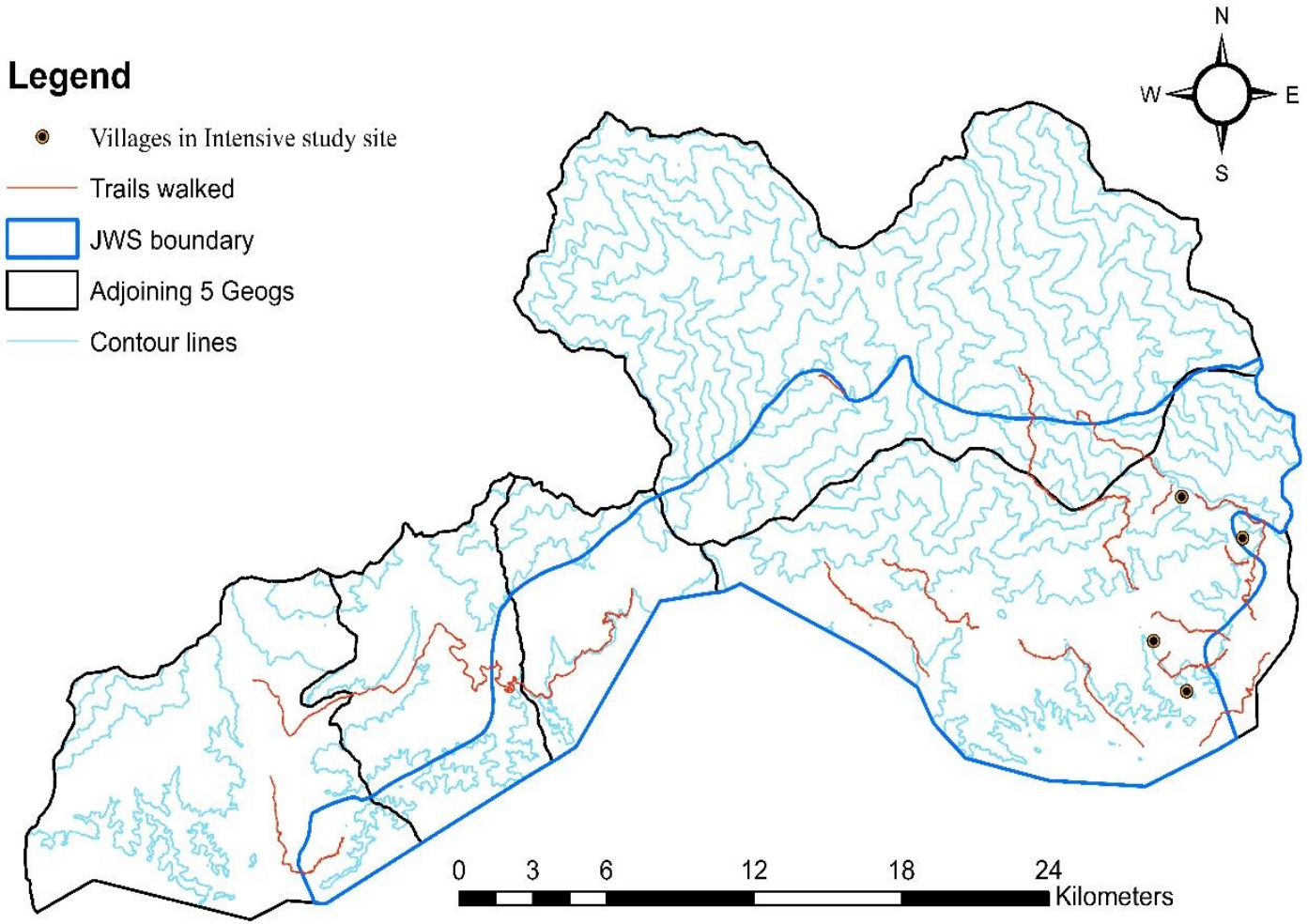
Materials and methods-Study area

Location of study area





Study area



- Area – 334.73 Sq.km
- Location - between 26°48'N to 26° 60'N and 91°42'E to 92°08'E

- **Inensive study area;**
  - Approx. 90 Sq.Km
  - 4 villages- Jampani
    - Tokaphu
    - Agurthang
    - Namchazor

Methodology-Population satus

- Walked 15 trails (2km to 27km) between 7:00 to 10:00 in the morning and 3:00 to 5:00 in the evening, except one trail was walked for whole day because of insurgency reason
- All the trails walked once but 9 trails in the intensive study area walked 3 times
- Walking rate -2km/hr.
- Sampling timing and starting and ending point of the trails in the intensive area were reversed on alternative survey
- Data were recorded upon sighting/hearing call (flying not counted) The recorded (1) focal species and number
  (4) detection cue/activity (visual, vocal or flying),
  (5) location (lat., lon. and elevation),
  (6) estimated distance
  (7) other information, tree species, height, DBH,canopy
- Analysis – Encounter rate

Methodology-Dietary study

- Observation on foraging
- Regurgitated seeds and middens below perching, nest and roosting site
- Nest watching (male deliver to female after female incarceration).

Methodology-Nest site study

- Nests were located by local people information
- Following lone male after initiation of breeding season
- Intensive search-by inspecting potential nest trees with cavities for middens

- Data recorded -nest tree species, DBH, height, distance to human habitation, road and river.
- The position of nest hole in the forest strata, cavity orientation and shape and dimension of the nest holes
- The diameter of tree trunk at nest cavity and dimension of the nest hole were visually estimated
- By taking nest tree as a center, tree species with DBH ≥30cm within the radius of 15m were enumerated

Methodology- Roost site study

- Roost site located based;
  - local people information
  - Following hornbills in the evening between 15:30 to 18:00
  - Looking for roosting sign (piles of regurgitated seeds) under potential roost trees
- Data recorded- Roosting tree species, DBH, height, roosting height, distance to human settlement, road and river
- Roosting site habitat, tree species with DBH≥30cm within the circular plot of 15m radius
- Time of arrival, hornbill species, number and direction from where they arrived.

Result- Population status

Table 1:No. of hornbills sighed along the 15 rails

Trail ID	Total KM walked	Number of sightings			
		GH	OPH	WH	RNH
T1 (Jomo-Tokaphu)	27	8	2	2	2
T2 (Jampani)	6	13	4	5	0
T3 (Chetori)	6	3	0	0	4
T4 (Jomo-Golanti)	18	2	0	0	0
T5 (Agurthang)	12	7	1	3	0
T6 (Namchazor)	15	2	1	0	0
T7 (Toka-M)	18	2	0	0	1
T8 (Ani uni)	21	1	0	1	1
T9 (Howrong)	24	2	2	0	0
T10 (Menji-Ani)	7	1	0	0	0
T11 (Kherkher)	7	1	1	0	0
T12 (Khalingduar)	7	2	0	0	1
T13 (Samrang)	27	8	1	1	0
T14 (Bangtar)	8	8	0	1	0
T15 (Chemari)	2	0	0	0	0
Total	**205**	**60**	**12**	**13**	**9**

Result- Population status

Table 2: Hornbills sighted at different altitude range

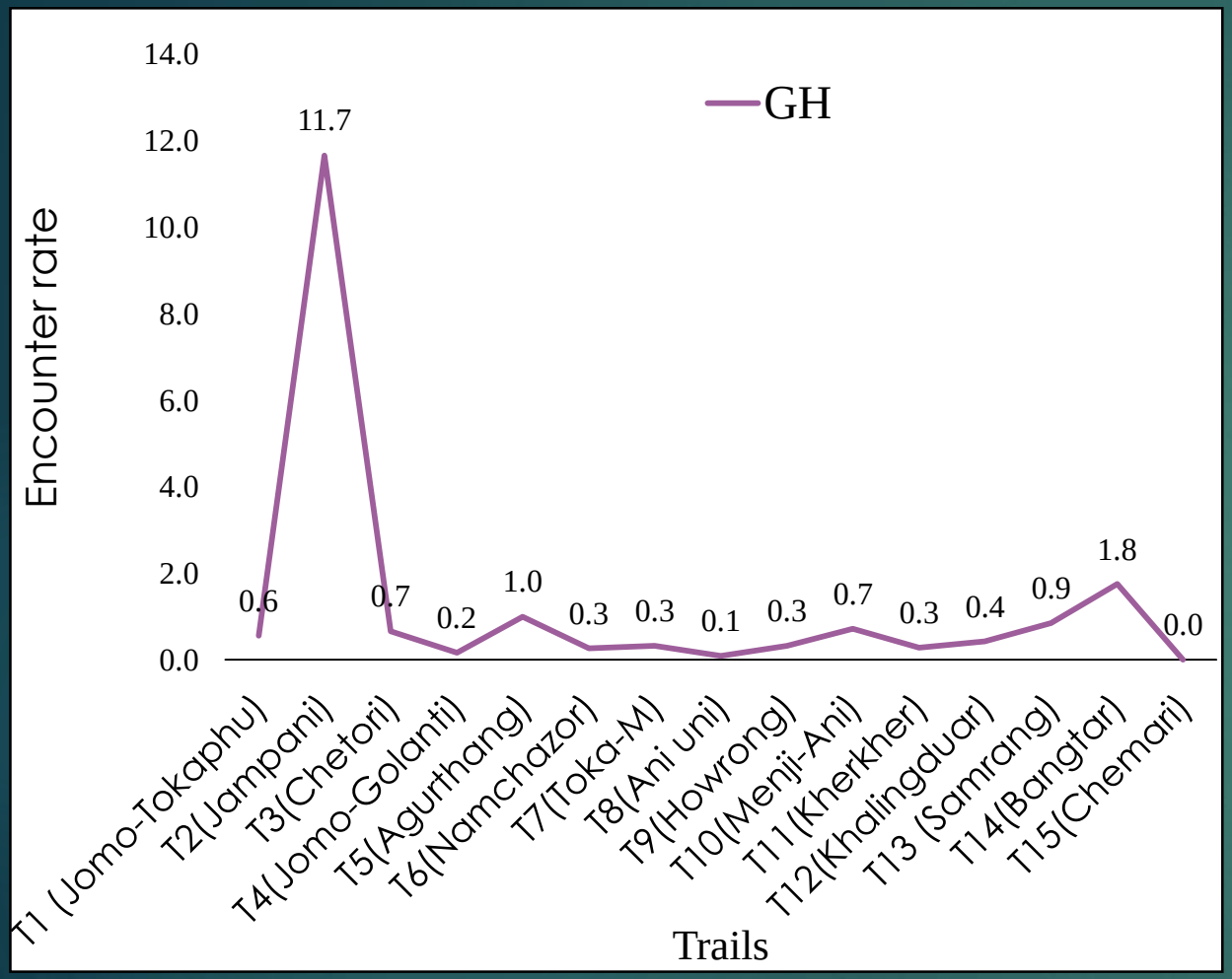
Hornbill Species	Altitude range (m)					Individuals sighted	
	<500	500-1000	1000-1500	1500-2000	Total	Flying	On trees
GH	94	75	2	0	171	23	148
OPH	28	9	0	0	37		37
WH	12	10	0	0	22	5	17
RNH	6	9	0	0	15	1	14
Total	**140**	**103**	**2**	**0**	**245**	**29**	**216**

Result – Population status

Table 3: Encounter rate (ER) of hornbills along 15 trails

Trail ID	Total KM	No. of individual sighted				Total	ER
		GH	OPH	WH	RNH		
T1 (Jomo-Tokaphu)	27	15	8	3	3	29	1.1
T2 (Jampani)	6	70	9	9	0	88	14.7
T3 (Chetori)	6	4	0	0	7	11	1.8
T4 (Jomo-Golanti)	18	3	0	0	0	3	0.2
T5 (Agurthang)	12	12	4	4	0	20	1.7
T6 (Namchazor)	15	4	5	0	0	9	0.6
T7 (Toka-M)	18	6	0	0	2	8	0.4
T8 (Ani uni)	21	2	0	2	2	6	0.3
T9 (Howrong)	24	8	4	0	0	12	0.5
T10 (Menji-Ani)	7	5	0	0	0	5	0.7
T11 (Kherkher)	7	2	2	0	0	4	0.6
T12 (Khalingduar)	7	3	0	0	1	4	0.6
T13 (Samrang)	27	23	5	2	0	30	1.1
T14 (Bangtar)	8	14	0	2	0	16	2.0
T15 (Chemari)	2	0	0	0	0	0	0.0

Result – Population status



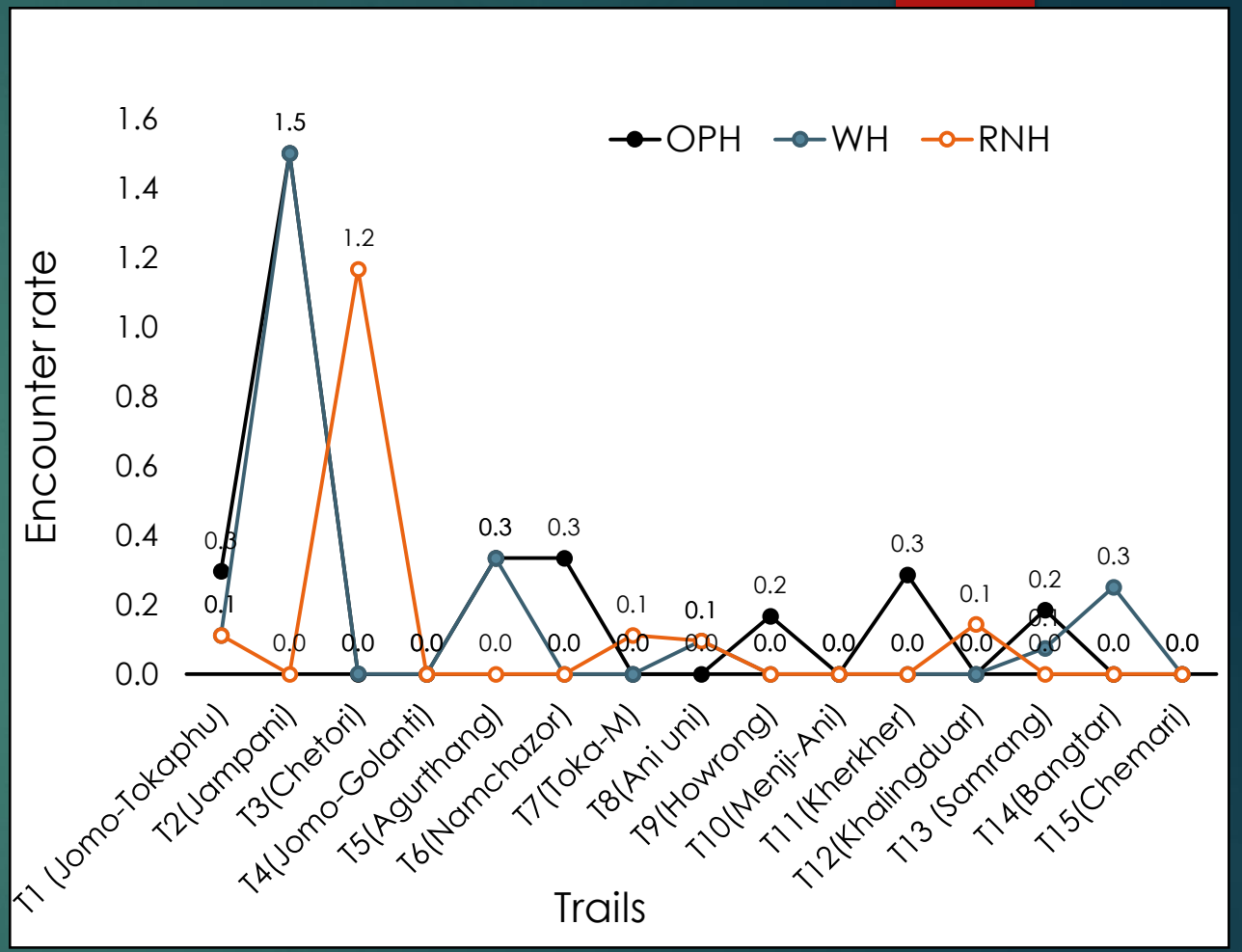


Figure 3: Encounter rate of different hornbill species

Overall ER- GH (0.8), Oriental Pied Hornbill (0.2) and Wreathed Hornbill and Rufous-necked Hornbills with (0.1) each

Result –Diet study

- Total of 46 food species (3 unidentified)
- Fruits comprise the largest proportion
- Total of 10 fig fruits species, 32 non-fig fruits species and 4 animal species
- Ripe fruits comprised 94.3% for Great Hornbill, 89.5% for Oriental Pied Hornbill, 95.8% for Wreathed Hornbill and 92.3% for Rufous-necked Hornbill

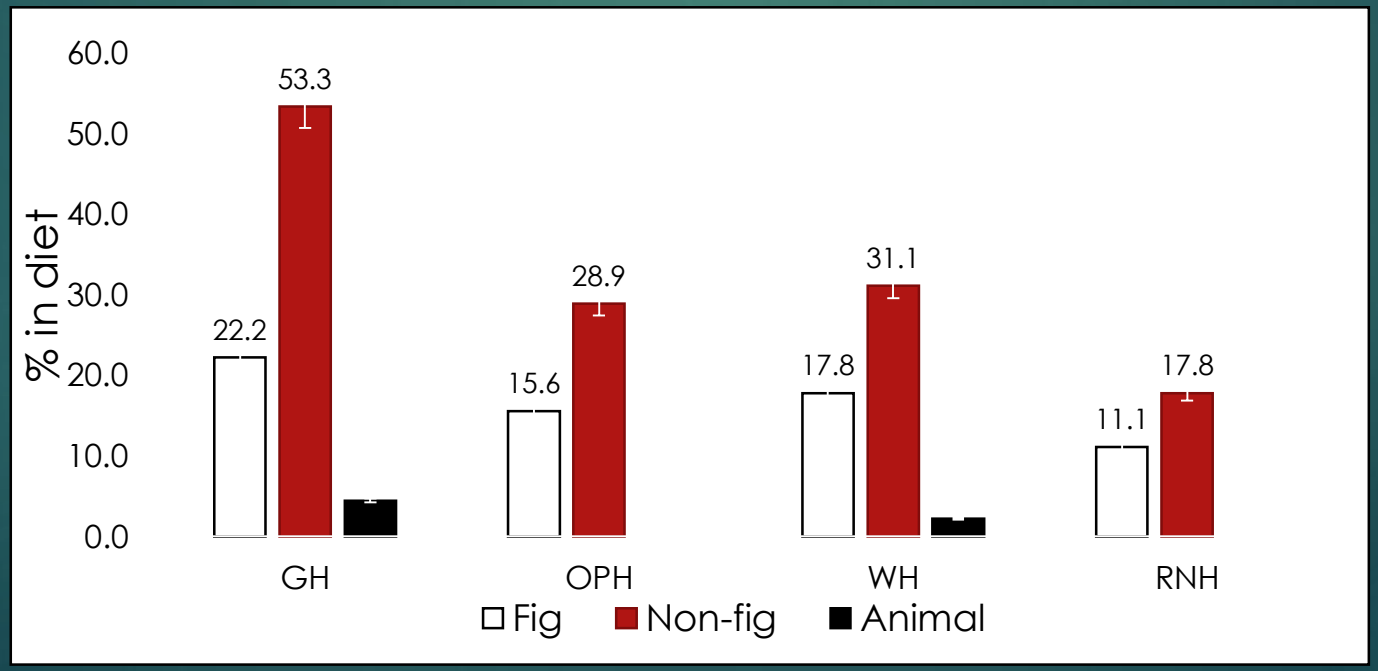


Figure 4: % consumption of different fruits by hornbills

Result –Diet study

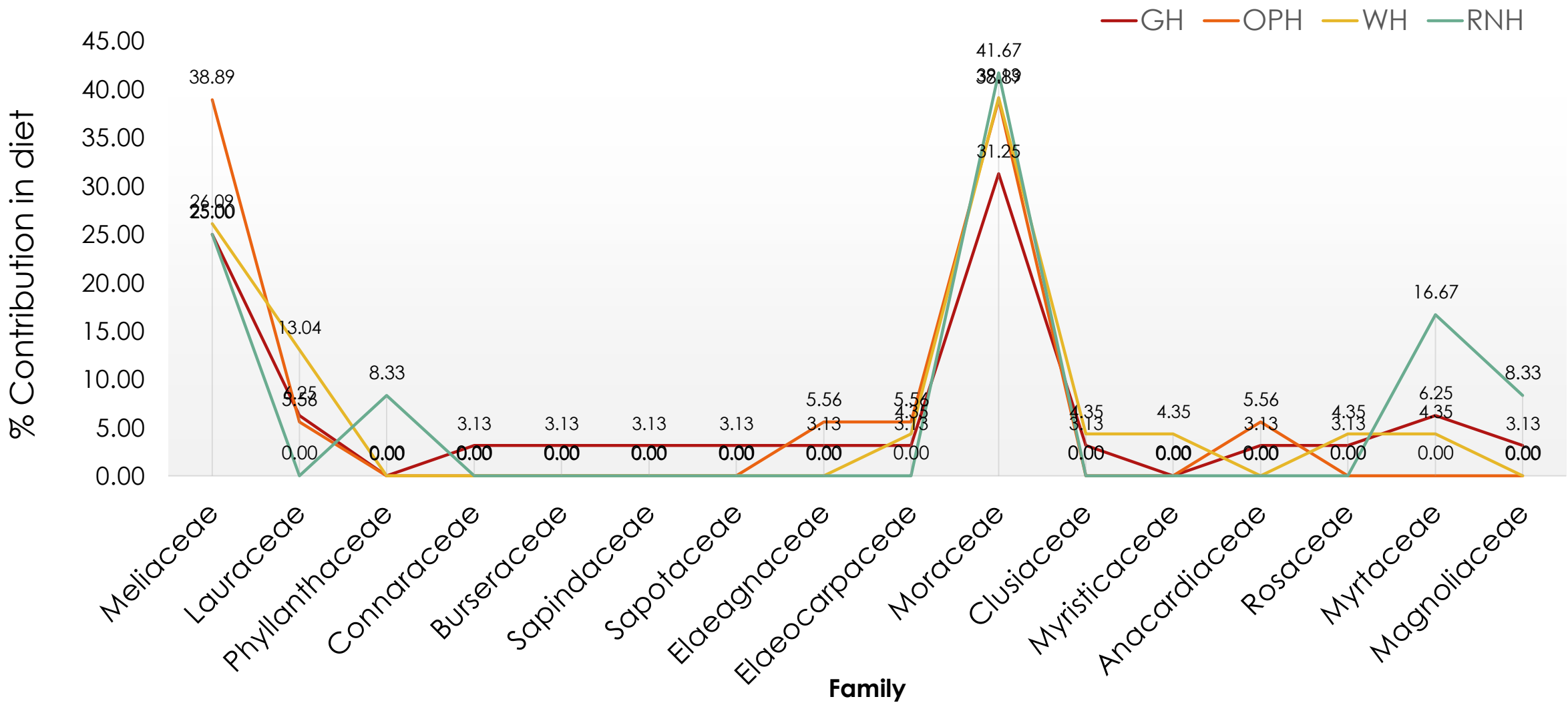
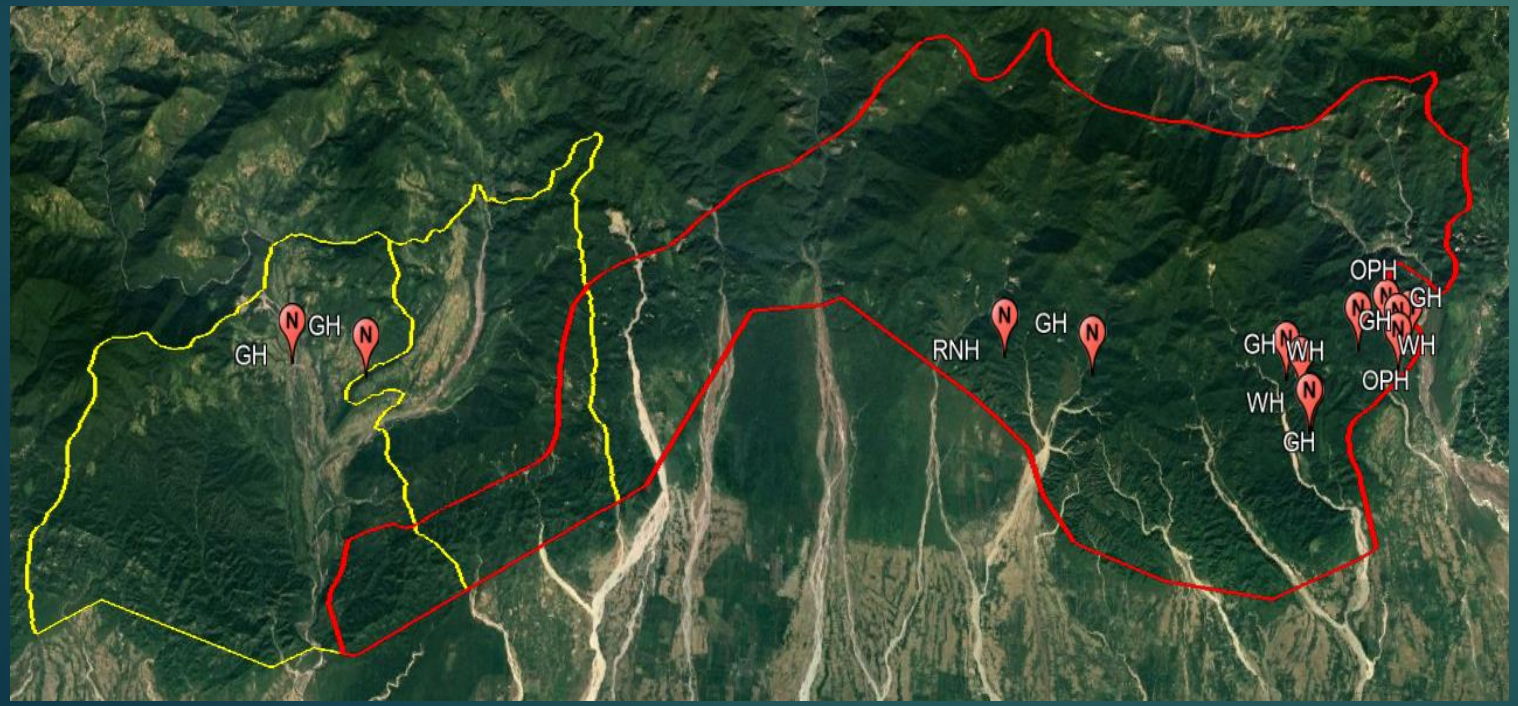


Figure 5: Fruits consumption by 4 hornbills from 16 plant families

Result –Nest site study

- Located 13 nesting sites (12 active and one abandoned)
- Both live (92.31%) and death
- Five species of tree were used for nesting and 69.23% of nest were found on *Tetrameles nudiflora*
- Mean height of nesting tree -40.31m and mean DBH -82.07cm
- Nest both in open forest and dense forest (8 nests)



- GH- 7 nests, OPH-2 nests, WH- 3 nests and one nest for Rufous-necked Hornbill.

Figure 6: Location of nest of different hornbills

Result –Nest site study

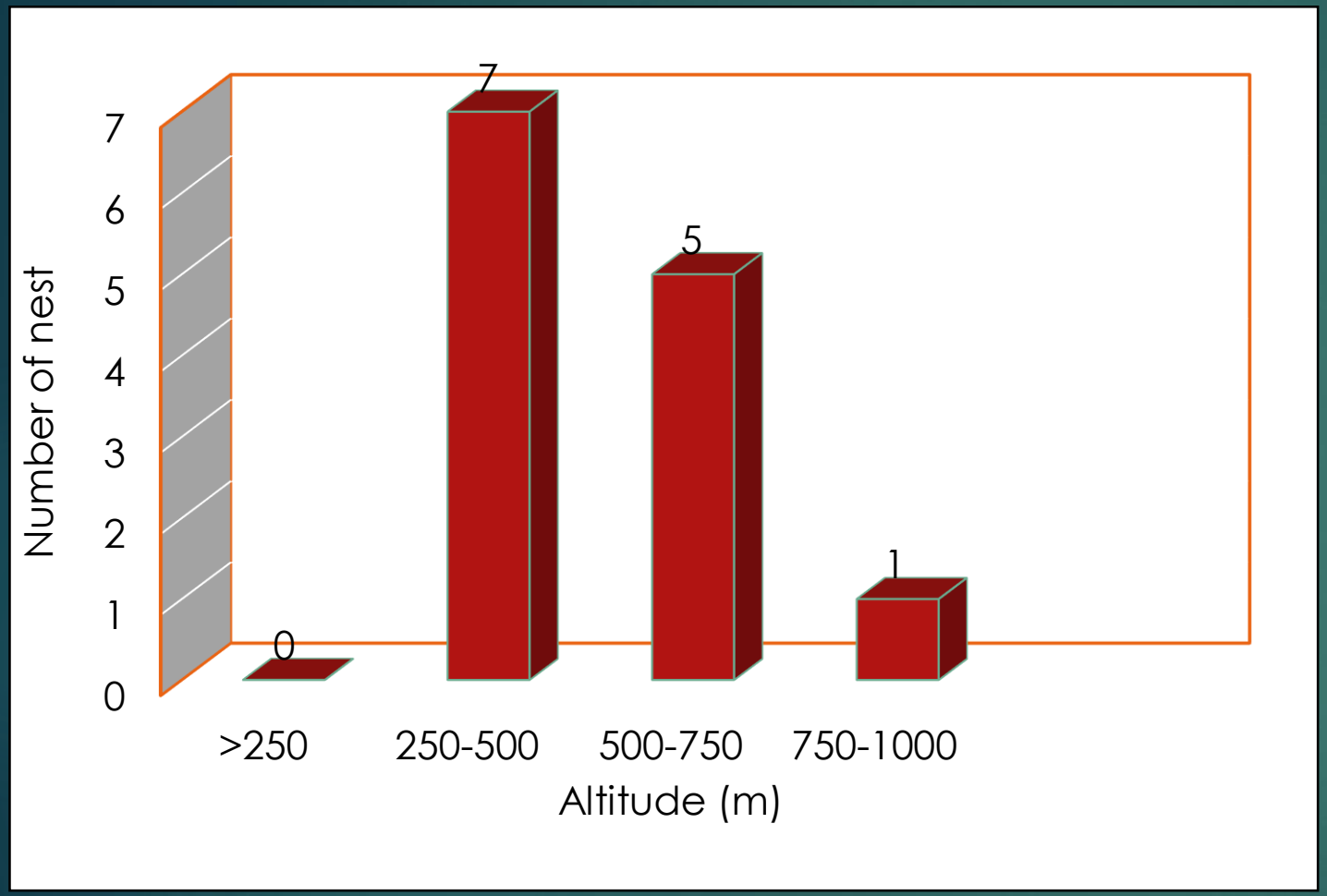


Figure 7: Nest location at different altitude range

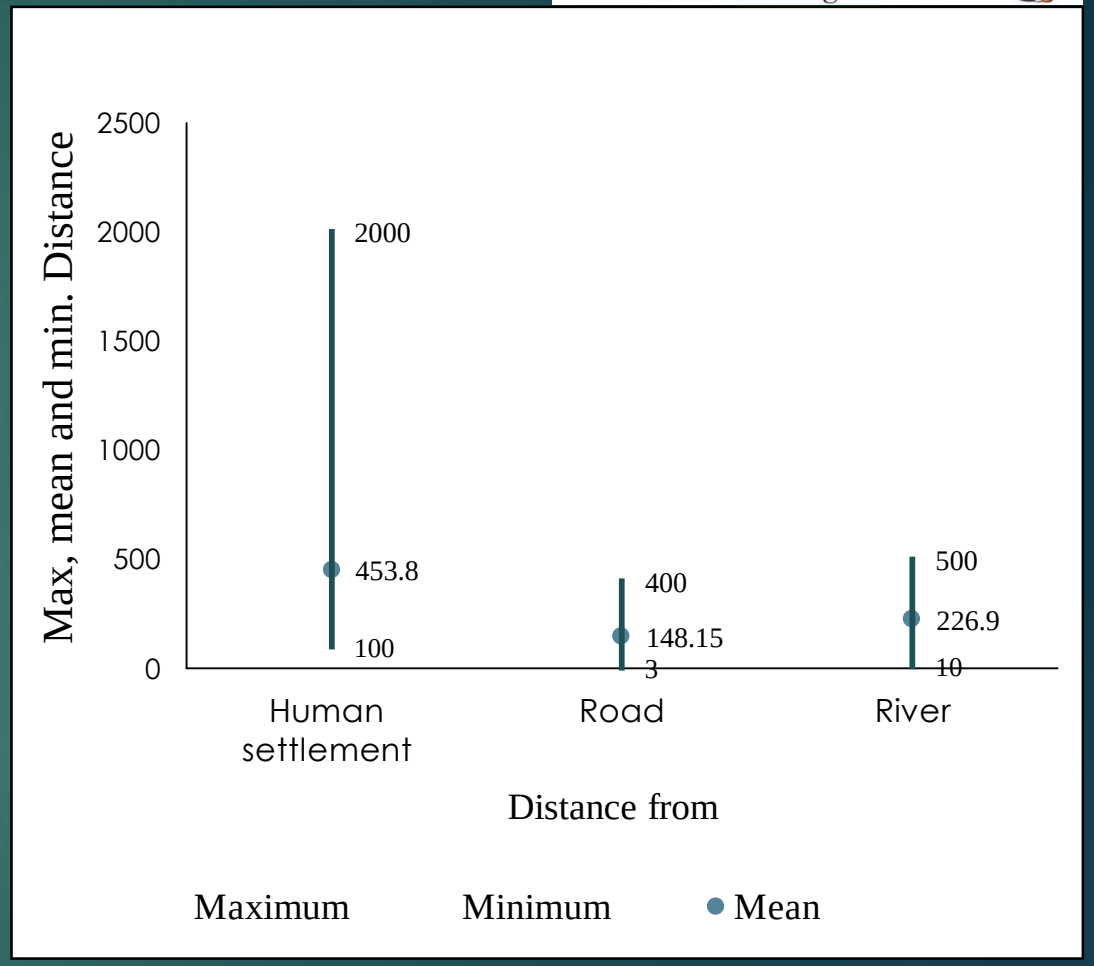


Figure 8: Distance of nest from human habitat, road and river

Result –Nest site study

Nest cavity characteristics

- Tree trunk and branch
- Upper third canopy (mostly doesn't emerge above surrounding trees)
- Circular and elongated
- Mean width (14.9cm) and mean Length (20.23cm)

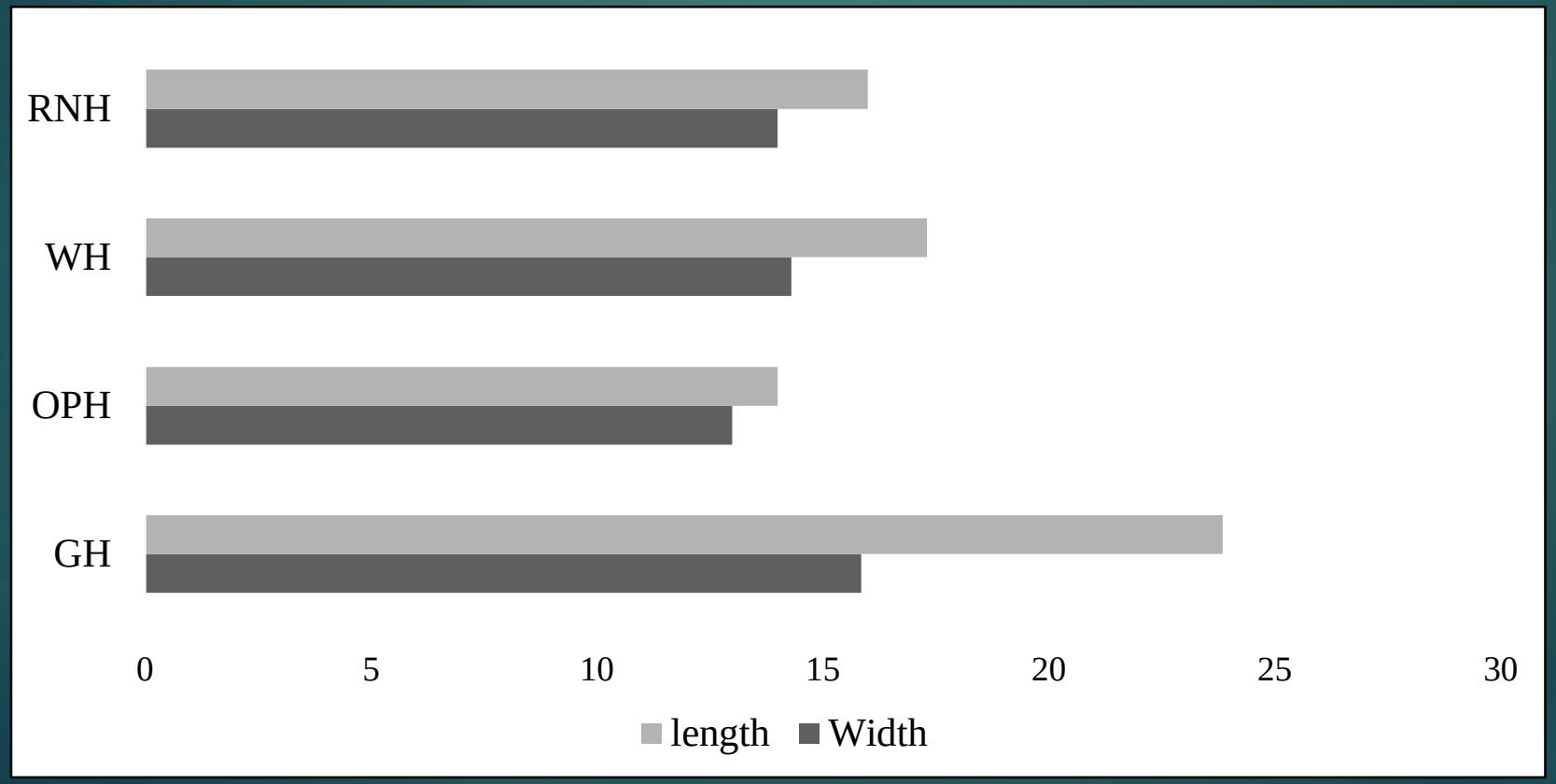


Figure 9: Mean width and length of nest holes of 4 hornbills

Result –Nest site study

- Nest cavity Orientation

- The orientation was in multi-direction (mostly North East and North West accounting 31% each
- The mean degree of nest orientation was 161.08°.

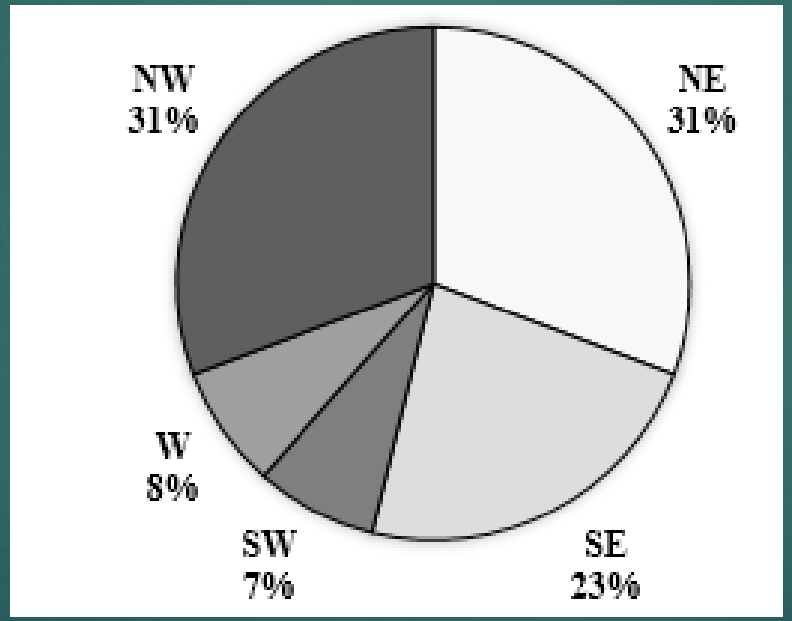


Figure 10: Orientation of nest cavity

Result –Roost site study

- 9 roosting site
- Roost on *Bombax ceiba, Tetrameles nudiflora, Albizzia procera, Quercus* sp. and *Tectona grandis*
- Mosly used *Tetrameles nudiflora* (55.56%)

Si.no.	Roost site characteristics	Mean
1	DBH of Roost trees	79.44cm ± 32.2, n=9
2	Roost tree height	38.11m ±5.3, n=9
3	Height of lowest limb of roost tree	23m ± 7.9, n=9
4	Distance to human habitation	536.67m ± 118.5, n=7
5	Distance to road	170m ± 99.2, n=9
6	Distance to River	362.22m ± 304.6, n=9
7	Altitude	393masl ± 92.6, n=9
8	Slope	40.66° ± 16.3, n=9
9	No. of trees in the roost plot (15m radius)	7 trees ± 1.6, n=9

- Roost on smaller tree than nesting tree

Figure 11: Characteristics of roosting sites

Result- Roost site study

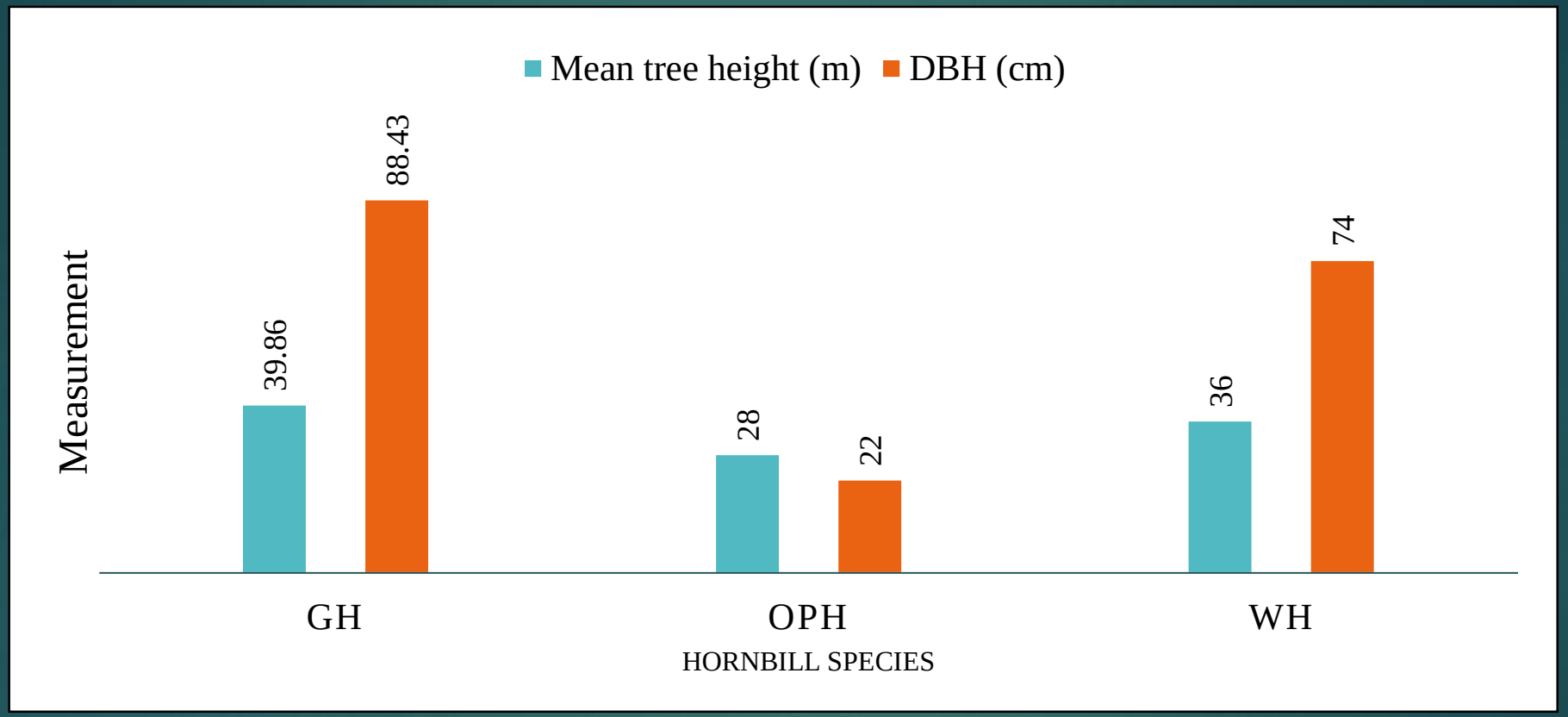


Figure 12: Mean height and DBH of roosting trees of 3 hornbills

Result –Roost site study

- Hornbill count at roost
  - Total of 156 hornbills were counted at roosts, (GH-104, OPH-27 and 25 Wreathed Hornbill)
  - The number of Great Hornbill in the roost range from 2 (pair) to 42 individuals (flock)

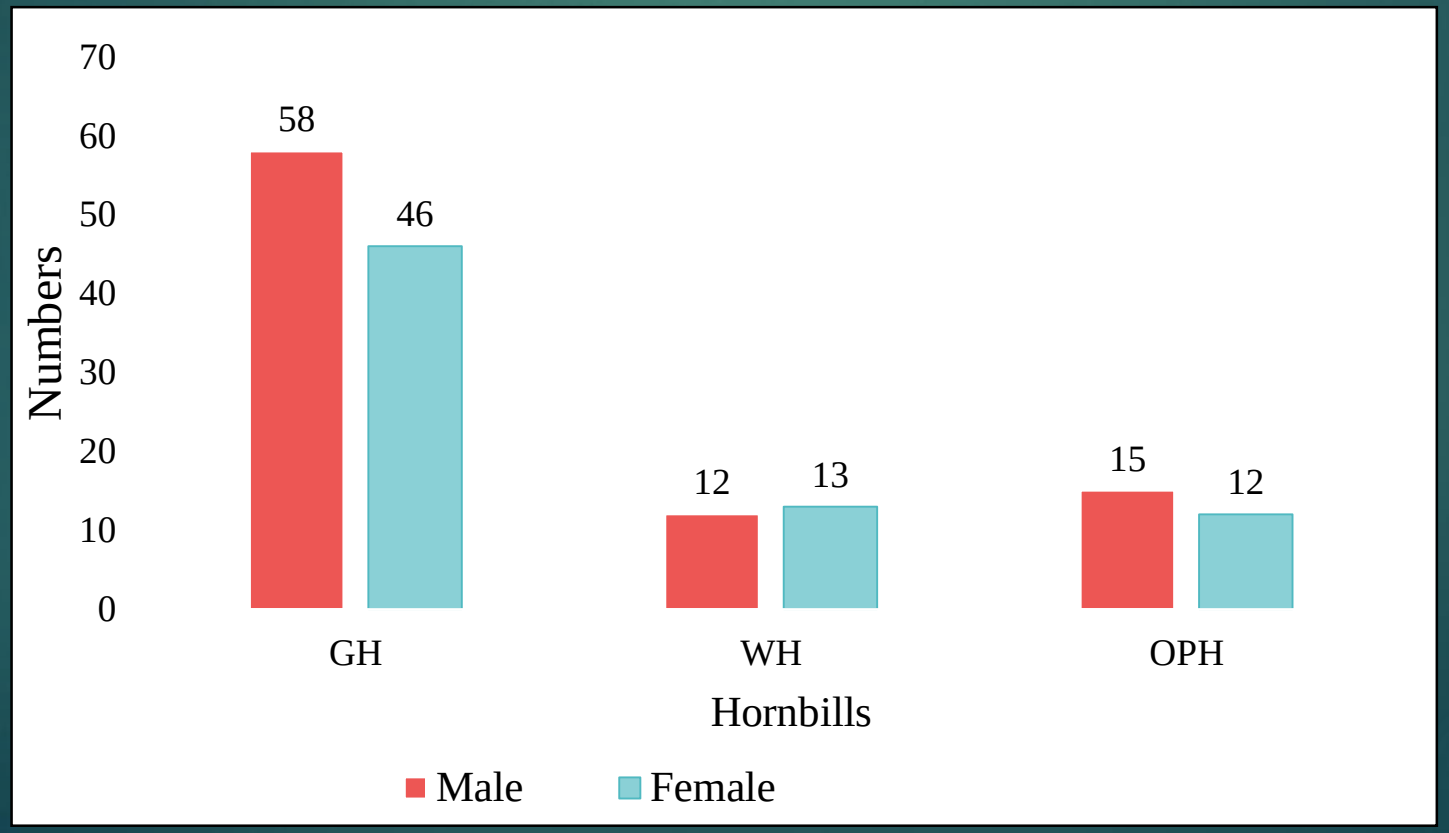


Figure 13: Count of hornbills at roost

Result and discussion

- ✓ General observation on threats and disturbances to the hornbills and habitat

- ➢ Poaching for local medical tradition
- ➢ Habitat encroachment
- ➢ Logging
- ➢ Grazing and fodder collection
- ➢ Infrastructure development

Conclusion and recommendation

Conclusion

- Highest sighting of GH and highest encounter rate (0.8), followed by OPH (0.2) and least was WH and RNH with ER of 0.1 each
- Diet from 16 plant families, mostly consume fruit of Meliaceae and Moraceae family
- GH was most generalist in terms of dietary habit
- *Tetramales nudiflora* is mostly used for nesting (69.23%) and roosting (55.54%)
- Nesting trees are larger than roosting trees
- Nest or roost both near or far from human habitation

Conclusion and recommendation

Recommendation

- Study didn't cover most of the northern part (high altitude)
- Depth study on dietary behavior
- Include hornbill conservation in management plan
- Protection of hornbill occurrence sites including nesting trees and roosting trees
- Educate and encourage local people for hornbill conservation

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Bibliography

Aparajita Datta, R. N. (2012). *Nature Conservation Foundation*. Retrieved from Hornbill seed dispersal and conservation: http://ncf-india.org/projects/hornbill-seed-dispersal-and-conservation

Balasubramanian, E. S. (2010). breeding biology and nest tree used by Indian Grey Hornbill Ocyceros birostris in the Eastern Ghats, India. *Forktail*(26), 82-85.

Cheki, K. (2017, December 12). *KUENSEL*. Retrieved from Timber extraction, a threat to Rufous-necked hornbill: http://www.kuenselonline.com/timber-extraction-a-threat-to-rufous-necked-hornbill/

Corinne P. Kozlowski, K. L. (2015). Reproductive Behavior of the Great Hornbill (Buceros bicornis). *Zoo Biology*(34), 328-334.

Corlett, R. T. (2017). Frugivory and seed dispersal by vertebrates in tropical and subtropical Asia: An update. *Global Ecology and Conservation*, 1-22. doi:http://dx.doi.org/10.1016/j.gecco.2017.04.007

Datta, A. (2001). *An Ecological study of sympatric hornbills and fruiting patterns in a tropical forest in Arunachal Pradesh.* Dehradun: Wildlife Institute of India.

Dorji, T. (2017). Habitat Modeling and Ecology of Hornbills (Bucerotidae) in Three Gewogs of Panbang, Bhutan. *Unpublished B.Sc. thesis submitted for the partial fulfillment of B.Sc. in Forestry*. Lobesa, Punakha, Bhutan: College of Natural Resources, Royal University of Bhutan.

Erik Klop, E. C. (2000). Breeding biology, nest site characteristics and nest spacing of the Visayan Tarictic Hornbill Penelopides panini panini on Panay, Philippines. *Bird Conservation International*(10), 17-27.

Franck Trolliet, P.-M. F.-L.-F. (2017). Frugivorous birds influence the spatial organization of tropical forests through the generation of seedling recruitment foci under zoochoric trees. *Acta Oecologica*, 69-76.

HRF. (2017). *Hornbill Research Foundation*. (T. H. Project, Producer) Retrieved from Breeding: http://hornbill.or.th/about-hornbills/breeding/

International, B. (2016, December 9). *ASIA*. Retrieved from BirdLife Partnership stretches its wings to Bhutan: https://www.birdlife.org/asia/news/bhutan-%E2%80%98land-thunder-dragon%E2%80%99-joins-birdlifes-flock

Ismail. S.A., G. J. (2017). Evaluating realized seed dispersal across fragmented tropical landscapes: a two-fold approach using parentage analysis and the neighbourhood model. *New Phytol*. doi:http://dx.doi.org/10.1111/nph.14427

K. Anggraini, M. K. (2000). The effects of fruit availability and habitat disturbance on an assemblage of Sumatran Hornbills. *Bird Conservation International*(10), 189-202.

Kannan, D. A. (2009). Nesting Habitat of the Great Hornbill (Buceros bicornis) in the Anaimalai Hills of Southern India. *Ornithology , 121*(3), 485-492. doi:http://dx.doi.org/10.1676/08-022.1

Kauth, M. E. (1998). Observations on the breeding biology of the Writhed-billed Hornbill (Aceros waldeni) in the Philippines. *Ornithol*(139), 475-483.

Kinley. (2016). *Ecology, people's perception and Conservation status of Rufous-necked Hornbill (Aceros nipalensis, Hodgson 1829) in South-central Bhutan.* Rufford Small Grant. The Rufford Foundation .

Bibliography

Kitamura. (2011). Frugivory and seed dispersal by hornbills (Bucerotidae) in tropical forest. *Acta Oecol*(37), 531-541.

Kitamura, S. (2011). Frugivory and seed dispersal by hornbills (Bucerotidae) in tropical forests. *Acta Oecologica*, 531-541.

Leighton. (1982). Food resource and patterns of feeding, spacing andgrouping among sympatric bornean hornbills (Bucerotidae). *Unpublished Ph.D. thesis*. University of California, Davis.

Margareta Rahayuningsih, N. E. (2017). Short Communication: The nest characteristics of Wreathed Hornbill (Rhyticeros undulatus) in Mount Ungaran, Central Java, Indonesia. *BIODIVERSITAS*, 1130-1134. doi:10.13057/biodiv/d180334

Morea, R. E. (1937). The Comparative breeding biology of African Hornbills (Bucerotidzae). *African Agriculture research station,Amani*, 331-346.

Mudappa, D. (2000). Breeding biology of the Malabar Grey Hornbill Ocyceros griseus in southern Western Ghats, India. *Bombay Natural History Society*, 15-24.

Naish, D. (2011, June 22). *ScienceBlogs*. Retrieved from Tetrapod Zoology; An introduction to hornbills: http://scienceblogs.com/tetrapodzoology/2011/06/22/hornbill-introduction/

O'Brien, M. F. (2007). *The ecology and conservation of Asian hornbills:farmers of the forest* (Vol. 27). University of Chicago Press.

Ornithology. (2016). *Ornithology-The science of the Birds*. Retrieved from Saia-Bird list: ornithology.com/travel-guides/asia-bird/

Paleri, A. (2007). Malabar Grey Hornbill Ocyceros griseus nesting near human habitation. *Indian Birds, 2*(3), 152–153.

Pilai Poonswad, A. C. (2013). *Hornbills of the World; A photographic guide*. Draco Phublishing.

Pilai Poonswad, A. T. (1985). Some Aspects of food and feeding ecology of Sympatric hornbill species in Khao Yai National Park, Thailand. *Thailang Hornbill Project*, 137-157.

Pilai Poonswad, A. T. (2004). Estimation of nutrients delivered to nest inmates by four sympatric species of hornbills in Khao Yai National Park, Thailand. *Ornithological Science*(3), 99-112.

Poonswad, P. (1994). Nest site characteristics of four sympatric species of hornbills in Khao Yai National Park, Thailand. *IBIS*(137), 183-191.

Raman, D. M. (2009). A conservation status survey of hornbills (Bucerotidae) in the Western Ghats, India. *Indian Birds, 5*(4), 90-102.

Ra-online. (2000). *Bhutan's Nature-Animal-Birds* . Retrieved from Bhutan - The last bastion of the hornbill: https://www.raonline.ch/raohomefr00.html

Rawat, A. D. (2004). Nest-site selection and nesting success of three hornbill species in Arunachal Pradesh, north-east India: Great Hornbill Buceros bicornis, Wreathed Hornbill Aceros undulatus and Oriental Pied Hornbill Anthracoceros albirostris. *Bird Conservation International, 14*, S39-S52. doi:10.1017/S0959270905000213

Bibliography

Rawat., A. D. (2003). Foraging Patterns of Sympatric Hornbills during the Nonbreeding Season in Arunachal Pradesh, Northeast India. *BIOTROPICA, 2*(35), 208-218.

Robin C. Whytock, B. J. (2018). Quantifying the scale and socioeconomic drivers of bird hunting in Central African forest communities. *Biological conservation, 218*, 18-25.

Rohit Naniwadekar, C. M. (2014). Farming the forest: hornbills govern the spatial distribution of tropical trees.

Sherub, K. (2017). Foraging behavior, food resources, and habitat use of Rufous-necked hornbill (Aceros nipalensis) in Jigme Singye Wangchuck National Park, Bhutan. Dehradun, Forest Research Institute (FRI): Unpublished, M.Sc. thesis.

Aparajita Datta, R. N. (2012). *Nature Conservation Foundation.* Retrieved from Hornbill seed dispersal and conservation: http://ncf-india.org/projects/hornbill-seed-dispersal-and-conservation

Balasubramanian, E. S. (2010). breeding biology and nest tree used by Indian Grey Hornbill Ocyceros birostris in the Eastern Ghats, India. *Forktail*(26), 82-85.

Cheki, K. (2017, December 12). *KUENSEL*. Retrieved from Timber extraction, a threat to Rufous-necked hornbill: http://www.kuenselonline.com/timber-extraction-a-threat-to-rufous-necked-hornbill/

Corinne P. Kozlowski, K. L. (2015). Reproductive Behavior of the Great Hornbill (Buceros bicornis). *Zoo Biology*(34), 328-334.

Corlett, R. T. (2017). Frugivory and seed dispersal by vertebrates in tropical and subtropical Asia: An update. *Global Ecology and Conservation*, 1-22. doi:http://dx.doi.org/10.1016/j.gecco.2017.04.007

Datta, A. (2001). *An Ecological study of sympatric hornbills and fruiting patterns in a tropical forest in Arunachal Pradesh.* Dehradun: Wildlife Institute of India.

Dorji, T. (2017). Habitat Modeling and Ecology of Hornbills (Bucerotidae) in Three Gewogs of Panbang, Bhutan. *Unpublished B.Sc. thesis submitted for the partial fulfillment of B.Sc. in Forestry*. Lobesa, Punakha, Bhutan: College of Natural Resources, Royal University of Bhutan.

Erik Klop, E. C. (2000). Breeding biology, nest site characteristics and nest spacing of the Visayan Tarictic Hornbill Penelopides panini panini on Panay, Philippines. *Bird Conservation International*(10), 17-27.

Franck Trolliet, P.-M. F.-L.-F. (2017). Frugivorous birds influence the spatial organization of tropical forests through the generation of seedling recruitment foci under zoochoric trees. *Acta Oecologica*, 69-76.

HRF. (2017). *Hornbill Research Foundation*. (T. H. Project, Producer) Retrieved from Breeding: http://hornbill.or.th/about-hornbills/breeding/

International, B. (2016, December 9). *ASIA*. Retrieved from BirdLife Partnership stretches its wings to Bhutan: https://www.birdlife.org/asia/news/bhutan-%E2%80%98land-thunder-dragon%E2%80%99-joins-birdlifes-flock

Ismail. S.A., G. J. (2017). Evaluating realized seed dispersal across fragmented tropical landscapes: a two-fold approach using parentage analysis and the neighbourhood model. *New Phytol*. doi:http://dx.doi.org/10.1111/nph.14427

K. Anggraini, M. K. (2000). The effects of fruit availability and habitat disturbance on an assemblage of Sumatran Hornbills. *Bird Conservation International*(10), 189-202.

Kannan, D. A. (2009). Nesting Habitat of the Great Hornbill (Buceros bicornis) in the Anaimalai Hills of Southern India. *Ornithology , 121*(3), 485-492. doi:http://dx.doi.org/10.1676/08-022.1

Kauth, M. E. (1998). Observations on the breeding biology of the Writhed-billed Hornbill (Aceros waldeni) in the Philippines. *Ornithol*(139), 475-483.

Kinley. (2016). *Ecology, people's perception and Conservation status of Rufous-necked Hornbill (Aceros nipalensis, Hodgson 1829) in South-central Bhutan.* Rufford Small Grant. The Rufford Foundation .

Bibliography

Kitamura. (2011). Frugivory and seed dispersal by hornbills (Bucerotidae) in tropical forest. *Acta Oecol*(37), 531-541.

Kitamura, S. (2011). Frugivory and seed dispersal by hornbills (Bucerotidae) in tropical forests. *Acta Oecologica*, 531-541.

Leighton. (1982). Food resource and patterns of feeding, spacing andgrouping among sympatric bornean hornbills (Bucerotidae). *Unpublished Ph.D. thesis*. University of California, Davis.

Margareta Rahayuningsih, N. E. (2017). Short Communication: The nest characteristics of Wreathed Hornbill (Rhyticeros undulatus) in Mount Ungaran, Central Java, Indonesia. *BIODIVERSITAS*, 1130-1134. doi:10.13057/biodiv/d180334

Morea, R. E. (1937). The Comparative breeding biology of African Hornbills (Bucerotidzae). *African Agriculture research station,Amani*, 331-346.

Mudappa, D. (2000). Breeding biology of the Malabar Grey Hornbill Ocyceros griseus in southern Western Ghats, India. *Bombay Natural History Society*, 15-24.

Naish, D. (2011, June 22). *ScienceBlogs*. Retrieved from Tetrapod Zoology; An introduction to hornbills: http://scienceblogs.com/tetrapodzoology/2011/06/22/hornbill-introduction/

O'Brien, M. F. (2007). *The ecology and conservation of Asian hornbills:farmers of the forest* (Vol. 27). University of Chicago Press.

Ornithology. (2016). *Ornithology-The science of the Birds*. Retrieved from Saia-Bird list: ornithology.com/travel-guides/asia-bird/

Paleri, A. (2007). Malabar Grey Hornbill Ocyceros griseus nesting near human habitation. *Indian Birds, 2*(3), 152–153.

Pilai Poonswad, A. C. (2013). *Hornbills of the World; A photographic guide*. Draco Phublishing.

Pilai Poonswad, A. T. (1985). Some Aspects of food and feeding ecology of Sympatric hornbill species in Khao Yai National Park, Thailand. *Thailang Hornbill Project*, 137-157.

Pilai Poonswad, A. T. (2004). Estimation of nutrients delivered to nest inmates by four sympatric species of hornbills in Khao Yai National Park, Thailand. *Ornithological Science*(3), 99-112.

Poonswad, P. (1994). Nest site characteristics of four sympatric species of hornbills in Khao Yai National Park, Thailand. *IBIS*(137), 183-191.

Raman, D. M. (2009). A conservation status survey of hornbills (Bucerotidae) in the Western Ghats, India. *Indian Birds, 5*(4), 90-102.

Ra-online. (2000). *Bhutan's Nature-Animal-Birds* . Retrieved from Bhutan - The last bastion of the hornbill: https://www.raonline.ch/raohomefr00.html

Rawat, A. D. (2004). Nest-site selection and nesting success of three hornbill species in Arunachal Pradesh, north-east India: Great Hornbill Buceros bicornis, Wreathed Hornbill Aceros undulatus and Oriental Pied Hornbill Anthracoceros albirostris. *Bird Conservation International, 14*, S39-S52. doi:10.1017/S0959270905000213

Rawat., A. D. (2003). Foraging Patterns of Sympatric Hornbills during the Nonbreeding Season in Arunachal Pradesh, Northeast India. *BIOTROPICA, 2*(35), 208-218.

Robin C. Whytock, B. J. (2018). Quantifying the scale and socioeconomic drivers of bird hunting in Central African forest communities. *Biological conservation, 218*, 18-25.

Rohit Naniwadekar, C. M. (2014). Farming the forest: hornbills govern the spatial distribution of tropical trees.

Sherub, K. (2017). Foraging behavior, food resources, and habitat use of Rufous-necked hornbill (Aceros nipalensis) in Jigme Singye Wangchuck National Park, Bhutan. Dehradun, Forest Research Institute (FRI): Unpublished, M.Sc. thesis.

Bibliography

Shumpei Kitamura, S. S. (2004). *Tropical Ecology*(20), 421–427.

Shumpei Kitamura, S. S. (2009). Evidence of the Consumption of Fallen Figs by Oriental Pied Hornbill Anthracoceros albirostris on the Ground in Khao Yai National Park, Thailand. *Ornothological Science, 8*(1), 75-79. doi:http://dx.doi.org/10.2326/048.008.0110

Shumpei Kitamura, T. Y. (2004). Characteristics of hornbill-dispersed fruits in a tropical seasonal forest in Thailand. *Bird Conservation International*(14), 81-88.

Teampanpong, J. (2014). *Maintaining Hornbills in the Working Landscape of the Southern Tenasserim Western Forest Complex Corridor in Thailand.* UNIVERSITY OF MINNESOTA.

Tsuji, P. P. (1994). Ranges of males of the Great Hornbills Buceros bicornis, Brown hornbillsPtilolaemus tickelli and Wreathed hornbill Rhyticeros undulatus in Khao Yai National Park. *Ibis, 136*, 79-86.

UWICER. (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. Lamai Goempa, Bumthang : Ministry of Agriculture and Forests. Royal Government of Bhutan.

Williams, R. R. (1986). Breeding the Great Indian hornbill Bureros bicomis at the Cotswold Wild Life Park. *Int. Zoo Yb, 25*(24), 248-252.

WWF. (2009, January 1). *WWF Global*. Retrieved from An ecological study of Rufous-necked Hornbill: http://wwf.panda.org/wwf_news/?156721/rufous-necked-hornbill-in-Bhutan

WWF. (2017). *WWF Global*. Retrieved from Habitat loss: http://wwf.panda.org/our_work/wildlife/problems/habitat_loss_degradation/

Y. C. Wee, K. C. (2008). Oriental Pied Hornbill: two recent failed nesting attempts on mainland Singapore. *BirdingASIA, 9*, 72-77.

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For your time