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**Research Article**

# SUBSTRATE USE AND FEEDING BEHAVIOR OF WESTERN HOOLOCK GIBBON (*HOOLOCK HOOLOCK*) AT SATCHARI NATIONAL PARK, HABIGANJ, BANGLADESH

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**ABSTRACT**

Substrate use and feeding behavior of wild primates depend upon the nature of the forest, composition of plant species, food items and distribution of food at different heights and site. We investigated the Substrate use and feeding behavior of the western hoolock (*Hoolock hoolock*) from December 2017 to December 2018 at Satchari National Park, Habiganj. Data were collected using a scan sampling method from dawn to dusk on the visible members of one group (five individuals) at every 5-min interval. Hoolock gibbon spent 38% of their active time in feeding followed by 27% travelling, 14% social activities, 13% foraging, and 8% resting. Gibbon performed most of their activities at the middle canopy (10-20 m) substrate height (52%) and it was followed by upper canopy (>20 m) substrate height (41%) and lower canopy (<10 m) substrate height (7%). Traveling, resting and social activity were higher (49%, 52%, and 47%, respectively) in thick branches, where foraging and feeding activities were higher in twig (40 % in both). Gibbons consumed leaves (27%), flowers (13%), fruits (50%), and animal materials (10%) as food. The study group used a total of 65 plant species belonging to 26 families. Different Fruit parts were consumed includes whole fruit with the seed (38%), peel (25%), aril (19%), the pulp (11%), and stalk (7%). Some fruits were consumed only by outer parts and the seeds remained intact. A total of 108 intact seeds of different fruits were counted from fecal counting. Intact seeds indicated that the species help in forest regeneration. This study suggests that by using the different forest substrate levels gibbons avoid intraspecific conflict and knowing their feeding habit might be helpful for the further conservation of this critically endangered species.

**Keywords:** *Hoolock gibbon, substrate use, feeding behavior, seed dispersion*

## Introduction

Western hoolock gibbon or white-browed gibbon (*Hoolock hoolock*) is a small arboreal, acrobatic, brachiating, bipedal, and tailless primate that we traditionally call “lesser ape”. Gibbons is the least known among the apes since more attention has been traditionally devoted to the great apes (Geissmann 2002). Gibbons holds a very important position in the ecology of tropical forests

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and have been under considerable threats primarily due to habitat destruction (Preuschoft *et al.*, 1984; Chivers 2001).

Among the gibbons, Hoolock Gibbons *(Hoolock hoolock)* are perhaps under the greatest threat throughout their geographic range (Mootnick *et al.*, 1987, 2000; Choudhury 2001). Currently, hoolocks are declared as globally endangered (IUCN 2005) and, critically endangered in Bangladesh (IUCN 2015).Gibbons does not use their habitat uniformly. They are very selective of their times of activity and their spatial use of habitat. Another aspect of habitat use in a forest is the substrate height above the ground where the animals are found (Rodman 1978; Sussman 1972). As gibbons are mainly arboreal primate so the use of vertical and horizontal substrates are very important to know the using patterns of forest level during the different activities of gibbon (Hasan 2007). The substrate use of primates depends upon the profile of the forest, nature of plant species abundance and distribution of food at different levels and sites of forest (Feeroz 2007). Gibbons spend most of the time in thin branches of the trees because the terminal thin branch may contain a greater proportion of young leaves and more fruits and its activity varies in different substrate height usually preferred between 6m and 20 m substrate height (Hasan *et al.*, 2007). In substrate use, they performed most of the activities on small branches than the trunk of trees (Islam 2007). Substrate height and substrate use during different activities varied significantly and between different age sex classes (Feeroz 2000). Hoolocks are considered mostly frugivorous but it was observed feeding on ant eggs and larvae by destroying the nests and trees with hands (Borah 2017). Gibbons also consume insects from the rolled dry leaves of trees; especially spiders (Arachnida) and they also collect large insects (treehoppers) by unfolding the dry leaves and eating them directly (Das 2002). Feeding behavior of gibbons depends on the nature of forest and the availability of food sources within their habitat (Feeroz 1991, 1999; Islam 1992).

Hoolock consumed more fruits (70) than leaves (15%) in the forests areas of Lawachara and Chunati in Bangladesh (Feeroz 1992; Ahsan 2001). In another low land in Hollongapa, Assam, where hoolock spent 67% of their feeding time on fruits during winter seasons (Tilson 1979). Gibbons act as important seed dispersal agents sometimes intact seeds can be found in their fecal sample that plays an significant role in the spreading of seeds and the regeneration of the forest (Kaplin and Timothy 1998). This type of behavior of gibbons helps the forest to regenerate newly where the forest is damaged. So it is an important species for forest regeneration. The aim of our study was to understand how the gibbons use their different forest substrate during different activities and observing their dietary composition, selection of food plants and preference of food items and finally ascertaining that hoolocks act as a truly arboreal and frugivorous ape species.

## Material and Methods

### *Study Area*

Satchari National Park (24°5'24°10' N, 91°25'91°30' E) is located at Chunarughat Upazilla (Sub-district) of Habiganj District, situated on the old Dhaka-Sylhet highway and is about 130-140 km north-east of the capital city, Dhaka. The Southern part of the park is surrounded by the Indian border. The Park area was a part of Raghunandan Hills Reserve Forest is 243 ha (Uddin 2007). The Park is surrounded by tea estates. This is a mixed evergreen forest but the forest type has changed due to the conversion of the indigenous forest cover to plantations (e.g., Lemon) and losses its classical forest entity (Mukul *et al.*, 2008). It is also noticed that 43 of 243ha contains

the secondary forests and the rest of the 200 ha remain the natural forests (Mukul *et al.*, 2008). A number of small, sandy-bedded streams drain the forest, all of which dry out in the winter season after November. The mixed evergreen forest of Satchari National Park forms a part of the transition zone between the Indian subcontinent and the Indo-Chinese ecological region (Sharma 2006). This forest is one of the most important habitats of the hoolock gibbons (*Hoolock hoolock*) in Bangladesh (Mukul 2007).

### *Data Collection*

Data were collected on one group (consisted of five individuals: one adult male. one adult female , two sub adult male and one infant) of Hoolock Gibbons at Satchari National Park between December 2017 and December 2018 by using scan sampling method (Altmann 1974) at 5-minute intervals. Scan sampling provides a suitable method for collecting a large sample of data under conditions of poor visibility in the forest, where a continuous 5 min interval focal sampling will not be Possible (Gupta 1996). A total of 1640 observations (8200 minutes) of activity were recorded from the gibbons during the study period. The group was followed for 3 days in a month for 13 months (a total of 136.67 hours ranging from approximately 5 hours per day). Observation periods were divided into four different time blocks; early morning (6-9 am), late morning 9 am-12 pm), early afternoon (12-3 pm), and late afternoon (3-6 pm). To observe the pattern of substrate use and substrate height, following major activities (feeding, travelling, resting, foraging, and social activities) were maintained and recorded. The height of the animal above the ground was also recorded which provided the substrate height used by the group. By measuring height, substrates were divided in three categories: (i) Lower canopy (<10 m) (ii) Middle canopy (10-20 m) (iii) Upper canopy (>20m). The thickness of the substrate was categorized into three portions named, thick branch, thin branch, and twig. Feeding behavior of gibbons were recorded when an individual was actively manipulating a potential food source, putting food into mouth or masticating. Approach on fruit (ripe or unripe), fruit parts (peel, aril, seed, pulp, stalk, whole fruit), flower (bud or full bloom), leaf (young or mature leaf), and fruit color was observed very distinctly and carefully. The percentage of time spent on different food items was calculated following equation: $\mathbf{Tf = (nf \times 100) / N}$ (Gupta and Kumar 1994; Feeroz 1999), where **Tf** = time spent on particular food item as % of total feeding time; **nf** = number of feeding records on a particular food item; and **N** =The total number of feeding records. For plant species identification, we took the photos of every plant and identified the species by using the Encyclopedia of Flora and Fauna of Bangladesh, published by Asiatic Society of Bangladesh and sometimes we took the help of plant taxonomists. Due to the scarcity of time alone to maintain the full work, the local assistant also helped in marking the plants, locating food plants, and counting plant density.

## Results and Discussion

### *The Overall Pattern of Substrate and Height use During Activities*

In Shatchari National Park, hoolock gibbon spent most of the time in feeding (38%= 3145 min) followed by traveling (27%= 2235 min), social activity (14%= 1140 min), foraging (13%= 1040 min) and resting (8%= 640 min). Feeding was the highest in October 2018 and the lowest in December 2017. Social activity was the highest in February 2018 and the lowest in August 2018. Traveling, foraging, and resting were on an average similar diagram (Fig. 1).

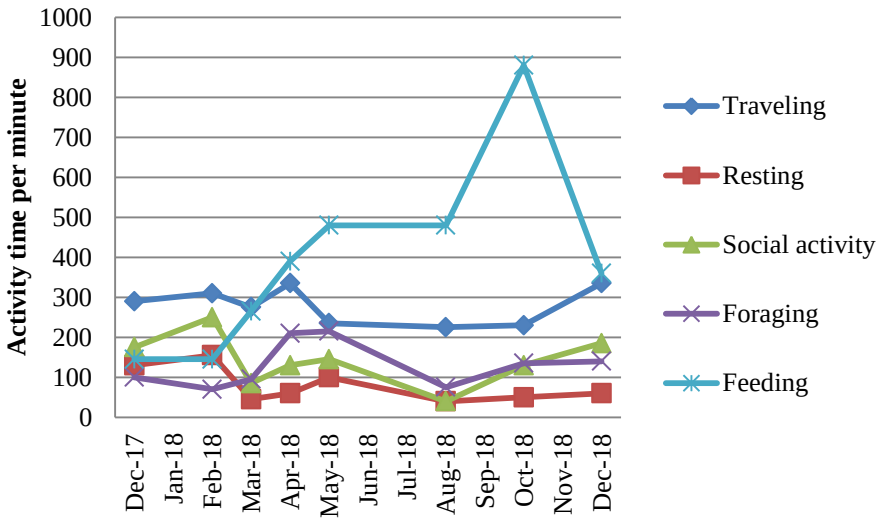


**Fig. 1.** Monthly time spent in different activity by hoolock gibbon at Satchari National Park.

Gibbons activity varies at different substrate height of the forest. Gibbons preferred to perform their activities at the middle canopy substrate height (52%) which was 10 to 20m above the ground and it was followed by upper canopy substrate height (41%) (Greater than 20m above the ground) and lower canopy substrate height (7%) (Lower than 10m above the ground) (Fig.2). Maximum feeding (58%), traveling (46%), resting (49%), foraging (51%), and social activity (48%) were recorded at the middle canopy of the forest. Minimum feeding (2%), traveling (12%), resting (9%), foraging (8%), and social activity (8%) were recorded at the lower canopy substrate height of the forest (Fig.2). In the mixed evergreen forest like Satchari National Park, maximum fruits are produced in the middle canopy and frugivore animals prefer to use the middle canopy (McKey 1981). By using this type of canopy level hoolocks mitigate their conflict with other non-human primates, i.e., *Macaca mulatta*, *Macaca leonine*, *Trachypithecus pileatus* at Satchari National Park. *M. mulatta* spend most of their active time on the ground (Sarker 2005), but *T. pileatus* and *H. hoolock* usually do not use the ground. *M. leonina* and *T pileatus* spend (87.5% and 76.2%, respectively) most of their active time between 5-15 m substrate heights (Feeroz 2000) but gibbons preferred to spend 83.6% active time between 6-20 m (Hasan *et al.*, 2007) which is very similar to present findings (10- 20 m).

In thick branches, movement, rest, and social activity were higher (49%, 52%, and 47% respectively), where foraging and feeding activity was higher in twig (40 % in both) (Fig. 3). *H. hoolock* eats most of the fruits which are mainly distributed on twigs and thin branches near the periphery while *T. pileatus* is folivore and they eat most of the young and mature leaves which are distributed throughout the canopy (Feeroz 2000). Capped langurs utilize the both thick and thin branches of trees for their feeding and they occasionally used the trunk as their feeding substrate (Kabir 2002), which is dissimilar with the gibbons. The reasons may be that gibbons are frugivorous while the langurs are folivorous.

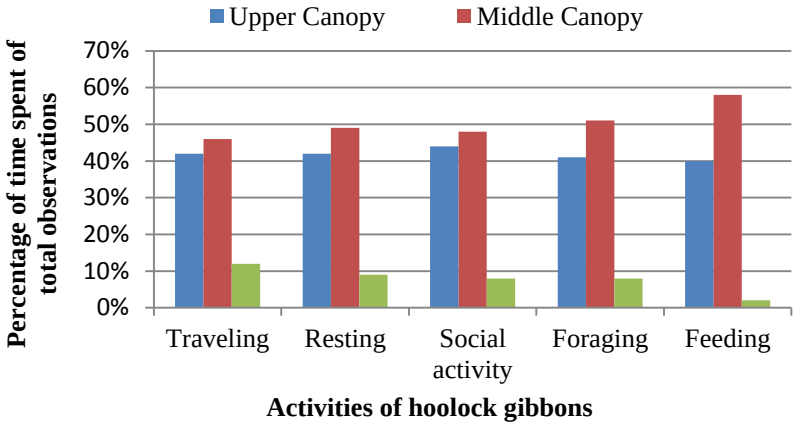


**Fig. 2.** Behavioral activities displayed at different substrate level by hoolock gibbon.

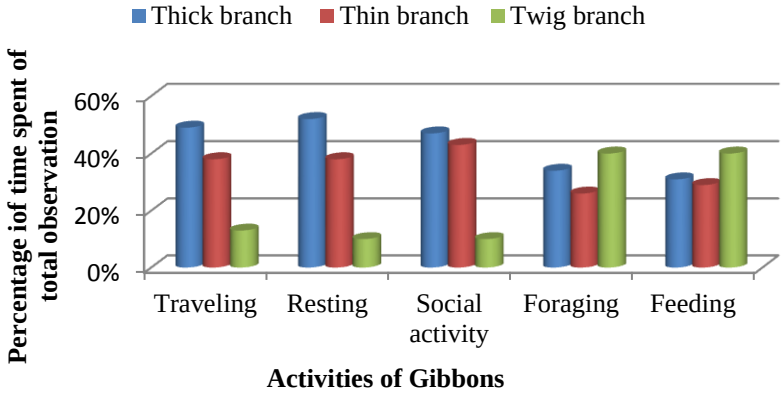


**Fig. 3.** Behavioral activities in different substrate branches by hoolock gibbon.

Body size and locomotion patterns of primates allow them to use different substrates, which may play an important role in resource partitioning (Hasan 2007). The brachiation and suspensory movement of gibbons helped them to spend more time on the thin branches of trees while relatively large-bodied *T. pileatus* spend less time (Feeroz 2000). According to Ahsan (1994) and Hasan (2007) range of substrate height for feeding in gibbons was 3m-26m, but the present study has shown that most of the activities performed at 10m-20m substrate height. The reason might be that during the last 10-15 years many large trees have been cut down illegally by encroachers, resulting in a reduction of the canopy height of the forest.

## Feeding Behavior

**Food Resources:** Hoolock gibbon spent 38% of total active time on feeding during the research period. Though plants are the main food sources of gibbons, at Satchari National Park, but two occasional animal sources (termites and caterpillars) were consumed by the gibbon. The consumption rate of termites was greater than cater pillars. The fruit was encountered for 348 times,

leaf encountered for 190 times, flower encountered for 86 times, and animal matters encountered for 71 times during observation (Fig. 4). Gibbons consumed leaves (27%), flowers (27%), fruits (50%) and animal materials (10%) as food. Fruits, leaves, and flowers are the main parts of the diet of forest-dwelling primates (Milton 1987, 1993). But no primate is found to be fully frugivorous; some animal and leaf materials seem to be essential components for the frugivore primates (Hladik 1978). The present study showed that gibbons at SNP are highly frugivorous, as has been supported by several studies (Tilson 1979; Feeroz and Islam 1992; Alfred and Sati 1994; Ahsan 2001; Das 2002). Fruits provide essential nutrient, vitamins, antioxidants, and water for the body (Milton and Jenness 1987; Milton 1999). Animal matters were mostly consumed from April to September, because during these hot and rainy months insect availability were higher or due to the presence of quality and nutritious animal items during this period.

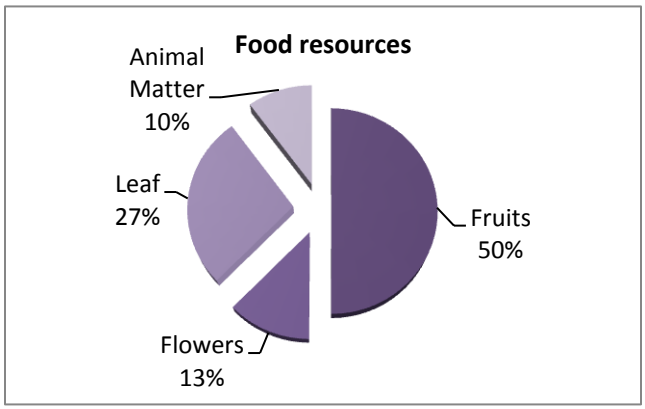


**Fig. 4.** Diet composition percentage of hoolock gibbon.

**Plant Materials as Food:**

The study group used a total of 65 plant species for their feeding activity belonging to 26 families. Of these plant species, 45 (69%) were trees, 6 (9%) were stranglers, 6 (9%) were lianas, 8 (13%) were vines (Fig. 5). Of these plants, 42 species were used for fruits, 28 species were used for leaves, and 13 species used for flowers as shown in the Table 1.

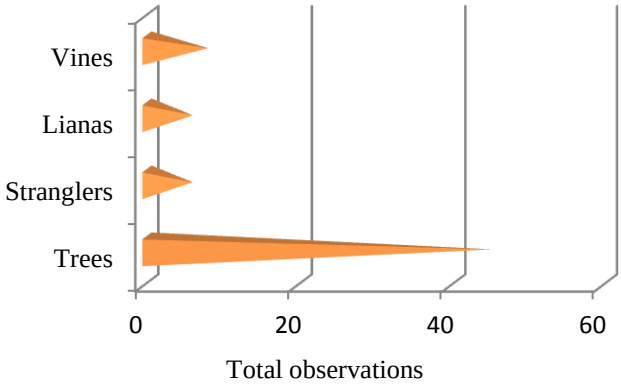


**Fig. 5.** Different types of plants usedby hoolock gibbonduring total observation.

**Table 1. Food items attributed to plant species that were eaten by gibbons**.

| Family | Species Name | Life Form | Food Items |
|---|---|---|---|
| Acanthaceae | *Thunbergia grandifolia* | Vine | Lf, Fl |
| Anacardiaceae | *Holigarna longifolia* | Tree | Fr |
| | *Spondias pinnata* | Tree | Lf, Fr |
| Aonaceae | *Artabotrys hexapelalus* | Vine | Lf, Fl, Fr |
| | *Desmos chinensis* | Liana | Lf, Fl |
| | *Melodorum fruticosum* | Liana | Lf, Fl |
| | *Polyalthia Longifolia* | Tree | Fr |
| Apocynaceae | *Alstonia Scholaris* | Tree | Lf |
| Arecaceae | *Caryota urens* | Tree | Fr |
| Asteracea | *Mikania scandens* | Vine | Lf, Fl |
| Bombaceae | *Bombax ceiba* | Tree | Fl |
| Burseraceae | *Protium serratum* | Tree | Fr |
| Combretaceae | *Terminalia catappa* | Tree | Fr |
| | *Terminalia bellirica* | Tree | Fr |
| Convolvulaceae | *Arreia nervosa* | Vine | Lf |
| | *Merremia umbellata* | Vine | Lf |
| Dilleniaceae | *Dillenia scabrella* | Tree | Fl, Fr |
| | *Dillenia pentagyna* | Tree | Fr |
| | *Tetracera sarmentosa* | Liana | Lf, Fr, Fl |
| Elaeocarpaceae | *Elaeocarpus floribundus* | Tree | Fr |
| | *Elaeocarpus robusta* | Tree | Fr |
| Euphorbiaceae | *Aporusa dioica* | Tree | Lf, Fr |
| | *Mallotus albus* | Tree | Lf, Sh |
| | *Sapium baccatuni* | Tree | Lf, Fr |
| Guttiferae | *Garcinia cowa* | Tree | Lf |
| | *Garcinja xanthochymu* | Tree | Fr, Lf |
| Lauraceae | *Lilsea glutinosa* | Tree | Fr |
| | *Liisea monopetala* | Tree | Fr |
| Leeaceae | *Leea guineens* | Tree | Fl |
| | *Leea sambucina* | Tree | Fr |
| Malvaceae | *Hibiscus surattensis* | Tree | Lf, F1 |
| Meliaceae | *Amoora wallichii* | Tree | Fr |
| | *Chukrasja tabularlc* | Tree | Lf, Fr |
| | *Toona culata* | Tree | Lf, Fr |
| Moraceace | *Artocarpus chaplasha* | Tree | Fr |
| | *Artocarpus lacucha* | Tree | Fr |
| | *Ficus variegata* | Tree | Fr |

| | | | |
|---|---|---|---|
| | *Ficus hispid* | Tree | Fr |
| | *Ficus benjamina* | Strangler | Lf, Fr |
| | *Ficus racemosa* | Strangler | Fr |
| | *Ficus bengalensis* | Strangler | Fr |
| | *Ficus retusa* | Tree | Fr |
| | *Ficus religiosa* | Strangler | Fr |
| | *Ficus gibbosa* | Tree | Lf, Fr |
| | *Ficus auriculata* | Tree | Fr |
| | *Ficus geniculata* | Strangler | Fr |
| | *Ficus pumila* | Vine | Fr |
| | *Ficus lamponga* | Tree | Fr |
| | *Ficus obtusfolia* | Strangler | Fr |
| | *Ficus nervosa* | Tree | Fr |
| Myrsinaceae | *Maesa ramentacea* | Tree | Fr |
| Myrtaceae | *Syzygium cumini* | Tree | Fr |
| | *Syzygium fruticosum* | Tree | Fr |
| Teliaceae | *Microcos paniculata* | Tree | Fr |
| Rhizophoraceae | *Carallia brachiata* | Tree | Lf, Fr |
| Rubiaceae | *Anthocephalus chinensis* | Tree | Lf, Fr |
| Rutaceae | *Zanthoxylum rhetsa* | Tree | Lf |
| Fabaceae | *Acacia pennata* | Liana | Lf |
| | *Albizia chinensis* | Tree | Lf |
| | *Cassia siamea* | Tree | Lf,Fl |
| | *Erthrina variegate* | Tree | Fl |
| | *Abru sprecatorius* | Vane | Lf |
| | *Dalbergia tamarindfolia* | Liana | Fl |
| | *Mucuna monosperma* | Vine | Fl |
| | *Entada phaseoloides* | Liana | Lf |

*** Lf= Leaf, Fl= Flower, Fr= Fruit

**Leaf**

Hoolocks ate both young and mature leaves and they consumed young leaves more (65%) than mature ones (35%). But young leaves consumption rates were not constant throughout the year. During the pre-monsoon, the availability of young leaves is increased so on that time the young leaves consumption rate was higher. On the other hand, mature leaves consumption rate was higher during winter due to the decreased availability of young leaves on the food plants as the dry season progresses (Oates *et al.*, 1980). Young leaves are also known to have more nutrients and medicinal properties than mature leaves.

**Flower**

Flowers and buds were irregularly available and form a small portion of the gibbon diet. The short duration of inflorescences and their irregular availability make flowers a temporally patchy food

source (Hasan 2005). Gibbons consumed the least amount of flowers than other food resources during the study period. It was observed that the ratio of bud and full-bloomed flowers consumed by gibbons were in equal proportion.

**Fruit**

As fruits are the main food item of the gibbons, they consumed both ripe and unripe fruits and unripe fruits (72%) were consumed more than ripe fruits (28%).

**Fruit Parts**

Fruit parts were classified with five categories; i) peel ii) aril, iii) pulp, iv) stalk and v) whole fruit. Sometimes gibbons crunched the fruits but, most of the time they consumed the fruits wholly with seeds (38%). Other parts were consumed respectively peel (25%), aril (19%), pulp (11%), and stalk (7%). Eating only peel, aril, pulp or stalk keeps the seed safe when it is not crunched. These seeds drop on the forest floor and regenerate. Gibbons dropped a large number of fruits from the mother trees. Some fruits of following fruiting trees like litsea, garcinia, caryota, artocaprpus were eaten only outer layers and not consumed fully and these fruits were dropped. The rate of dropped and semi consumed fruits with intact seeds was very high and a total of 108 intact seeds of different fruits were estimated from fecal sample during the study period. This behavior revels that gibbons are seed dropper and it is very important for the forest that the seeds were not destroyed and the regeneration process can precede through the gibbons very significantly.

In some cases, primates feed in a fruiting tree, fill their mouths and then travel away from the tree, spitting seeds out as they travel (Corlett and Lucus 1990; Rowell and Mitchell 1991). Seeds transported in mouth can be carried about 30-50 m from the parent tree, and up to 100 m, before being discarded (Rowell and Mitchell 1991). For some species of fruiting trees, this type of seed dispersal may play a significant role in its propagation and recruit under or nearby the parent canopies as a reproductive strategy.

## Conclusion

Western hoolock gibbon (*Hoolock hoolock*) is one of the most important species of primate in South Asia. IUCN red data list has already placed the species under the critically endangered category in Bangladesh. So an effective conservation plan needs to be introduced in the degraded habitats of gibbons to introduce in the degraded habitats of gibbons to protect minimum viable population. Planting the most preferred and fruiting plants species that may increase the natural food sources for gibbons as well as provide canopy links that will be helpful to explore more food resources and different substrate height. So this study provides useful information which may help in the management of the Satchari National Park that will play a long-term conservation effect for this only frugivore ape existing in our country.

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## References

Ahsan, M.F. (1994). Behavioral ecology of the hoolock gibbon (*Hylobates hoolock*) in Bangladesh. *Ph D Dissertation, University of Cambridge, UK*, pp. 446.

Ahsan, M.F. (2001). Socio-ecology of the hoolock gibbon (*Hylobates hoolock*) in two forests of Bangladesh. Brookfield Zoo, compiler. *The apes: challenges for the 21st century: Conference proceedings. Brookfield Zoo, Brookfield*, pp. 286-299.

Alfred, J.R.B. and Sati, J.P. (1994). Diet and feeding in the hoolock gibbon of Garo Hills in North-eastern India. *Ann. Forest*, 2: 109-122.

Altmann, J. (1974). Observational study of behaviour: Sampling methods. *Behaviour*, 49(3): 227-267.

Borah, M., Devi, A. and Kumar, A. (2017). Diet and feeding ecology of the western hoolock gibbon (*Hoolock hoolock*) in a tropical forest fragment of Northeast India. *Springer*:

Chivers, D.J. (2001). The swinging singing apes: Fighting for food and family in far-east forests. In: The apes: Challenges for the 21st century. Conference Proceedings, *Chicago Zoological Society*, Brookfield, Illinois, U.S.A., pp. 1-28.

Choudhury, A. (2001). Primates in northeast India: An overview of their distribution and conservation status. *ENVIS Bulletin: Wildlife and Protected Areas*, *1*(1), 92-101.

Corlett, R.T. and Lucas, P.W. (1990). Alternative seed-handling strategies in primates: seed spitting by long-tailed macaques (*Macacafascicularis*). *Oecologia*, 82: 166-171.

Das, J. (2002). Socio-ecology of hoolock gibbon in response to habitat change. *Ph.D. thesis, Department of Zoology, Guwahati University, Guwahati, India.*

Das, J., Feeroz, M.M., Islam, M.A., Biswas, J., Bujarboura, P., Chetry, D., Medhi, R. and Bose, J. (2003). Distribution of hoolock gibbon (*Bunopithecus hoolock hoolock*) in India and Bangladesh. *Zoos´ Print Journal*, 18(1): 969-976.

Feeroz, M.M. (1991). The ecology and behavior of hoolock gibbons (*Hylobates hoolock*) of Bangladesh.*Unpublished M. Sc. Thesis, Jahangirnagar University, Bangladesh*.

Feeroz, M.M. (1999). The ecology and behavior of the pig tailed macaque (*Macaca nemestrina leonina*) in Bangladesh. *Ph.D. Thesis, University of Cambridge, Cambridge*, pp. 402.

Feeroz, M.M. (2000). Height and substrate use during feeding and foraging by the Pig-tailed Macaque (*Macaca nemestrina leonina*) in Bangladesh. *Journal of Asiatic Society*, Bangladesh, 26 (2): 237-244.

Feeroz, M.M. (2001). Species diversity and population density of non-human primates in north-east and south-east of Bangladesh. *Ecoprint*, 8(1): 53-57.

Feeroz, M.M. and Islam, M.A. (1992). Ecology and behaviour of hoolock gibbons of Bangladesh. Multidisciplinary Action Research Centre ( MARC ). Dhaka, Bangladesh (a p art of NORAD/IUCN supported environmental education Program in Bangladesh). pp. 76.

Geissmann, T. (2002). Gibbons: Communication, Radiation and Conservation Biology of the Forgotten Apes. D.Phil. Thesis, *InstitutfürZoologie*.

Gittins, S.P. (1984). The distribution and status of hoolock gibbons in Bangladesh. *In*: Preuschoft, H., Chivers, D.J., Brockelman, W.Y. and Creel, N. (Eds). The Lesser Apes: Ev olutionary and Behavioural Biology. *Edinburgh University Press*, Edinburgh. pp.13-15.

Gittins, S.P. and Akonda, A.W. (1982). What survives in Bangladesh? *Oryx.*,16: 275-281.

Gittins, S.P. and Tilson, R.L. (1984). Notes on the ecology and behavior of the hoolock gibbon *In*: Preuschoft, H., Chivers, D. J., Brockelman, W. Y. and Creel,N. (Eds). The Lesser Apes: Evolutionary and Behavioural Biology. *Edinburgh University Press*. Edinburgh. pp. 258-266.

Gupta, A.K. (1996). Conservation ecology of primates and human impact in the forest of north-east India. *Ph.D. thesis, University of Cambridge, UK*.

Gupta, A.K. and Kumar, A. (1994). Feeding ecology and conservation of the Phayre'sleaf monkey (*Presbytis phayrei*) in Northeast India. *Journal of Biological Conservation*, 69: 301-306.

Hasan, M.K., Feeroz, M.M., Islam, M.A., Kabir, M.M. and Begum, S. (2007). Substrate use by the western hoolock gibbon (Hoolock hoolock) in a semievergreen forest of Bangladesh. *Zoos' Print Journal*, 22(6): 2702-2705.

Hladik, A. (1978). Phenology of leaf production in rain forest of Gabon: distribution and composition of food for folivores. In: Montgomery GG (Ed.). The ecology of arboreal folivores.*Smithsonian Institute Press*, Washington, pp. 51-71.

Islam, M.A. and Feeroz, M.M. (1992). Ecology of hoolock gibbon of Bangladesh *Primates*, 33: 451-464.

Islam, M.A., Feeroz, M.M., Kabir, M. M., Begum, S. and Muzaffar, S. B. (2004). Conservation of hoolock gibbons (*Bunopithecus hoolock*) of Bangladesh. *Technical Report. US Fish and Wildlife Service*, 52.

IUCN. (2005). Red list of threatened species. www.redlist.org.

IUCN. (2015). Red List Book of Threatened Mammals of Bangladesh. IUCN-The World Conservation Union, Bangladesh.

Kabir, M.M. (2002). Behavioral ecology of two sympatric langur species in the semi evergreen forest of Bangladesh. *Ph.D. thesis, University of Cambridge, Cambridge*, pp. 351.

Kaplin, B.A. and Timothy, C.M. (1998). Variation in seed handling by two species of forest monkeys in Rwanda. *American Journal of Primatol*, 45: 83-101.

McKey, D.B., Gartlan, J.S., Waterman, P.G. and Choo, G.M. (1981). Food selection by black colobus monkeys (Colobus satanas) in relation to plant chemistry. *Biological Journal of the Linnean Society*, 16(2): 115-146.

Milton, K. (1987). Primate diets and gut morphology: implications for human evolution. In: Harris, M. and Ross, E.B. (Eds.). Food and evolution: toward a theory of human food habits. *Temple University Press*, Philadelphia, pp. 93-116.

Milton, K. (1993). Diet and primate evolution. *Scientific American*, 269(2): 86-93.

Milton, K. (1999). Nutritional characteristics of wild primate foods: do the diets of our closest living relatives have lessons for us? *Nutrition*, 15:488-498.

Milton, K. and Jenness, R. (1987). Ascorbate content of Neotropical plant parts available to monkeys and bats. *Experientia*, 43:339.

Mootnick, A.R., Haimoff, E.H. and Nyunt-Lwin, K. (1987). Conservation and captive management of hoolock gibbons in the Socialist Republic of the Union of Burma. In *AAZPA Annual Proceedings*, 398424.

Mukul, S.A., Uddin, M.B. and Tito, M.R. (2007). Medicinal plant diversity and local healthcare among the people living in and around a conservation area of northern Bangladesh.*International journal of forest usufructs management*, 8 (2): 50-63.

Mukul, S.A., Uddin, M.B., Uddin, M.S. and Marzan, B. (2008). Protected areas of Bangladesh: c urrent status and efficacy for biodiversity conservation. *Proceedings of the PakistanAcad emyof Sciences*, 45(2): 59-68.

Oates, J.F., Waterman, P.G. and Choo, G.M (1980). Food selection by the South Indian leaf monkey *Presbytis johnii*, in relation of leaf chemistry. *Oecologia*, 45:45-56.

Preuschoft, H., Chivers, D.J., Brockelman, W.Y. and Creel, N. (Eds.). (1984). The Lesser Apes: Evolutionary and Behavioural Biology. *Edinburgh University Press*, Edinburgh, UK.

Rodman, P. (1978). Diets, densities and distribution of Bornean primates.*In*:MontogomeyG. (Ed. The ecology of arboreal folivores. *Smithsonian Institution Press*, Washington, D.C. pp. 465-478.

Rowell, T.E. and Mitchell, B.J. (1991). Comparison of seed dispersal of guenons in Kenya and capuchins in Panama. *Journal of Tropical Ecology*, **7**: 269-274.

Sarker, G.C., Kabir, M.M., Feeroz, M.M. and Hasan, M.K. (2005). Substrate and height use of Rhesus Macaque- *Macaca mulatta* at Gazipur of Bangladesh. *Bangladesh Journal of Life Sciences*, 1l7(l):83-92.

Sharma, R. (2006). Management Plan for Satchari National Park. *Nishorgo Support Project, Forest Department, Government of the People's Republic of Bangladesh*, 1: 1-70.

Sussman, R.W. (1972). Ecological distinctions in sympatric species of Lemur. In: Martin, R.D., Doyle, G.A. and Walker, A.C. (Eds.). *Prosimian biology. Duckworth, London*. pp. 75-108.

Tilson, R.L. (1979). On the behaviour of hoolock gibbon (*Hylobates hoolock*) during different seasons in Assam, India. *Journal of the Bombay Natural History Society*, 76: 1-16.