Biodiversity Status of Biological Corridor 4 (BC4)

Zhemgang Forest Division
Department of Forests and Park Services
Zhemgang : Bhutan
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Authors

2022

Panthera tigris (Royal Bengal Tiger scent marking)

Acronyms and Abbreviations

BC 4	Biological Corridor 4
BMG	Biodiversity Monitoring Grid
BMSSPB	Biodiversity Monitoring and Social Survey Protocol of Bhutan
CATS	Conservation Assured Tiger Standard
CBL	Cool Broad Leaved
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
DBH	Diameter at Breast Height
DoFPS	Department of Forests and Park Services
EN	Endangered
FMCB	Forest Management Code of Bhutan
IUCN	International Union for Conservation of Nature and Natural Resources
JSWNP	Jigme Singye Wangchuck National Park
km	Kilometer
m	Meters
masl	Meters above sea level
NT	Near Threatened
PNP	Phrumsengla National Park
RBA	Rapid Biodiversity Assessment
RBA%	Relative Basal Area Percentage
SES	Socio-Economic Survey
TFD	Territorial Forest Division
VU	Vulnerable
WBL	Warm Broad Leaved
ZFD	Zhemgang Forest Division

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Executive summary

The habitat fragmentation due to developmental activities and other threats has significantly impacted biodiversity loss and species survival. As a result, conservation efforts were put in place to minimize such impacts. The significant effort includes setting aside more extensive tracts of land or water bodies as protected areas and creating a connectivity landscape between these areas as wildlife corridors. Wildlife corridors are shown to successfully connect the isolated wildlife population and thereby ensure their survival.

Guided by the firm and inspirational leadership of His Majesty the Kings of Bhutan and strong conservation legislations, more than half of the country's land is covered by forest. The protected area system in Bhutan comprises national parks, wildlife sanctuaries, strict nature reserves, and biological corridors. Biological corridors in Bhutan were first declared in 1999 by Her Majesty the Queen Ashi Dorji Wangmo Wangchuck as a "Gift to the Earth" from the people of Bhutan. Among the eight biological corridors in Bhutan, Biological Corridor 4 is the most significant corridor that connects Jigme Singye Wangchuck National Park in the northwest, Phrumsengla National Park in the north, and Royal Manas National Park in the south.

As a requirement for the conservation management planning for BC4, the Rapid Biodiversity Assessment (RBA) was carried out, focusing on three significant taxa, including trees, mammals, and birds, from November to December 2021. The assessment aimed to assess the diversity and abundance of major taxa and the species inventory of the other taxa. Guide by the Biodiversity Monitoring and Social Survey Protocol of Bhutan, 2020 (BMSSPB), 14 sample grids were systematically distributed across the corridor, and vegetation, bird, and mammal distribution were determined using field camera traps. The species inventory also encompasses the biodiversity survey conducted by Phrumsengla National Park in 2006, Zhemgang Forest Division in 2016, and opportunistic observation records of the species.

Tree species is dominated by *Symplocos* species (IVI=24.4), followed by *Rhododendron grande* (IVI=14.6) and *Castanopsis tribuloides* (IVI=11.9). Vegetation of the corridor is classified into three categories, Warm Broad-Leaved Forest (WBL), Cool Broad-Leaved Forest (CBL), and Fir Forest. WBL and CBL have the highest similar species diversity index and richness index. The species index of dominance is more in Fir Forest than in the other two vegetation types. Species similarity is more similar between WBL and CBL. The relative basal area of the tree is dominated by *Castanopsis tribuloides* (11.1%), followed by *Altingia excelsa* (7.7%) and *Michelia doltsopa* (7.3%). The largest Diameter at Breast Height (DBH) recorded was 128 cm with *Abies densa.* Cluster Analysis using PC-ORD 5 classified four different types of forest composition based on the species dominance cluster. There are significantly fewer diseased, top broken, dead and forked trees. The corridor recorded 485 species of flora species belonging to 138 families. One species of Begonia was discovered as new to science from the corridor in 2021.

The corridor recorded 26 species of mammals through camera traps. Three cubs belonging to two individual Tigris were captured in the camera trap from the corridor. The photographic capture index calculated from a 10-minute interval indicated that Barking Deer has the highest (n=457) independent capture rate, followed by Sambar deer (n=431). Among the carnivore species, the photographic rate was highest for Royal Bengal Tiger, followed by the Himalayan Black Bear and Dhole. The Himalayan Black Bear was the most widely distributed terrestrial mammal present from the WBL forest to the Fir Forest, followed by Common Leopard. Wild Pig, considered a prey species to the predators and pest to the farmers, has the largest distribution from 1096 to 3082 masl. The naïve occupancy was highest for

Barking Deer (0.89, n=24) and, Sambar Deer (0.66, n=23), Yellow-throated Marten (0.66, n=23). Tiger (0.51, n=18) has the largest occupancy followed by Himalayan Black Bear (0.49, n=17), Dhole (0.43, n=15) and Common Leopard (0.29, n=10) among the predators. Royal Bengal Tigers are less active during the mid-night to dawn (07:00 to 09:00), and rest of the hours, they remain active with higher movement in the morning (05:00 to 0:700), mid-day (11:00 to 14:00), and in the evening (20:00 to 21:00). Wild Pig in the area is more active during the day and less at night. Barking Deer are active both day and night and are most active during morning hours (07:00 to 10:00). Sambar Deer are also active throughout the day and night. They are also more active from 03:00 to 06:00 in the early morning and the evening (17:00 to 21:00). Activity pattern of the Royal Bengal tiger is significantly (CI=95%) similar to its competing predators like Common Leopard, Dhole, and Himalayan Black Bear. It is also similar to prey species like Sambar Deer, Barking Deer, and Himalayan Serow.

Fir Forest recorded 11 bird species with 55 encounters, CBL recorded 63 species with 533 encounters, and WBL recorded 112 species with 972 bird encounters. Shannon-Wiener Diversity Index (H) indicates that the bird diversity is higher in WBL Forest, followed by CBL Forest, and Fir Forest has the least bird diversity. The corridor recorded 305 species of birds belonging to 61 families encompassing 9 threatened and 65 migratory birds. It is also home to the critically endangered White Bellied Heron with its active nesting in the corridor.

Other species record includes; 37 species of mushrooms, 38 species of ferns, 15 species of damselflies, eight species of dragonflies, 23 species of snakes, three species of frogs, 129 species of orchids, 150 species of orchids, and 36 species of moths.

Prime wildlife habitat inside BC4

1. Introduction

Globally, changes in land use patterns and other associated threats have decreased biodiversity (Newbold et al., 2020). The habitat fragmentation due to developmental activities and other threats has been shown to have significant negative impacts on species survival. One of the major conservation efforts to reverse this negative trend has been the setting aside large tracts of land and water bodies as "protected areas" (Caicedo-Torres et al., 2017). However, an effort has been geared toward connecting fragmented habitats in areas where such large tracts are unavailable. Such so-called 'wildlife corridors,' 'landscape linkages,' 'dispersal corridors, and others are successful in connecting isolated animal populations and thereby ensuring their survival. Such wildlife passages are paramount in the gene flow of the wildlife and enhance genetic diversity (Bennett 1998).

Bhutan has always taken proactive conservation initiatives guided by the firm and inspirational leadership of His Majesty the King and strong legislation in favor of conservation. Bhutan has 72% of its geographical land under covered forest. Protected areas (PA) in Bhutan cover 51.4% of the total country area, which is more than half of the country's land. Of the 51.4% protected area, 84% comprises a national park, wildlife sanctuaries, and strict nature reserves, and the remaining 16% comprises biological corridors (BC) (NCD, 2004). The biological corridor in Bhutan was declared a 'Gift to the Earth from the people of Bhutan by Her Majesty the Queen Ashi Dorji Wangmo Wangchuck in 1999. Biological corridors connect every protected area in Bhutan, ensuring gene flow through uninterrupted wildlife movements and succession of habitats (Tshering and Wangchuk 2003). After resetting protected areas' boundaries in 2020, we now have eight biological corridors in Bhutan.

It is pivotal to have a well-strategized conservation plan for better management and protection of the protected area. Aside from Biological corridors in Bhutan, all the other protected areas are guided by the conservation management plan. The emphasis on framing conservation management plan for biological corridors are now moving forward. However, no conservation management plan for the biological corridor was framed to manage the corridor after its declaration. Phrumsengla National Park took the initiative to prepare a conservation management plan for BC4, and they conducted a Rapid Biodiversity Assessment (RBA) and produced a report but were unable to frame a conservation management plan. Again, from 2015 to 2016, Zhemgang Forest Division took the lead in preparing a conservation management plan and produced a draft conservation management plan for ten years (2017-2022), but the plan was not finalized and approved for implementation.

This time, with the funding support from GEF-LDCF NAPA III, Zhemgang Forest Division is preparing a conservation management plan for BC 4. The framing of the conservation management plan for biological corridors is guided by the Forest Management Code of Bhutan 2020 (FMCB 2020) volume IV. Before formulating the conservation management plan, we need to assess the biodiversity and socio-economic status of the local communities inside the corridor. The biodiversity status of the corridor is assessed through Rapid Biodiversity Assessment (RBA) and socio-economic status through Socio-Economic Survey (SES). The following report presents the RBA findings on significant taxa, including plants, mammals, and birds, and a cumulative species listing of the all-available taxa.

The rapid biodiversity assessment was carried out with the following rationale:

1. To determine species abundance, composition, and diversity of significant taxa.
2. To create a baseline inventory of biodiversity in BC4.
3. To derive conservation management implications for managing BC4.

2. Materials and Methods

2.1 Study area

BC4, with a corridor area of 594.65sqkm, is the largest among eight biological corridors in Bhutan after the realignment of protected area boundaries by the Department of Forests and Park Services (DoFPS) in the year 2020. BC 4 is mainly designed to provide a wildlife corridor between three national protected areas: Royal Manas National Park in the south, Phruemsangla National Park to the north, and Jigme Singye Wangchuck National Park towards the northwest. The corridor stretches to a length of 40 kilometers (km), and it has one chock point in the north, created due to scattered human settlements. The corridor covers Nangkhor gewog, Shingkhar gewog and small portion of Trong gewog under Zhemgang Dzongkhag and part of Langthel gewog under Trongsa Dzongkhag (Figure 1). The lowest elevation is 228 masl, and the highest elevation is 4570 masl, which indicates that the corridor has a wide range of elevation gradients. As per the land use and land cover 2016, most of the corridor area is dominated by broad-leaved forest. The corridor also has Chirpine forest in the lower part and Rhododendron and Fir in the higher mountains. The primary national highway connecting Zhemgang and Trongsa passes through the corridor in the northwestern inside Langthel gewog and gewog center road to Shingkhar and Bardo also passes through the corridor in the middle from Buli to Therang bridge.

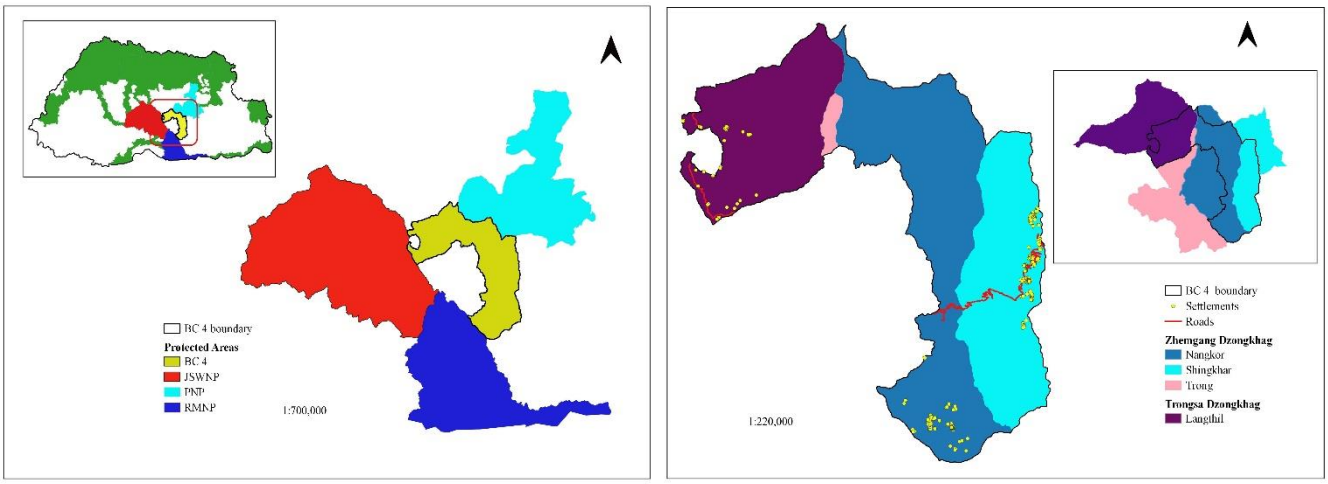

Figure 1. Location of BC4 and its administrative map

2.2 Sampling design

Survey design and sampling were prepared based on the Forest Management Code of Bhutan 2020 (FMCB 2020), chapter IV on protected area management. Protected areas (PAs) and Territorial Forest divisions (TFDs) under the Department of Forests and Park Services were provided with a 4x4 km Biodiversity Monitoring Grid (BMG) for carrying out any biodiversity survey for conservation management planning and biodiversity monitoring to provide standard future biodiversity monitoring protocols across all the PAs and TFDs. The majority of the corridor area is dominated by broadleaved forest, and based on the altitudinal gradient classification, three significant categories of landscape types were determined, and 13 BMG sample grids were identified along zones for Rapid Biodiversity Assessment (RBA). Assessment of all the taxa was done within these BMGs (Figure 2), but we could assess one additional sample grid, and the total sample grid taken was 14 for this survey.

A field survey for RBA was conducted from mid-November 2021 to the end of December 2021 for one and half months by a team comprising five technical forestry staff.

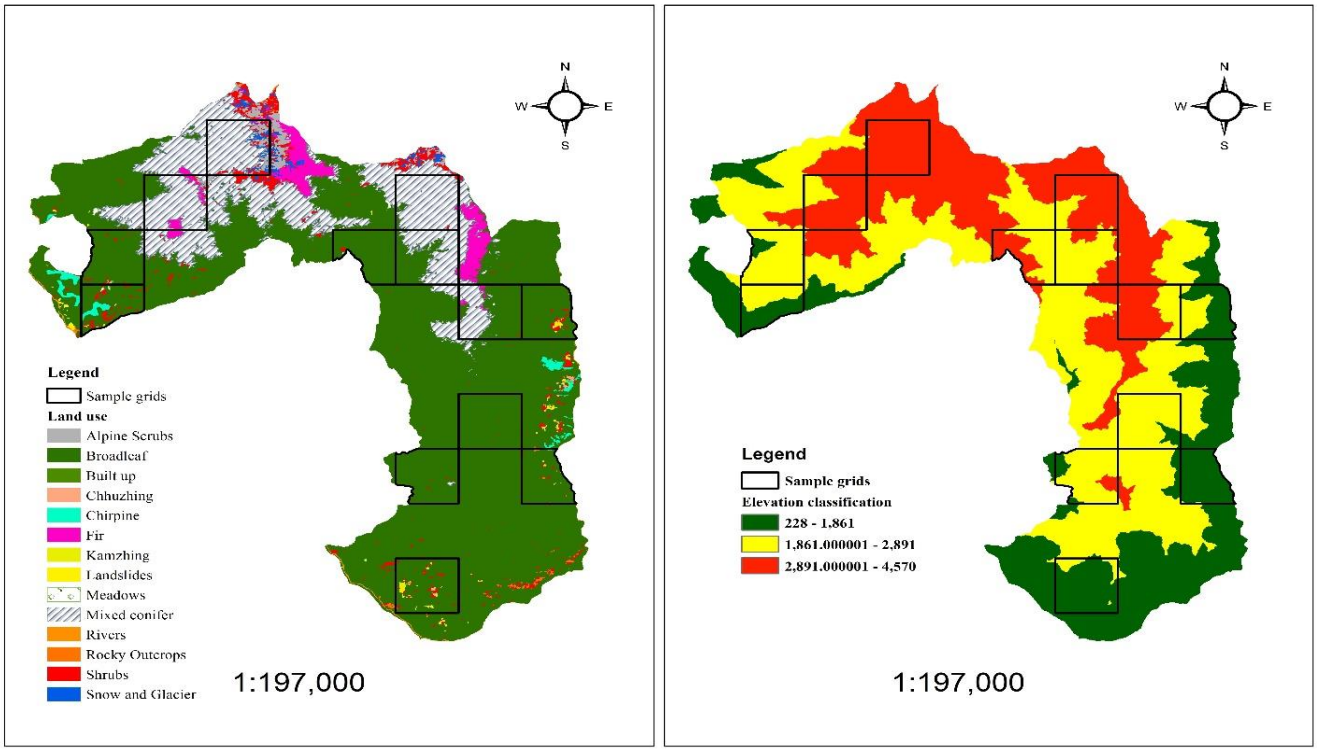

Figure 2. Sample grids stratified based on vegetation type and elevation

Classification of the primary vegetation type or the forest type is based on the vegetation type developed by Oshawa (1987) and the National Biodiversity Strategies and Action Plan of Bhutan, 2014. National Biodiversity Centre, Ministry of Agriculture and Forests. Three major vegetation types were determined in the corridor to determine the biodiversity status (Table 1).

Table 1. Forest type classification in the corridor

Eco-floristic zone (Ecological zone)	Forest type (NBC 2014)	Vegetation type (Oshawa 1987)	Elevation range
Sub-Tropical Zone Altitude – (150-2,000 masl)	Warm broadleaved forest	Warm temperate forest	less than 2000
Temperate Zone Altitude – (2,000-4,000 masl)	Cool broadleaved forest	Cool temperate	2000 to 3000
Alpine zone (>4000 masl)	Fir Forest	Subarctic	More than 3000

2.2.1 Flora diversity

Assessment of floristic diversity was designed based on the Biodiversity Monitoring and Social Survey Protocol of Bhutan, 2020 (BMSSPB 2020). There are 14 sample girds distributed systematically across the area, and for floristic composition assessment, enumerated two vegetation sample plots inside each sample grid, which accounted for 28 sample grids. The survey form was developed with epicollect 5, and data was collected through epicollect 5 app on a mobile phone. The vegetation sample plots were established 0.5 km apart from each plot after entering a minimum of 300 meters inside the sample grid. Navigation to the sample grids was done using the SW map mobile app.

Trees and shrubs were enumerated inside the fixed area plot of 20x20m. Enumeration grids were laid using nylon rope and wooden pegs. Trees and shrubs inside the plot were identified, and their Diameter at Breast Height (DBH) for those above 1.3 m height was measured, and other parameters like height, growth status, and stem status were assessed and recorded. Epiphytic species with individual species

counts were recorded inside the tree and shrub plot. Ground vegetation and regeneration status were assessed inside a 2x2 m quadrate within the tree and shrub plot. Species height and coverage percentage of herbs were recorded for ground vegetation, and species age and height of tree and shrub species were recorded for regeneration.

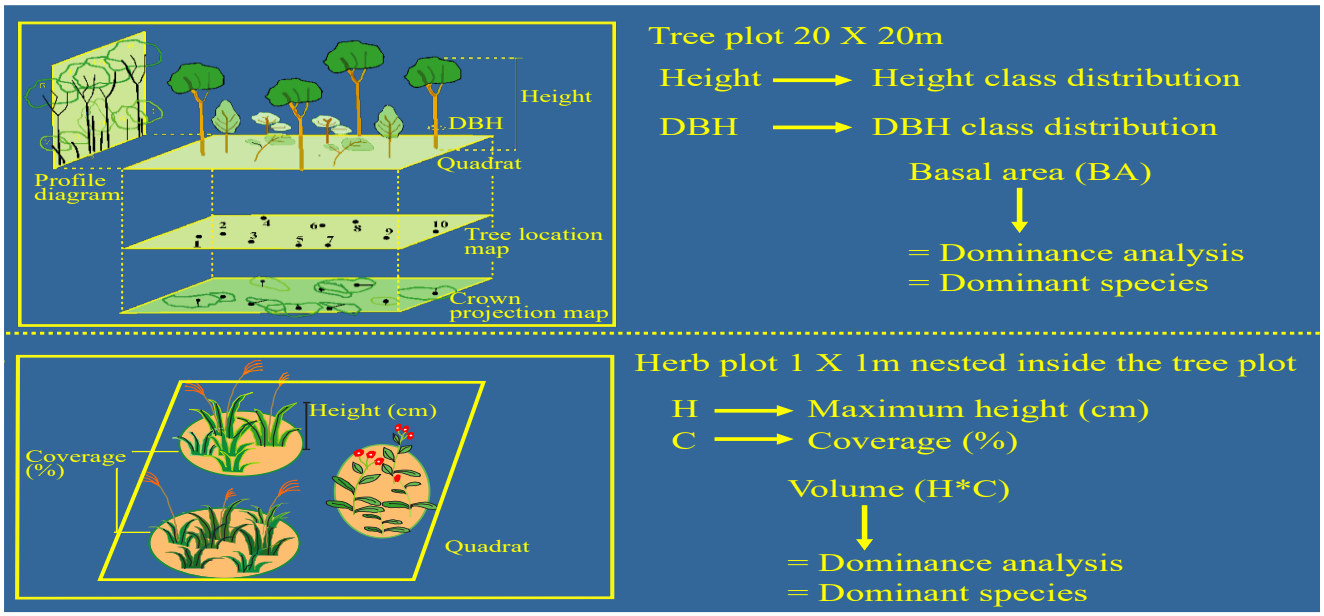

Figure 3. Vegetation data collection profile

2.2.2 Faunal diversity

Faunal diversity was assessed at two levels; level one includes assessment of mammals along the transect inside 14 sample grids, and level two includes camera trapping of mammal species. The total length of the transect enumerated for mammal account for 149.5 km. All the direct and indirect observations of wild animals were recorded along the survey transect. The parameters recorded for species evidence observation include species name, type of observation, count of individual species observed, geo-location of the observation, elevation, slope, aspect, habitat type, and threat or disturbance related to the observed species. Most indirect sightings include tracks, scats, dung, scratch marks, scrapes, and drops. The transect survey form was developed with epicollect 5, and data collection was done using epicollect 5 mobile app.

Camera trapping was carried out from January to June 2020 as a CA|TS assessment in Zhemgang Forest Division (ZFD), which was carried out based on BMSSPB 2020. Camera traps were installed inside 35 BMG, with two cameras at each station.

2.2.3 Avifauna diversity

A bird survey was conducted along transects inside and outside 14 sample grids in the corridor. Bird enumerations were conducted covering 149.5 km across the existing trails and recorded data for 135 hours with elevations ranging from 1080 to 3600 masl. MacKinnon species listing method was used to record information on birds, where the method is considered best for one-time rapid assessment of birds (MacKinnon & Phillipps, 1993; DoFPS, 2020). Binoculars and DSLR cameras were used for bird scanning and identification. Every observation, which includes direct sighting, calls, feathers, dead bodies, or droppings along the trail, was recorded with the instant observation time, cluster size based on their sex and age category, altitude, and behavior at the point of observation, and the observation site geo location. A transect survey form was developed with epicollect 5, and data was collected using the epicollect 5 mobile app.

2.2.4 Species inventory

The biodiversity species inventory listing was compiled using the species observation list from RBA conducted in 2006 by Phrumsengla National Park (PNP), RBA conducted by ZFD in 2016, and opportunistic species observation list recorded by field staff of ZFD and RBA conducted by ZFD in 2021. The species inventory list presented here is the cumulative list of the surveys mentioned above, and it will serve as the latest edition of the biodiversity species inventory of BC4. RBA was carried out using systematic sampling and well-defined methods, whereas the opportunistic observation records were maintained by the field staff during their species encounter.

2.3 Data analysis

2.3.1 Flora diversity

Data collected using Epicollect 5 were downloaded from the epicollect server, and cleaning and compilation were done using Microsoft excel. Data analysis was done using Microsoft Excel with pivot table function and PC-ORD (Ecological analysis package) for vegetation. The species diversity, richness, and evenness were analyzed using the Shannon-Weiner equation (Margalef, 1968). This equation was also applied for avifauna and mammal diversity analysis.

Shannon-wiener index (H) = $-\sum Pi \log_n Pi$

Where $Pi = \frac{Number.of.individual.of.one.species}{Total.number.of.all.individual(one.forest.only)}$

Species richness = $\frac{(S-1)}{LogN}$,

where S= total number of species; N= total number of individuals of all species

Evenness index = $\frac{H}{LogS}$

Where H= Shannon Wiener diversity index; S = Total number of species

Index of dominance = $\sum\left(\frac{n_i}{N}\right)^2 or \sum(Pi)^2$

Where n_i = number of individuals of a species (of one forest)

N = Total number of individuals of all species (of one forest)

The dominance of the species was determined using the Importance Value Index (IVI) of each species: IVI = importance value index = relative density +Relative frequency +Relative dominance. (Phillips, 1959)

R.D = Relative dominance, R.F = Relative Frequency; * = Basal area = πr^2 where r is radius (diameter/2)

Equation 1 Frequency** = $\frac{\text{Number of quadrates in which species occurred}}{\text{Total number of quadrates studied}}$ X 100

Equation 2 Relative dominance (RD) = $\frac{\text{Total basal area of species}}{\text{Total basal area of all the species}}$ X 100

Equation 3 Relative density = $\frac{\text{Number of individuals of the species}}{\text{Total number of individuals of all the species}}$ X 100

Equation 4 Relative frequency (RF)

RF = $\frac{\text{Number of occurrence of species (frequency**)}}{\text{Number of occurrences of all species (sum of frequency**)}}$ X 100

The similarity and dissimilarity of tree and shrub composition between different forest types were determined using Index of Similarity and Dissimilarity:

Index of similarity (S) = $\frac{2C}{A+B}$

Where:

A= number of species in community/forest A
B= number of species in community/forest B
C= number of species common in both A & B

Index of dissimilarity = 1-S

Classification of vegetation zones was analyzed using cluster analysis in PC-ORD 5. The forest zones were classified and analyzed based on the RBA of individual species in each plot within the grids. Cluster analysis grouped the homogenous plant communities into a cluster of forest zones by species similarity index in the dendrogram. The similarity index of 25% was performed using the distance measure of Relative Sorensen and Group Linkage Method using group average to determine the forest type in reserve.

The health of the trees/shrubs were determined based on the percentage composition of the health indicator parameters (condition of the stem bole, condition of the tree).

2.3.2 Faunal diversity

The composition of the species along the transect survey was determined using excel and a pivot table in percentage and frequencies, which includes species-wise evidence observation composition, family-wise composition, and species evidence observation composition. Species diversity, richness, and evenness from the transect survey were analyzed using the Shannon-Weiner equation (Margalef, 1968). Species of animals captured in the camera trap were identified and sorted into a species-specific folder. Images captured were renamed with meta tag information using ReNamer 6.8, and analyses were done with ReNamer software (Sanderson & Harris, 2013). Independent event of photo captures was taken at 10-minute intervals. Analysis of the image was based on the number of independent images. A total of 55612 images were processed, and 2809 independent images were used for analysis. Species diversity was determined for three trophic levels (Carnivore, Herbivore, and Omnivore). The species accumulation curve (SAC) was determined using DataOrganizeVer4.5 (1) and DataAnalyze-Ver.-7.1 in ReNamer to indicate the adequacy of the fauna survey in representing the fauna diversity and abundance in BC 4. Each species' composition of independent images was analyzed, and species diversity was evaluated. The distribution of species was determined using the elevation range of the species captured in the particular camera trap station, and naïve occupancy for each species is derived from the fraction of locations occupied calculated by computing the number of locations occupied by the species divided by the total numbers of the location shown. Activity patterns of primary carnivores and herbivores were analyzed, and chi-square analyses were performed for paired activity pattern similarity at a 95% confident interval.

2.3.3 Avifauna diversity

Data generated from the transect survey were cleaned and sorted in Microsoft excel using the pivot table function. Then, species diversity, richness, and evenness were performed using the Shannon-Weiner equation (Margalef, 1968) to determine the abundance based on the forest types. A species accumulation curve was also composed to determine the adequacy of the sample size for all possible species present. Finally, the family-wise bird species richness was graphed and presented.

2.3.4 Species inventory

The list of all taxa available from the BC4 RBA reports conducted in the years 2006, 2016, and 2020 and opportunistic observation of species listing by our field forestry staff were compiled to determine the species inventory for the corridor.

3 Results and discussion

3.1 Flora diversity

3.1.1 Floristic composition of trees and shrubs

A total of 28 enumeration plots were determined. Two plots each in a sample BMG were enumerated for flora diversity. Trees and shrubs were recorded in all the plots. Regeneration of tree species was recorded in 26 plots, and two plots were devoid of regeneration. Herbaceous ground cover and parasitic epiphytes were detected in all the enumeration plots.

RBA for vegetation survey revealed 90 species of trees/shrubs belonging to 38 families. The most widely distributed tree species was *Symplocos ramosissima*, which was observed in 16 enumerations plots. *Rhododendron grande* (8 plots) and *Persea clarkeana* (7 plots) were the following widely distributed species. Based on the importance value index (IVI), BC 4 is dominated by *Symplocos ramosissima* with an IVI of 24.4, followed by *Rhododendron grande* (IVI=14.6) and *Castanopsis tribuloides* (IVI=11.9).

The total species encounter count was highest in the CBL forest (N=3885), followed by the WBL forest (N=2767), and the lowest was counted in Fir Forest (N=795). The Shannon diversity index for the BC 4 is 3.6, with a species richness index of 30.5 and a species evenness index of 1.8, indicating high diversity of shrub/tree species in the corridor with stable species abundance distribution. Shannon diversity index was highest for the CBL forest, similar to the diversity index of the WBL forest. Fir forest has the lowest diversity index. Species richness is highest for WBL forest, followed by CBL forest. The species richness index of WBL forest and CBL forest is similar. Fir forest encountered only ten species of trees/shrubs, and it has the lowest species richness value compared to the other two types of forest. Species distribution evenness index was more even in the Fir Forest than in CBL and WBL forests. CBL forest has a little higher species evenness index than WBL forest. Fir Forest is more dominant over the warm WBL and CBL forests. There is minimal variation in the dominance index between WBL and cool CBL forests (Table 2).

Table 2. Diversity indices for Trees/Shrubs

Forest Type	S	N	Shannon wiener index(H)	Species richness	Evenness index	Index of Dominance
WBL forest	54	2767	-3.10	15.40	-1.79	0.08
Fir forest	10	795	-1.46	3.10	-1.46	0.33
CBL forest	53	3885	-3.23	14.49	-1.87	0.07

WBL forest and CBL has 20 species in common and has a similarity index of 0.37, which indicates that CBL and WBL have a similar species composition. CBF and Fir Forest share six species in common and are 81% dissimilar. WBL and Fir Forest have the lowest similarity index with 0.06, with only two species in common.

Table 3. Index of similarity and dissimilarity

Forest type	No. of common species	Similarity index	Dissimilarity index
WBL -CBL	20	0.37	0.63
CBL-FF	6	0.19	0.81
WBL-FF	2	0.06	0.94

Among Among the families, symplocaceae recorded the highest number (172) of trees/shrubs, followed by Fagaceae and Ericaceae. *Symplocos ramosissima* was the most encountered tree species, followed by *Rhododendron grande*, *Myrisine semiserrata*, and *Lithocarpus elegans*. Based on the calculated relative basal area (RBA%), trees in the corridor are dominated by *Castanopsis tribuloides* (11.1%), followed by *Altingia excelsa* (7.7%) and *Michelia doltsopa* (7.3%). The RBA% of the family is dominated by Fagaceae (23.2%), followed by Magnoliaceae (13.9%) and Pinaceae (8.6%). The largest Diameter at Breast Height (DBH) recorded was 128 cm with *Abies densa*, and the lowest was 1 cm for *Myrisine semiserrata*, a shrub or small tree growing plant, and the majority of the DBH were distributed between 10 to 20 cm (Figure). The maximum tree height observed was 32 meters, and the majority of the heights were less than 10 meters (Figure 4)

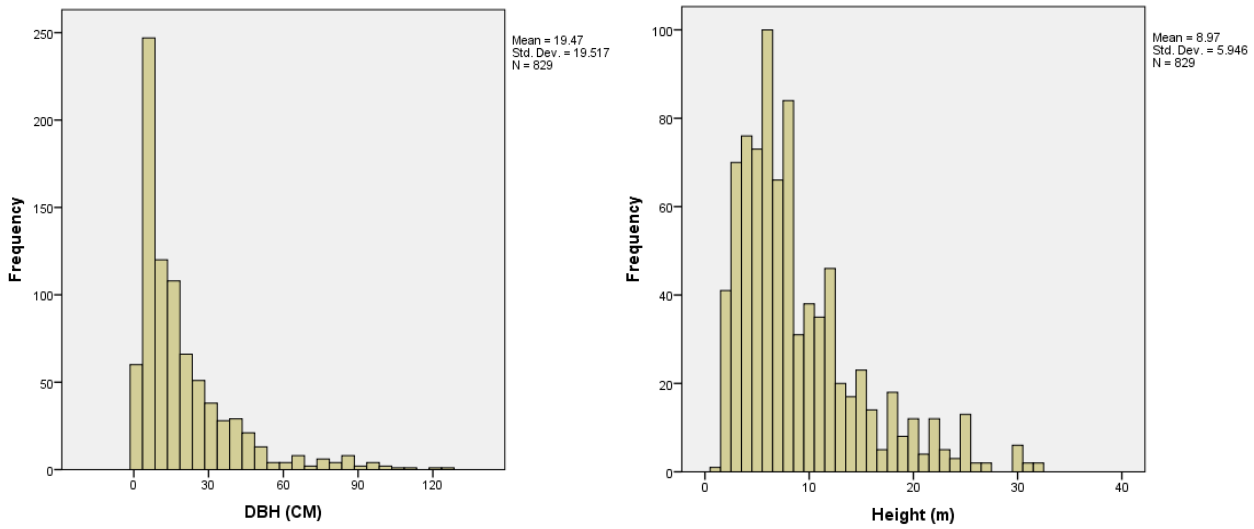

Figure 4. DBH and Height distribution histogram

3.1.2 Forest Zone classification

Cluster Analysis using PC-ORD 5 software grouped the homogenous plant communities into a cluster of forest zones by species similarity index value (%) in the dendrogram. The similarity index of 25% was performed for the species using the Relative Basal Area for the species gathered from 14 sample grids spread across the corridor. The cluster analysis at the 25% similarity index revealed four distinct clusters or zones of forest (Figure 5). Cluster I is located between the elevation range of 1370 to 1561 masl at the lower part of BC 4. This cluster is dominated by *Altingia excelsa*, *Casearia glomerata*, and *Boehmeria platyphylla*. Cluster II of the forest type is dominated by *Symplocos ramosissima* followed by *Pinus roxburghii* and *Quercus griffithii*, located between 1547 to 2241 masl. Grid 1505 was combined with the other two grids in the same cluster at a 52% similarity index, which was contributed by similar possession of *Quercus griffithii*. Cluster III is clustered between the elevation of 1218 to 3460, which is contributed by the dominance of *Persea clarkeana, Symplocos ramossissima, Rhododendron grande, Quercus lamellosa, Symplocus,* and *Quercus oxyodon*. Cluster IV is dominated by *Symplocos sumentia* followed by *Myrsine semiserrata*, *Symplocus ramossissima*, and *Lithocarpus elegans*, which is clustered between 1154 to 2992 masl.

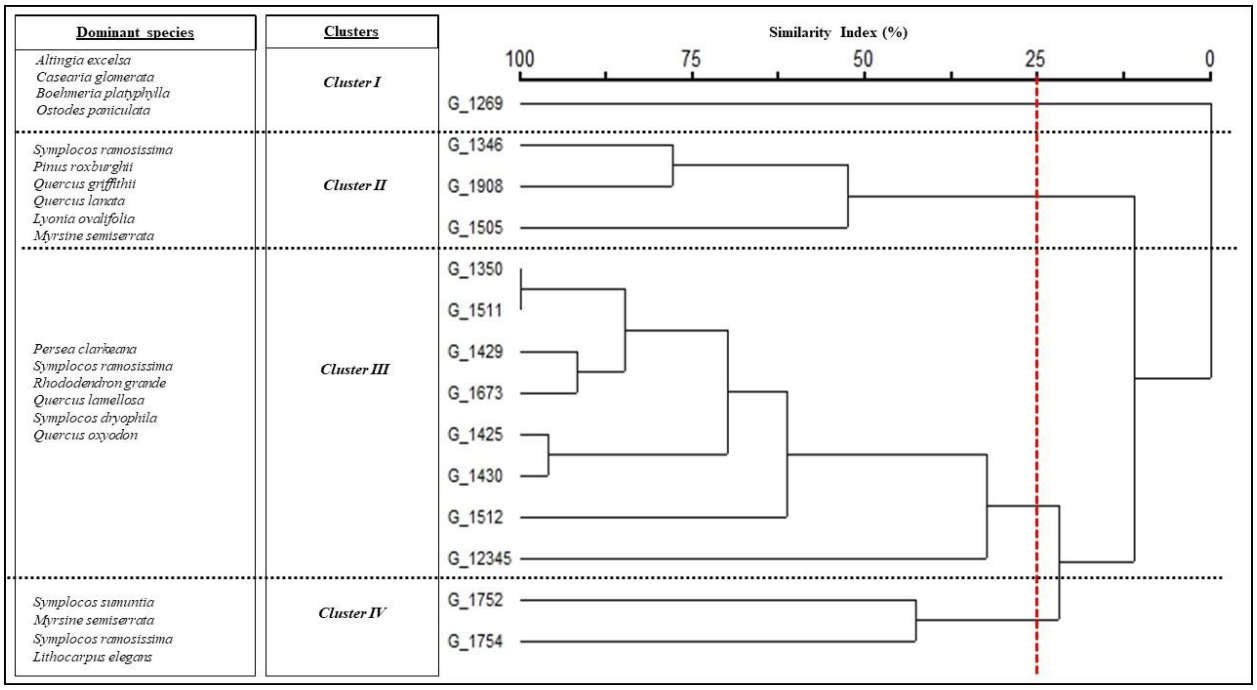

Figure 5. Cluster dendrogram of forest-type zones based on 25% similarity index

3.1.3 Health of trees/shrubs

The physical conditions of trees and shrubs were assessed visually and found that most (71%) of the trees and shrubs in the corridor are healthy, and 18% are leaning. In addition, there is less diseased, top broken, dead, and forked (Figure 6).

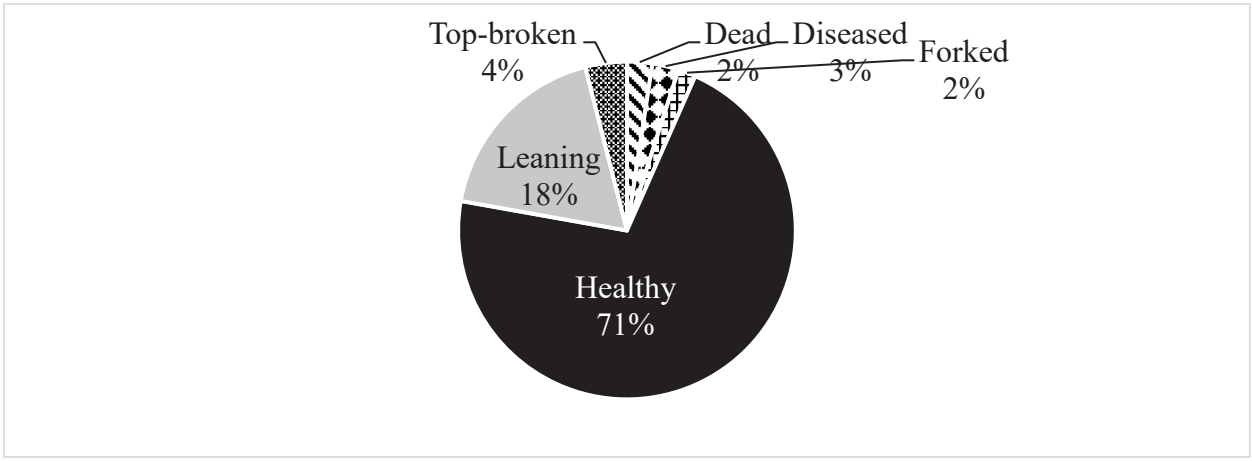

Figure 6. Composition of tree health condition

Dead and diseased trees were more in the CBL than the other two forest types. Forked trees and shrubs were more in Fir Forest, and top broken are more in WBL and CBL.

Table 4. Health of trees

Forest type	Dead	Diseased	Forked	Healthy	Leaning	Top-broken
Cool broadleaved forest	15	12	2	329	82	14
Fir Forest	2	4	7	28	40	5
Warm broadleaved forest	3	5	5	233	29	14

Trees and shrubs are composed of 81% single bole and 19% sprout. CBL has a larger composition of single and sprouting trees.

3.1.4 Regeneration status

Regeneration of the trees was observed in 26 plots and two plots were devoid of tree regeneration. A total of 119 regenerations were recorded from 35 species of trees. Regeneration was dominated by *Persea clarkeana* (17%) followed by *Symplocos sumuntia* (14%) and *Symplocos ramosissim*a (14%). Symplocaceae followed by Lauraceae and Fagaceae have the larger portion of regenerations and the rest have very negligible regeneration (Figure 7).

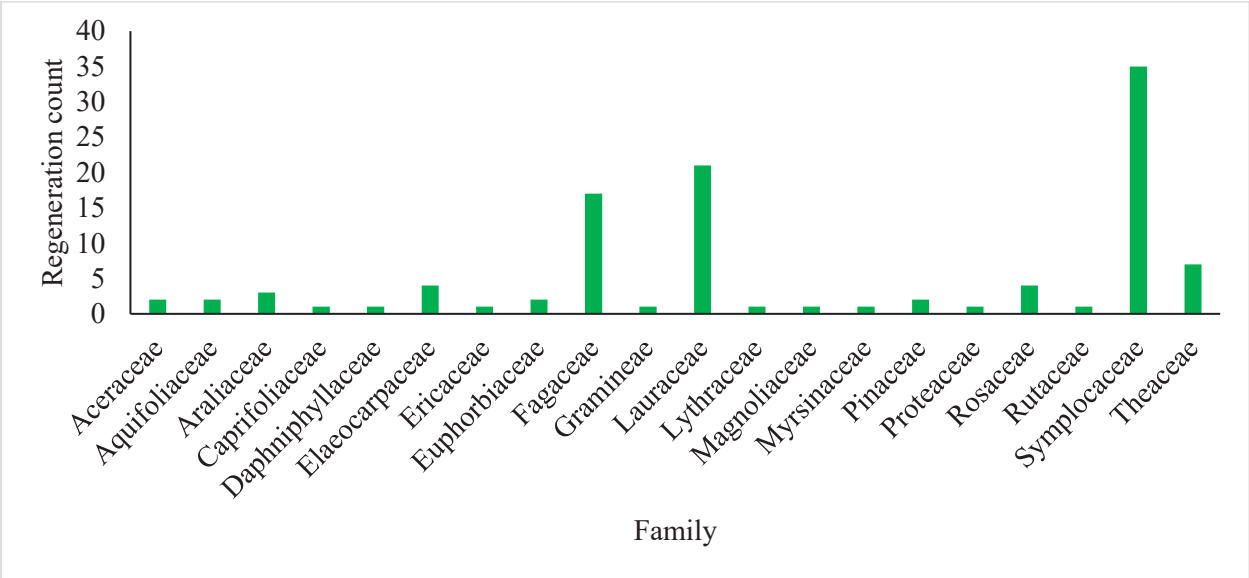

Figure 7. Regeneration status of the trees across the family

The height class of the regenerations was evenly distributed, and there was no significant difference between the height classes (Table 5).

Table 5. Regeneration height class composition

Height class of seedling	1 to 20 cm	20 to 40 cm	> 40 cm
Count	47	31	41
%	39.5	26.1	34.5

Regeneration of seedlings is more concentrated in the lower age range between 1 to 2 years old and less regeneration above four years (Table 6), indicating that the corridor has a very weak distribution of tree seedlings.

Table 6. Regeneration distribution across age categories

Age class of seedlings	1 to 2	2 to 3	3 to 4	>4
Count	68	28	15	8
%	57.1	23.5	12.6	6.7

3.1.5 Herbaceous species

The presence of herbs was recorded in all the plots. Ground vegetation cover plants were classified into six categories and the central plant habit encountered was Shrubs (35%) and least with Bamboo (2%), whereas the ground vegetation coverage proportion was highest with ferns and grasses. (Figure 8).

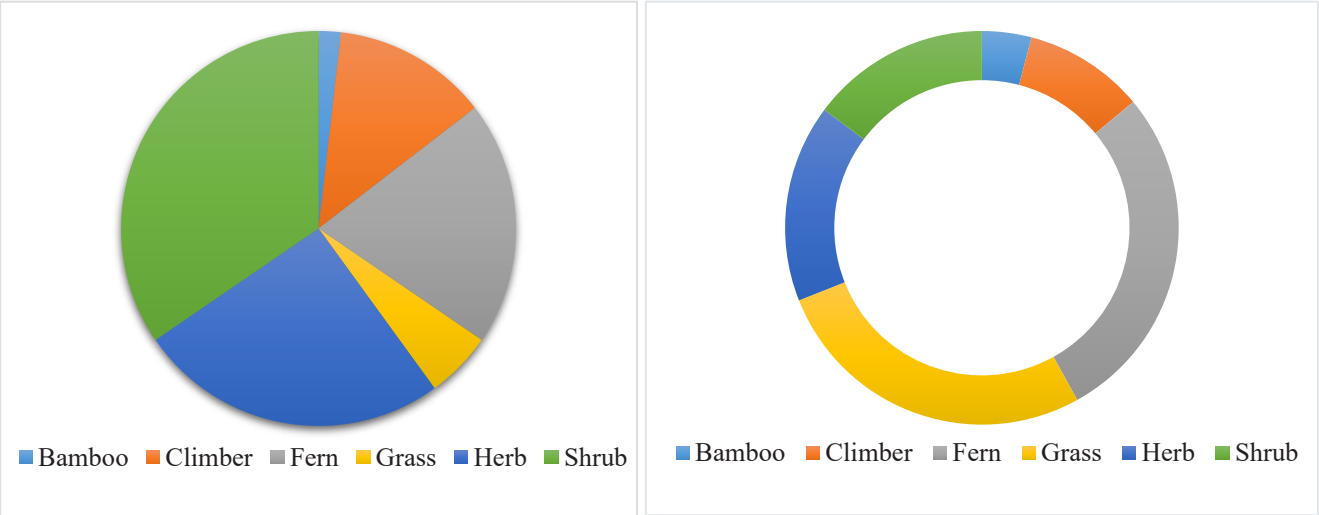

Figure 8. Composition of herbaceous plants

3.1.6 Epiphyte species

Epiphytic species were recorded in all 28 enumeration plots. WBL forest has the highest proportion of epiphytes and the very least inside Fir Forest (Table 7).

Table 7. Epiphyte composition based on the forest type

Vegetation type	Epiphyte count
CBL	28
Fir forest	10
WBL	45
Grand Total	83

Six different types of plant habit epiphytes were recorded in the area. Epiphytes are dominated by fern species, followed by orchid and climber species. Mistletoes were also recorded in 8 plots with 54 individual counts (Figure 9)

Figure 9. Epiphytic plants proportion

3.1.7 Flora species inventory

BC 4 recorded 485 flora species (excludes fern and orchids) of 301 genera belonging to 128 families (Annexure 1). The biological corridor also holds 5 flora species endemics to Bhutan.

There are nine conservation significant species recorded, namely, *Aquilaria malaccensis* (CR), *Sapria himalayana* and *Trillium tschonoskii* (EN), *Aglaia edulis*, *Phoenix rupicola* and *Quercus lamellosa* (NT), *Macaranga grandifolia*, *Paris polyphylla* and *Rhododendron dalhousiae* (VU). *Aquilaria malaccensis* and *Dioscorea deltoidea* are also listed under Appendix II of CITES. Inaddition, five species of plants (*Artemisia bhutanica*, *Lobela nubigena*, *Rhododendron bhutanense*, *Rhododendron kesangiae and Rubus sengorensis)* are endemic to Bhutan.

Four species of plants and three species of orchids were discovered as new to the flora of Bhutan from the corridor within the past three years, and one Begonia species was discovered as new to science from the corridor in the year 2021 (Table 8).

Table 8. New plant discoveries from the corridor

Habit	Year recorded	Scientific name	Remarks
Herb			
	2020		
		Impatiens sikkimensis	*New to Bhutan*
	2021		
		Begonia bhutanensis	*New to Science*
		Begonia flaviflora hara	*New to Bhutan*
		Begonia gemmipara	*New to Bhutan*
		Impatiens pseudolavigata	*New to Bhutan*
Orchid			
	2021		
		Panisea panchaseensis	*New to Bhutan*
		Plathanthera dunglonggenisis	*New to Bhutan*
		Bulbophyllum andersonii	*New to Bhutan*

3.2 Faunal diversity

3.2.1 Abundance and diversity of mammals from transect survey

A total of 14 grids were enumerated for the sign survey covering a 149.5 km transect. Through direct and indirect observation, recorded 22 species of terrestrial mammals belonging to 11 families and Felidae has the highest record of observations followed by Bovidae and Ursidae (Figure 10).

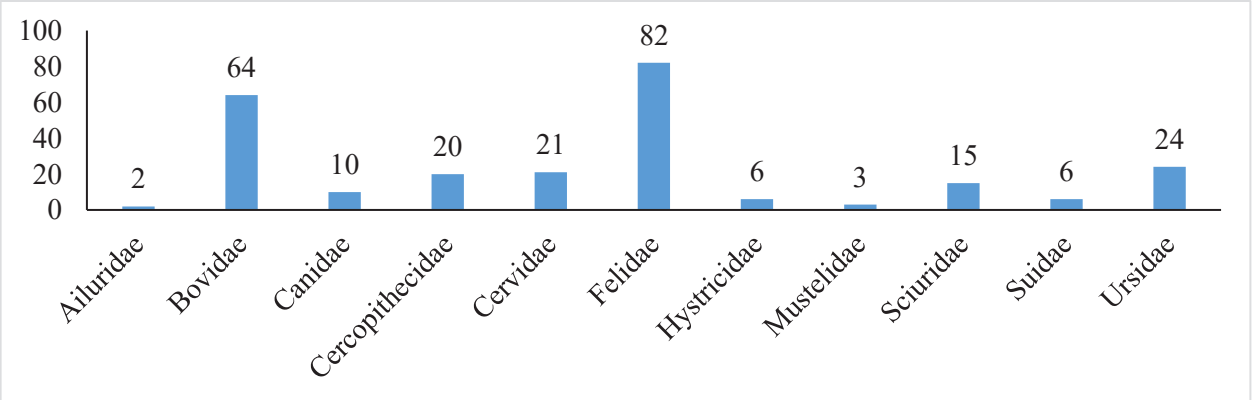

Figure 10. Mammal species distribution across its family

Out of 22 species records, 13 are threatened, comprising 5 Endangered, 6 Near Threatened, 2 Vulnerable, and the remaining nine are listed as Least concerned as per the International Union for Conservation Nature (IUCN) Red List Status 2020. A total of 253 observations were made, with 38 direct sightings and 250 indirect observations. Wildlife observation evidence was most substantial for Sambar Deer, followed by Tiger and Himalayan Black Bear (Figure 11). Tiger, Himalayan Black Bear, Asiatic Golden Cat, and Sambar Deer were widely distributed, where their presence evidence was recorded in all the forest types.

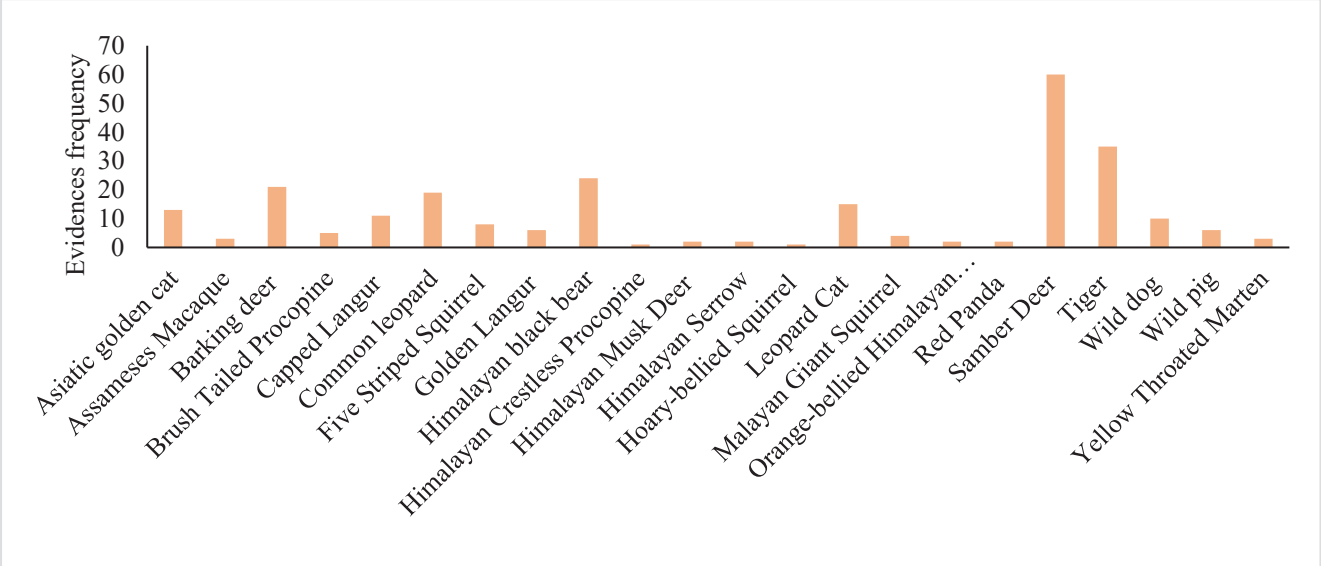

Figure 11. Mammal evidences count

Directly sighted mammals are Tiger, Capped Langur, Golden Langur, Assamese Macaque, Barking Deer, squirrels, Sambar Deer and Yellow-throated Marten. The highest direct observation was on squirrels, followed by Capped Langur and Golden Langur. It was a short, scary moment when the RBA team came face to face with a Tigress and its sub-adult cub at an elevation of 2466 masl on our way from Buli to Bridungla, along Burgongchu. The slope at the encounter site was a 40-degree inclination, and it was facing west. The Tigress with its cub was coming downward while RBA team was moving up towards northern enumeration plots.

The observation evidence was categorized into 12 types, most of which were based on wild animal droppings (37.5%) and wildlife tracks (36.8%). Direct observation accounted for 15%, and the rest was at a minimal record (Table9).

Table 9. Mammal observation evidences type

Evidence type	Frequency	%
Acoustic	1	0.4
Bedding	2	0.8
Body part	3	1.2
Carcass	1	0.4
Dropping	95	37.5
Forage	3	1.2
Ploughing	2	0.8
Scrape	1	0.4
Scratch	13	5.1
Sighting	38	15.0
Track	93	36.8
Wallow	1	0.4

Based on the species diversity index value, all the forest types have medium species diversity with a diversity index ranging from 1.6 for Fir Forest followed by CBL with 2.3 and WBL with 2.6. Diversity is higher in WBL than other two forest types. The overall species distribution is evenly distributed and has a stable species abundance distribution condition across all forest types. When comparing the evenness between three forest types, WBL has a more evenly distributed species population, followed by CBL and least with FF. WBL (n=17) and CBL (n=18) have equal species richness, and Fir Forest has the lowest species richness with a record of only seven species (Figure 12).

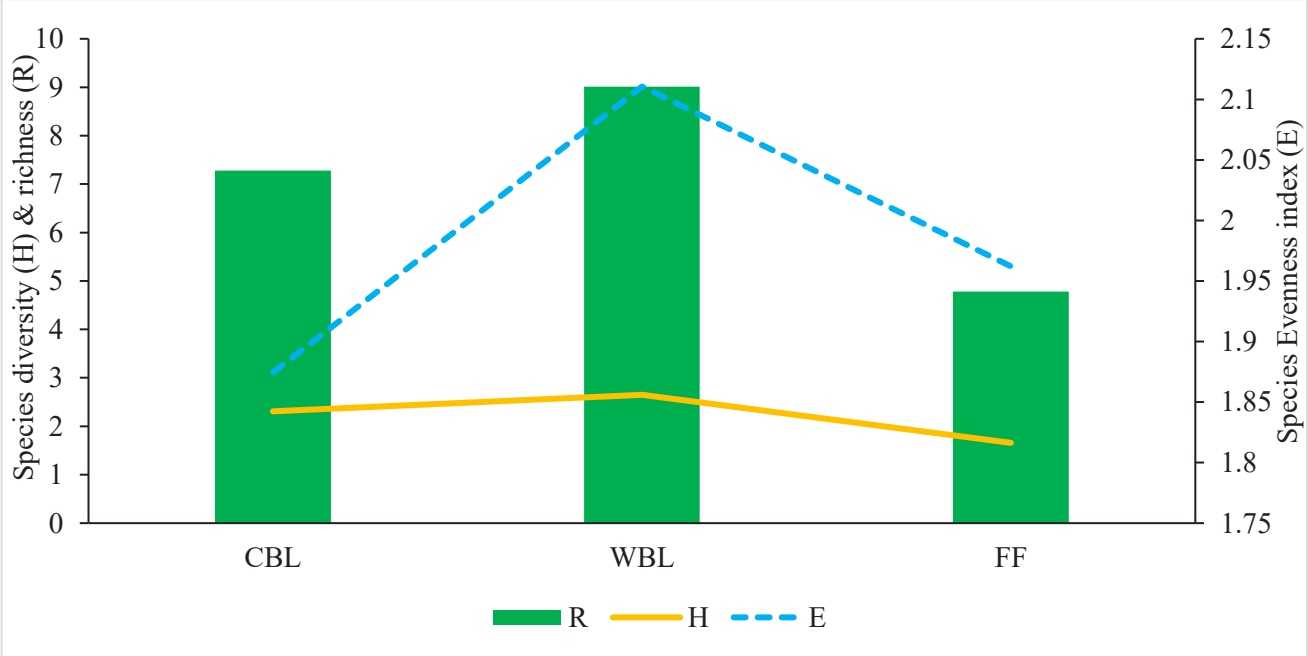

Figure 12. Species diversity (H), Richness (R), and Evenness (E) under vegetation types

3.2.2 Abundance and diversity of mammal from camera trap survey

Camera trap installation was carried out at the end of 2019 and the beginning of 2020. A total of 35 camera traps were installed with an average of 116 trap nights. The lowest camera trap night of a station was 58 days and the highest trap night for a camera trap station was 173 trap nights. The majority (54.3) of the camera traps were installed between 2000 to 3000 elevations, followed by 1000 to 2000 (28.6%) and the least (17.1%) above 3000 elevations.

The camera trapping resulted in capturing 26 species of mammal which comprised 13 threatened species (Endangered (4), Near Threatened (6), and Vulnerable (3)) and the remaining 13 are Least Concern as per the International Union for Conservation Nature (IUCN) Red List Status 2020. It indicates that 50% of the mammals in the corridor have high conservation significance. The majority of mammal species present are carnivores, followed by herbivores and omnivores (Figure 13).

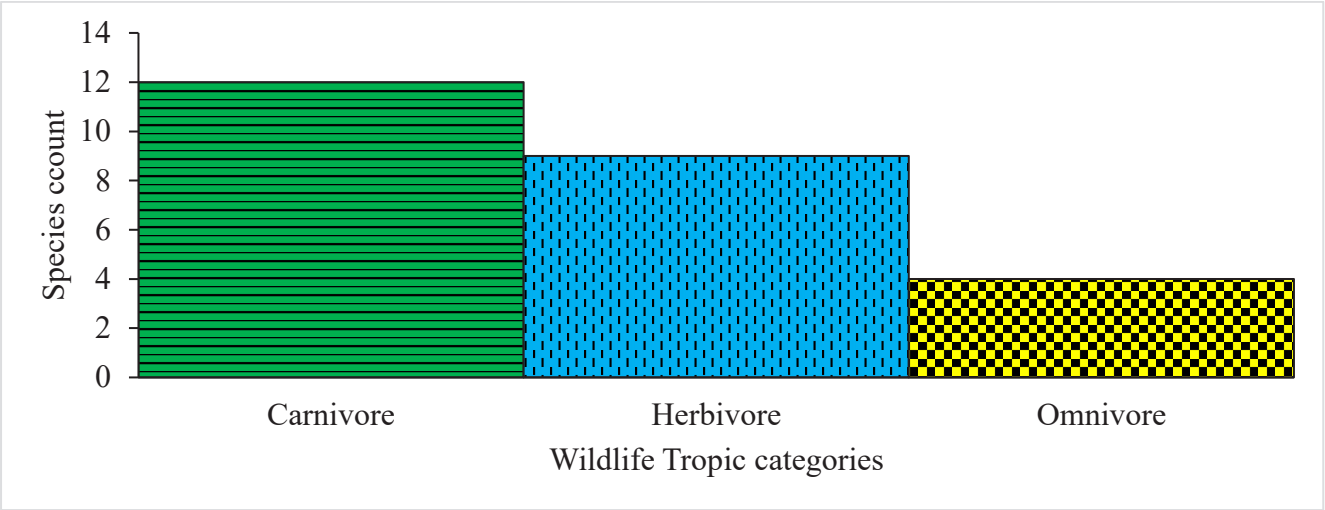

Figure 13. Mammal distribution across the trophic level

A total of 55612 pictures were processed from 3822 trap efforts. For analysis of the relative abundance and occupancy of the species, 2809 independent pictures were used, and for activity pattern calculation, 2691 pictures were processed. The independent event pictures of the species at a location were defined at 10 minutes intervals. The sequential pictures of the same species at the exact location within the period were 52803. The species accumulation curve showed that the different species captured rose exponentially after 45 days of camera trap installation, and the curve flattened slightly from the 100th day, but the curve was never flat, which indicates that more trap effort is required to capture additional species (Figure 14).

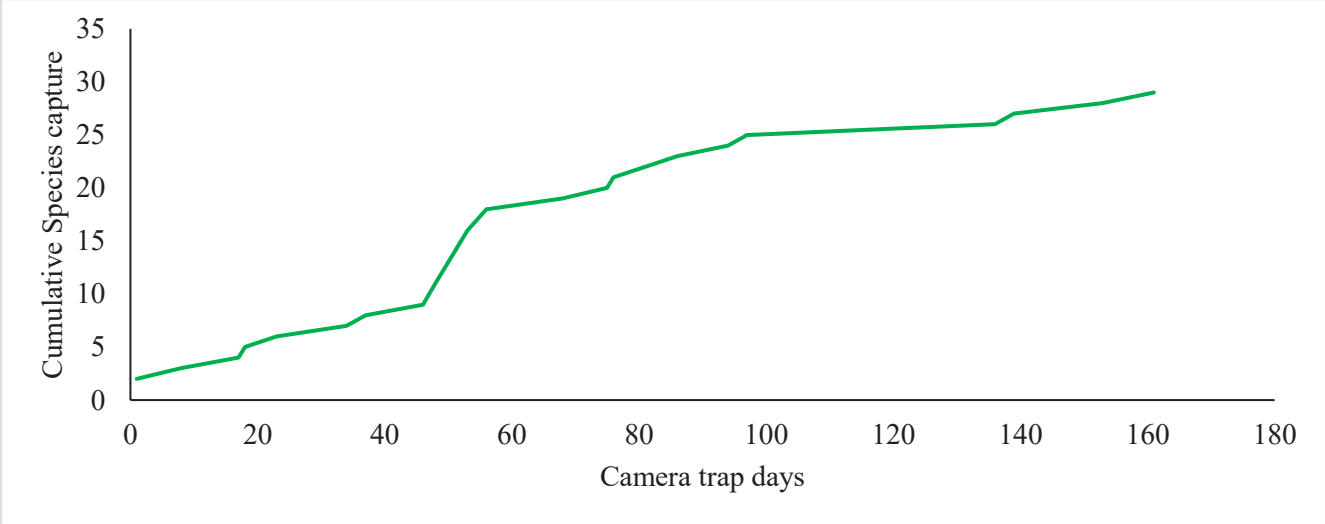

Figure 14. Mammal species-area curve

Based on the photographic captures, barking deer has the highest (n=457) independent capture rate, followed by Sambar deer (n=431), and the least captured species are Musk deer (n=1), Spotted linsang (n=1), Gaur (n=1), and capped langur (n=1). Herbivores (73%) are widely distributed and highly active wild animals, followed by small carnivores (17%) and large carnivores (9%), whereas the omnivores are least abundant because they are primarily feeding on the leaves and fruits on the trees and they are less available on the land (Figure 15).

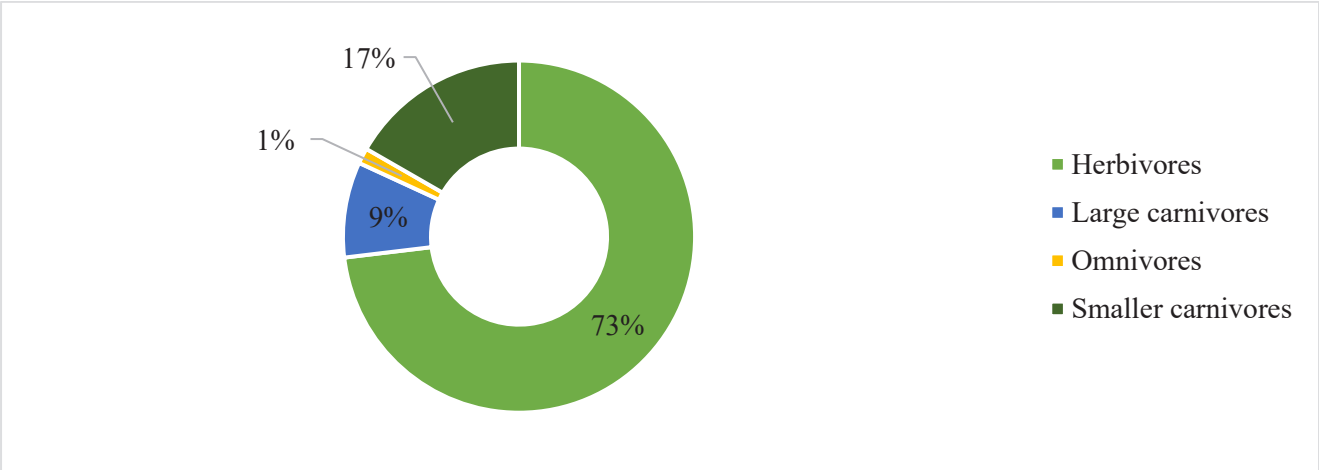

Figure 15. Mammal species compositions across different categories

Among the carnivore species, the photographic rate was highest for Royal Bengal Tiger followed by the Himalayan Black Bear, and least with Black Panther, indicating that Tigers in the corridor are most active and abundant (Table 10). Among small wild cats, Leopard Cat was most abundant (Independent Photo Capture (IPC) 101), followed by Marbled Cat (IPC=63), Asiatic Golden Cat (IPC=14), and Clouded Leopard (IPC=14).

Table 10. Independent photographic of carnivore species

Carnivore species	IPC (n)
Common leopard	36
Dhole	40
Himalayan black bear	52
Tiger	68

The species were recorded within the elevation range of 1096 masl to 3750 masl. The Himalayan Black Bear was the most widely distributed terrestrial mammal present from the WBL forest to the Fir Forest, followed by Common Leopard. Dhole was widely distributed from 1096 to 2990 masl, followed by Royal Bengal Tiger, with a distribution range from 1859 to 3750 masl among the top predators (Figure 16). Marbled Cat was widely distributed among the small cats, followed by Leopard Cat and Asiatic Golden Cat. Royal Bengal Tiger, Himalayan Black Bear, Marbled Cat, and Musk Deer were captured at the highest elevation (3750 masl). Among the ungulates, Sambar Deer and Barking Deer have a wide range of distribution from the warm broad-leaved forest to Fir Forest. Wild Pig, considered a prey species to the predators and a pest to the farmers, has the widest distribution from 1096 to 3082 masl. Six mammal species (Brush-tailed Porcupine, Capped Langur, Gaur, Musk Deer, Orange-bellied Squirrel, and Spotted Linsang) were recorded only in a particular location. Apart from a few species like Red Panda, Musk Deer, Yellow-bellied Weasel, Brush-tailed Porcupine, Gaur, and Spotted Linsang, the rest of the mammals are widely distributed inside BC4.

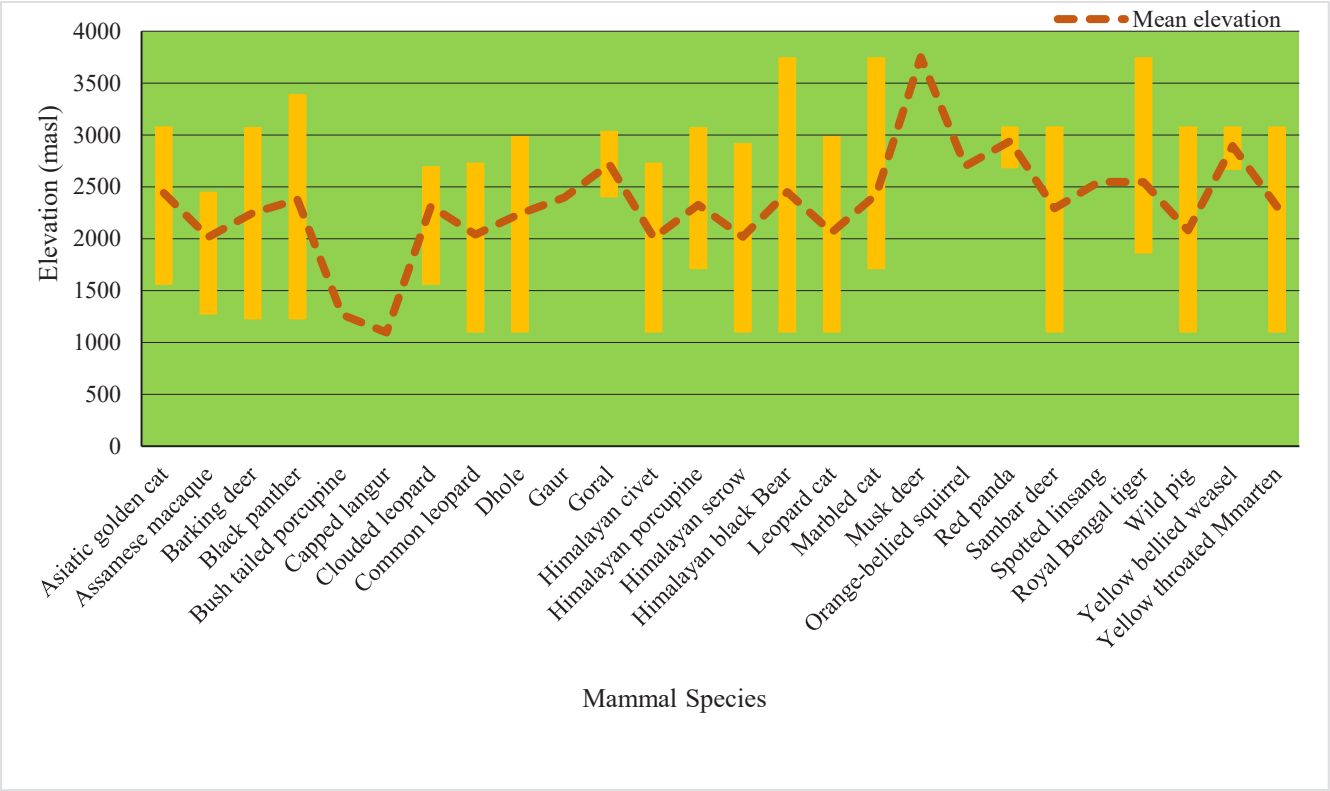

Figure 16. Mammal species distribution elevation range recorded from camera trap survey

The naïve occupancy was highest for Barking Deer (0.89, n=24) and, Sambar Deer (0.66, n=23), Yellow-throated Marten (0.66, n=23). Wild Pig also has the highest occupancy, similar to Leopard Cat, and both are considered a pest by the farmers. Among the ungulates, Himalayan Serow has the lowest (0.23, n=8) occupancy. Tiger (0.51, n=18) has the largest occupancy followed by Himalayan Black Bear (0.49, n=17), Dhole (0.43, n=15) and Common Leopard (0.29, n=10) among the predators. Thus, indicating that all these predators are widely distributed in the corridor.

The Gaur, Orange-bellied Squirrel, Musk Deer, Spotted Linsang, and Brush-tailed Porcupine have the least occupancy (0.03) inside BC 4 (Figure 17).

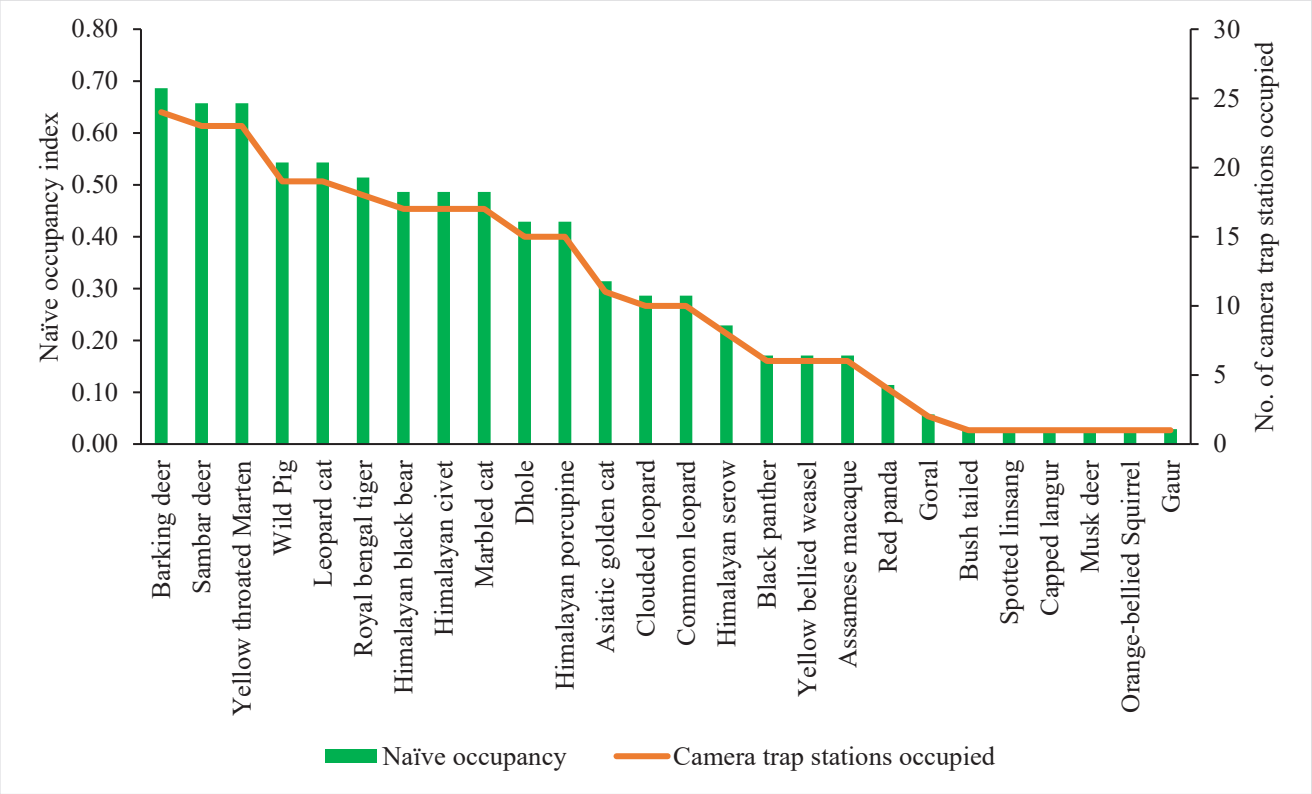

Figure 17. Mammal species naive occupancy proportion

The activity pattern for herbivore and carnivore species were determined from the frequency of the independent photographs captured for each species. The activity pattern graph was prepared by plotting the frequency of the independent photo capture events as a surrogate of the species activity against the time of the day the species was captured.

Activity patterns were derived among the three categories of wildlife: larger carnivores, small carnivores, and herbivores. Royal Bengal Tigers are less active during the mid-night to dawn (07:00 to 09:00), and rest of the hours, they remain active with higher movement in the morning (05:00 to 0:700), mid-day (11:00 to 14:00), and in the evening (20:00 to 21:00). Himalayan Black Bears are active during the day (06:00 to 20:00). Their movement is significantly minimal in the evening (21:00 to 24:00). They have no movement during mid-night to dawn (00:00 to 05:00). Dhole is also more active during the day time and significantly less active at night. Common Leopards are more active during the day and have no movement from 19:00 to midnight but are active from midnight to dawn (00:00 to 04:00) (Figure 18).

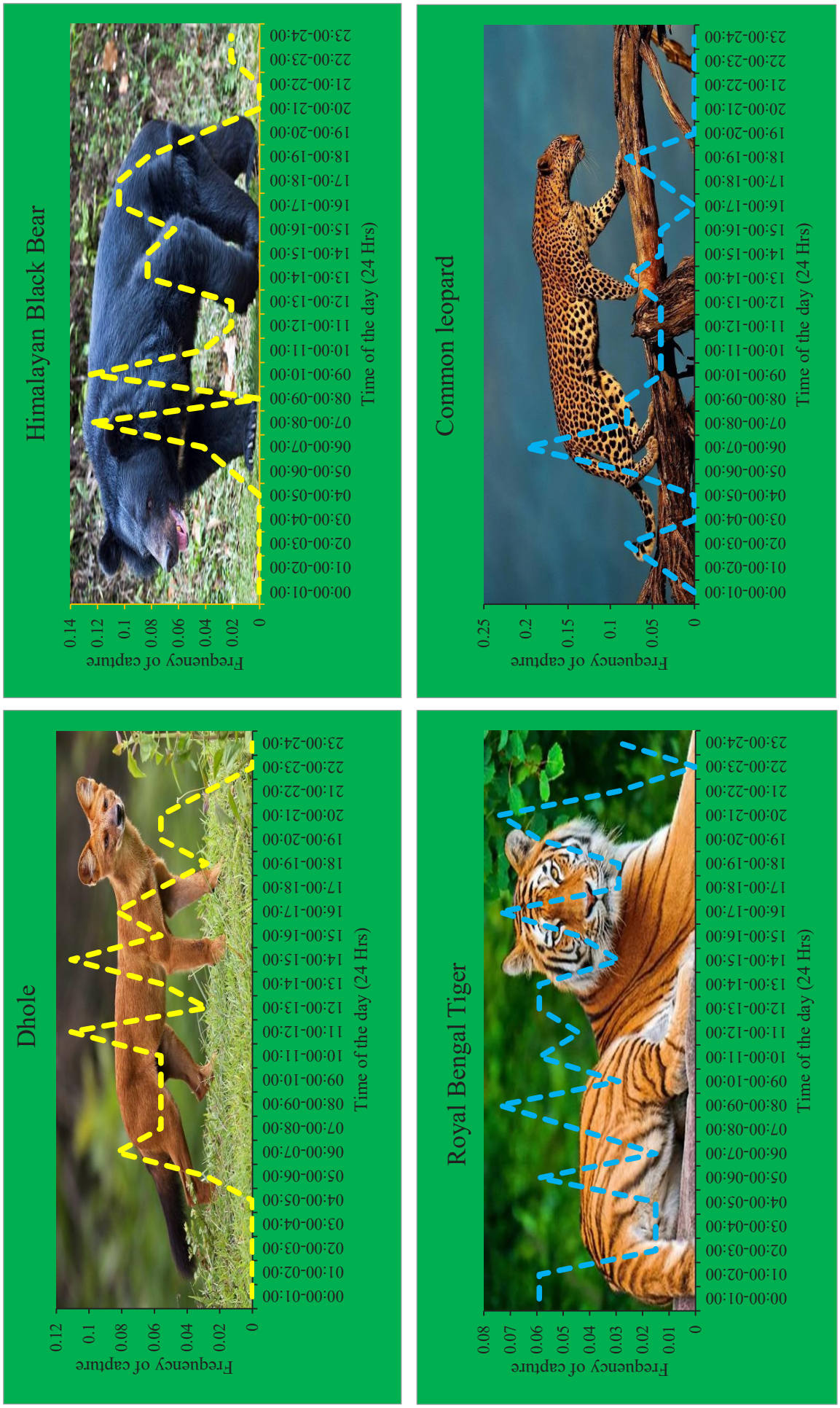

Figure 18. Activity pattern of large carnivores

Among small wild cats, Asiatic Golden Cats are active throughout the day and less active from 16:00 to 17:00. Clouded leopards are less active during mid-night and morning (06:00 to 09:00) and most active from 02:00 to 04:00 at night. Leopard Cats are more active at night and less during the day (Figure 19). Wild Pig in the area is more active during the day and less at night. Barking Deer is active both day and night and most active during morning hours (07:00 to 10:00). The activity pattern of Himalayan Serow is constant throughout day and night but more active from 03:00 to 04:00. Sambar Deer is also active throughout the day and night. They are also more active from 03:00 to 06:00 in the early morning and the evening (17:00 to 21:00). Activity pattern of Barking Deer is similar to Sambar Deer. Porcupines are more active during the night than during the day, whereas Yellow-throated Martens are most active during the day and significantly less at night (Figure 20).

Cuon alpinus (Dhole)

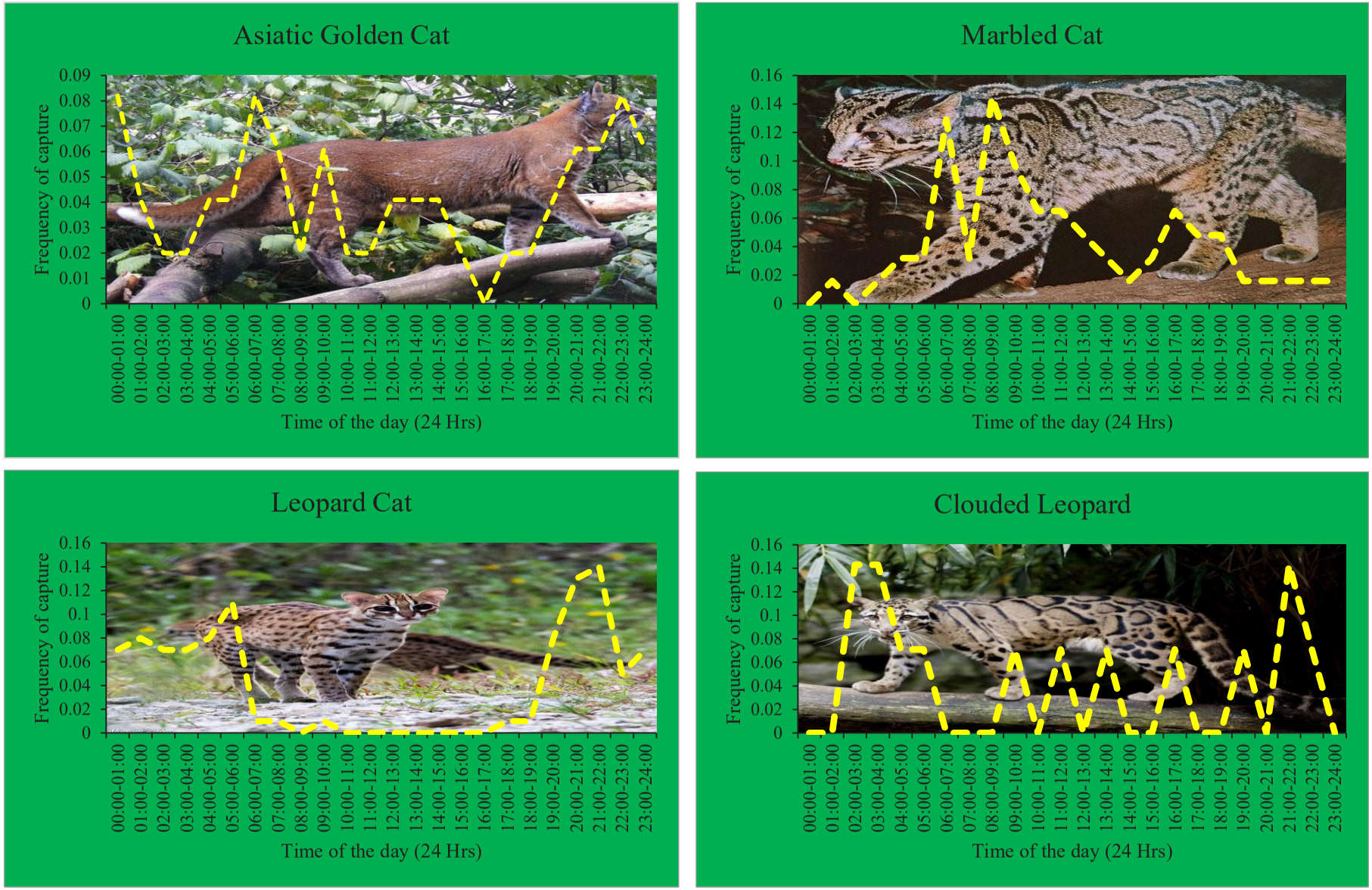

Figure 19. Activity pattern of small carnivores

Figure 20. Activity pattern of herbivores

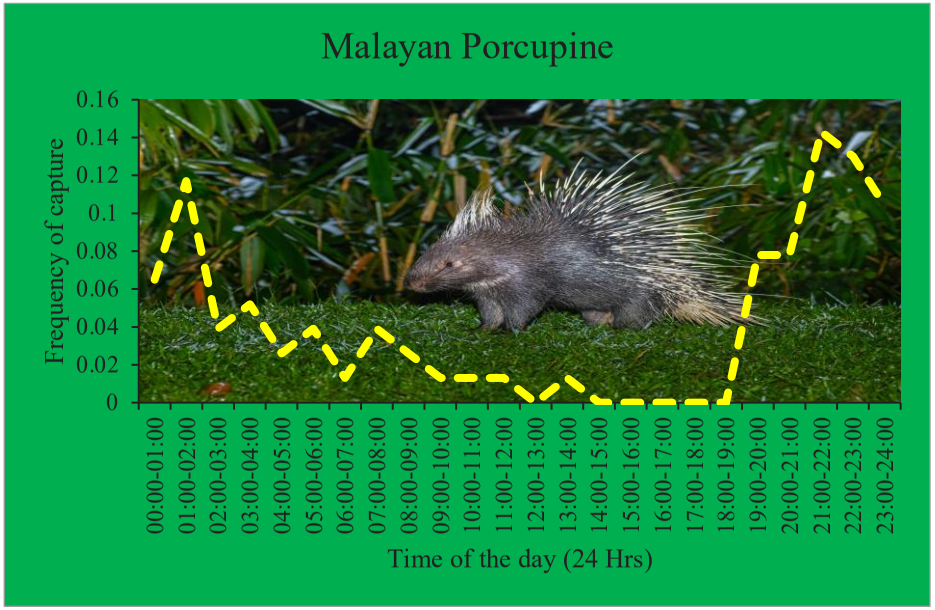

Figure 21. Activity pattern of marten and porcupine

The activity pattern of the Royal Bengal tiger is significantly (CI=95%) similar to its competing predators like Common Leopard, Dhole, and Himalayan Black Bear, and it is also similar to its prey species like Sambar Deer, Barking Deer, and Himalayan Serow. The activity pattern of the Tiger is similar to two small felids (Asiatic Golden Cat and Marbled Cat) among four small felids present in the corridor. The activity pattern of the Himalayan Black Bear is significantly similar to seven species of mammals, including carnivores like Royal Bengal Tiger, Common Leopard, Dhole, Marbled Cat, Asiatic Golden Cat, Yellow-throated Marten, and herbivores including Barking Deer and Wild Pig. The activity pattern of the Sambar Deer, the primary prey for Tigers, is significantly similar to that of the Royal Bengal Tiger, Asiatic Golden Cat, Common Leopard, Himalayan Serow, and Wild Pig (Table 11).

Table 11. Chi-square analysis of paired activity patterns.

Species	Asiatic Golden Cat	Barking deer	Black Panther	Clouded leopard	Common leopard	Dhole	Gaur	Goral	Himalayan civet	Himalayan porcupine	Himalayan serow	Himalayan black bear	Leopard cat	Marbled cat	Musk deer	Orange-bellied squirrel	Reb panda	Sambar deer	Spotted linsang	Tiger	Wild pig	Yellow-bellied weasel	Yellow-throated marten
Asiatic golden cat		+	0	0	+	+	0	0	+	+	+	0	0	+	0	0	0	+	0	+	0	0	0
Barking deer	0		0	0	+	0	0	0	0	0	+	0	0	0	0	0	0	0	0	+	0	0	0
Black Panther	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Common Leopard	0	0	0	0		+	0	0	0	0	+	+	0	+	0	0	0	+	0	+	+	0	0
Dhole	0	0	0	0	0		0	0	0	0	+	+	0	+	0	0	0	0	0	+	+	0	+
Himalayan civet	+	0	0	0	0	0	0	0		+	0	0	0	0	0	0	0	0	0	0	0	0	0
Himalayan porcupine	+	0	0	0	0	0	0	0	+		+	0	+	0	0	0	0	0	0	0	0	0	0
Himalayan serow	+	+	0	0	+	+	0	0	0	+		0	0	+	0	0	0	+	0	+	0	0	0
Himalayan black bear	+	+	0	0	+	+	0	0	0	0	0		0	+	0	0	0	0	0	+	+	0	+
Leopard cat	0	0	0	0	0	0	0	0	0	+	0	0		0	0	0	0	0	0	0	0	0	0
Marbled cat	+	0	0	0	+	+	0	0	0	0	+	+	0		0	0	0	0	0	+	+	0	0
Sambar deer	+	0	0	0	+	0	0	0	0	0	+	0	0	0	0	0	0		0	+	0	0	0
Tiger	+	+	0	0	+	+	0	0	0	0	+	+	0	+	0	0	0	+	0		0	0	0
Wild pig	0	0	0	0	+	+	0	0	0	0	0	+	0	+	0	0	0	0	0	0		0	+

Hypothesis (H0): Species A and B have similar activity patterns at 95%, Significant = +, Not significant = 0

3.2.3 Mammal species inventory

The corridor is home to charismatic and conservation significant mammal species like Royal Bengal Tiger, Clouded Leopard, Asiatic Golden Cat, Marbled Cat, Golden Langur, Capped Langur, Red Panda, Himalayan Musk Deer, and Spotted Linsang. Corridor recorded 40 species of mammals to date (Annexure 2). Out of 40 recorded species, five are listed as Endangered, six are Near Threatened, and

seven are Vulnerable. In addition, 16 species are protected under Appendix I of CITES and three species under Appendix II.

3.3 Avifauna diversity and richness

Fourteen BMG sample grids were identified inside the BC4. The survey team walked 23 transects covering 149.95Km stretch (total transect length) and recorded data for 135 hours. Old trails and roads were used as transects, covering the elevation range of 1080 to 3600 masl. During the current survey, 138 bird species belonging to 49 families were recorded across three forest types, namely, Fir Forest (>3000m), CBL Forest (2000-3000m), and WBL Forest (1000-2000m). Four species were recorded from all three forest types, 40 species from either two forest types, and 94 species from one forest type. A total of 1560 bird individuals were counted for the whole survey. From the list of recorded bird species, Mountain Hawk Eagle and Satyr Tragopan are listed as near threatened (NT) and Rufous-necked Hornbill as vulnerable (VU) in the IUCN Red List of threatened species. Further, 17 species are migratory birds (Birdlife International, 2022).

The highest bird species recorded are from Leiothrichidae and Muscicapidae family (16 species each) and one species each from Aegithalidae, Bucerotidae, Campephagidae, Chloropseidae, Dicaeidae, Emberizidae, Estrildidae, Eurylaimidae, Falconidae, Hirundinidae, Laniidae, Motacillidae, Passeridae, Pnoepygidae, Rhipiduridae, Sturnidae, Tichodromidae, Troglodytidae, Trogonidae, Vangidae and Vireonidae as the lowest (Figure 22).

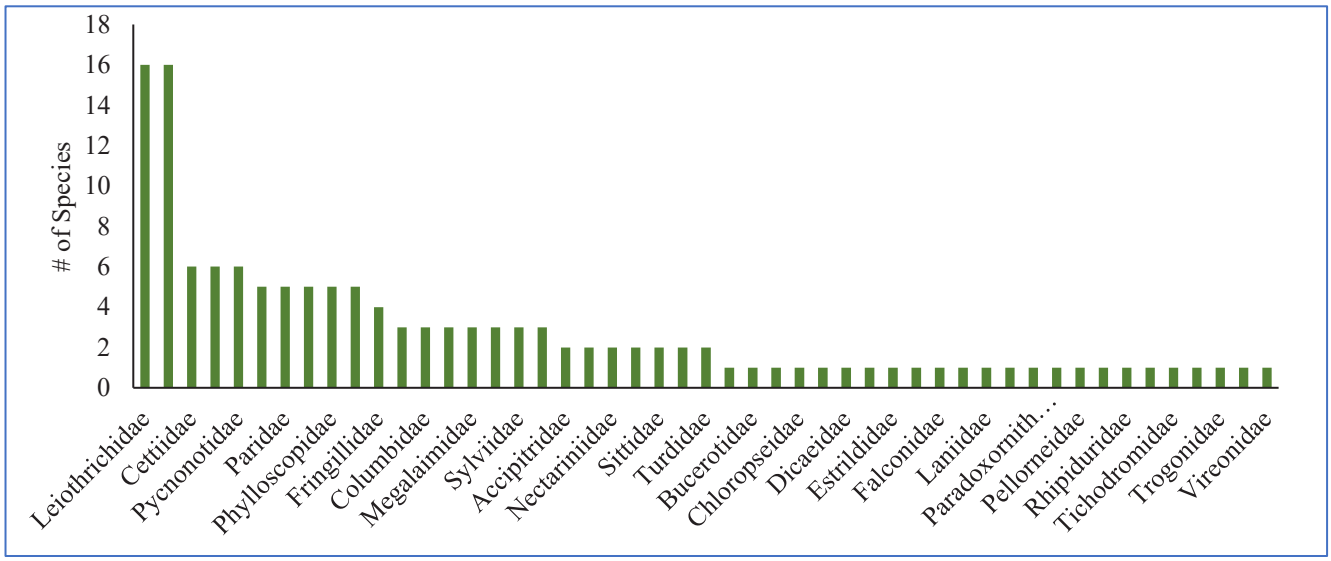

Figure 22. Bird species richness among the families

Fir Forest recorded 11 bird species with 55 encounters, CBL recorded 63 species with 533 encounters, and WBL recorded 112 species with 972 bird encounters. Shannon-Wiener Diversity Index (H) indicates that the bird diversity is higher in WBL Forest, followed by CBL Forest, and Fir Forest has the least bird diversity (Table 12), indicating that the WBL forests have a more considerable diversity and abundance of bird species.

Table 12. Bird diversity, richness, and evenness across forest types

Forest Type	Species Richness	Species Diversity (H)	Evenness (E)
CBL Forest	63	3.384	0.817
Fir Forest	11	1.904	0.794
WBL Forest	112	4.045	0.857

The current survey further expanded the checklist of birds for Zhemgang Forest Division by adding six new species (Plain Mountain Finch, Scaly Laughingthrush, White-throated Redstart, Grey-crested Tit, Rufous-vented Tit, and Maroon-backed Accentor). In addition, the species-area curve of bird observation records indicates a higher chance of observing additional species if we increase our survey effort.

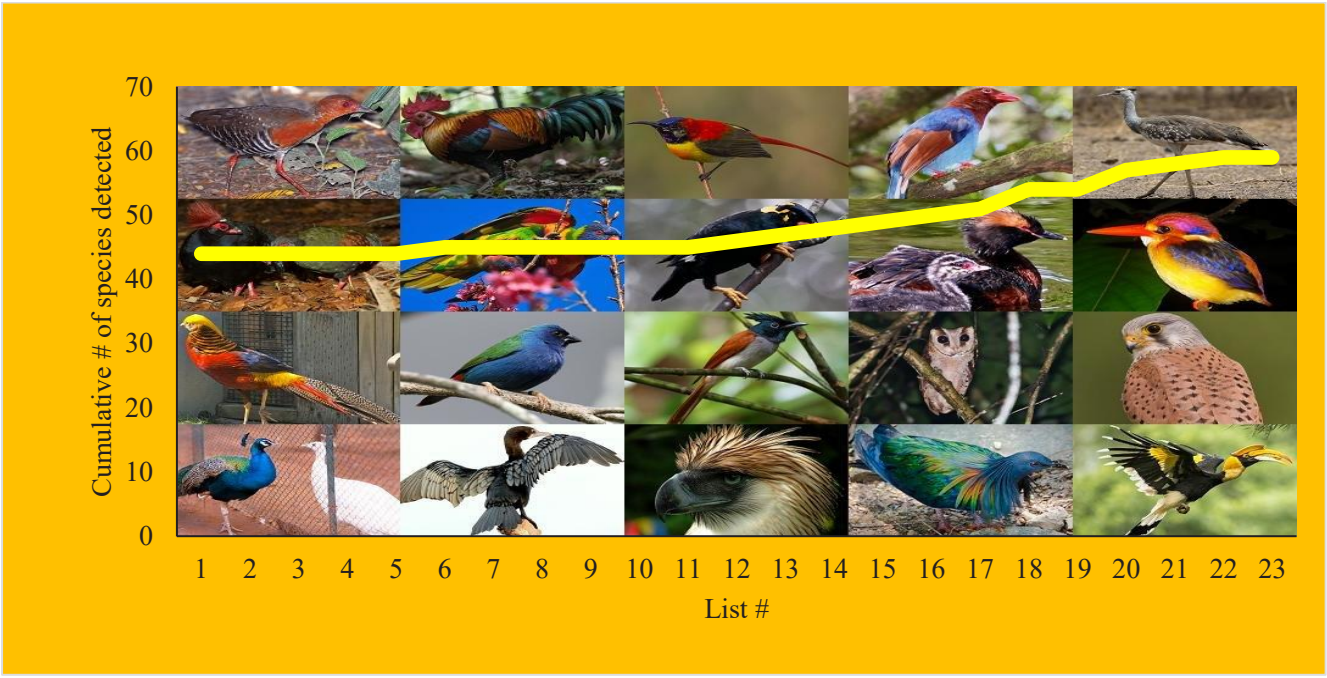

Figure 23. Species area curve of birds

3.3.1 Avifauna species inventory

Recorded 305 species of birds belonging to 61 families are recorded from the biological corridor Figure (Annexure 3). BC4 currently hosts nine conservation significant species and 65 migratory bird species. On addition, the corridor is home to one critically endangered bird with its active nesting in the corridor (Table 13).

Table 13. IUCN Red list category of birds

IUCN Status	Common name
Critically Endangered (CR)	White Bellied Heron
Endangered (EN)	Steppe Eagle
Near Threatened (NT)	Mountain Hawk Eagle, Rufous-bellied Eagle, Himalayan Griffon, Great Hornbill, Yellow-rumped Honeyguide, Satyr Tragopan, Ward's Trogon
Vulnerable (VU)	Greater Spotted Eagle, Rufous-necked Hornbill, Grey-crowned Prinia, Beautiful Nuthatch

3.4 Other species inventory

As an initial checklist of fungi for the corridor, mushroom species were also recorded during RBA, 2021. The team was able to record 37 species of mushrooms under 27 genera, covering 20 families (Annexure 4). The opportunistic species listing during the RBA 2021 could identify and record 38 species of ferns belonging to 16 families (Annexure 5). In addition, damselflies with 15 species belonging to 7 families and Dragonflies with eight species belonging to three families were recorded to date (Table 14).

Table 14. Check list of damselflies and dragonflies

Damselflies		Dragonflies	
Family	**# Species**	**Family**	**# Species**
Calopterygidae	1	Aeshnidae	1
Chlorocyphidae	2	Gomphidae	3
Coenagrionidae	5	Libellulidae	4
Euphaeidae	3		
Lestidae	2		
Platycnemididae	1		
Platystictidae	1		
Total	**15**		**8**

We recorded 23 species of snakes, including two threatened and one data deficient (DD), belonging to four families (Annexure 6). Three frog species were recorded far from the corridor, including one Endangered species under the IUCN Red List (Annexure 6). Corridor has high potential as a habitat for orchids, and we were able to record 129 species of orchids (Annexure 7) under 52 genera. A total of 150 species of butterflies (Annexure 8) belonging to 6 families and 36 species of moths (Annexure 9) belonging to 16 families were recorded so far. No systematic inventory for orchids, butterflies, moths, and other smaller insects was conducted in the corridor.

4 Recommendations for management implication

Thinning operation: Most of the corridor area is broad-leaved forest, and the higher elevation area is dominated by Fir and Rhododendron species. Symplocos species and Castanopsis species dominate the overall vegetation composition, and there are limited desired timber species for use by the local communities. Plantation of desired native species and thinning over dominant species will help create a mixed stand of forest. The DBH of the trees is thin, which could be due to an overcrowded stand with maximum crown coverage, and thinning of the forest stand is recommended to create space for lateral growth.

Figure 24. Overcrowded *Castanopsis* tree species

Research and development: Several new records of plants for Bhutan and new to science were discovered from the corridor in the past three years (Figure 23). The corridor has the high potential of harboring many flora species, which is still undiscovered, and it is recommended to explore and

inventory the plant species during all seasons and create an inclusive flora database for the corridor. In addition, there are lesser-known mammal and bird species, which warrants studying these species concerning BC 4. Creating a database for other taxa is also pivotal for determining the functionality of the corridor and its value in a protected area. Assessing the structural connectivity of the corridor for wildlife movement between the parks is paramount.

Figure 25. *Begonia bhutanensis* (New species to science)

Wildlife habitat management: The corridor has an equal proportion of predator and prey species. It also harbors conservation significant species that need more conservation focus. Therefore, protecting the current habitat and enhancing the habitat based on the habitat management guideline is crucial in protecting and enhancing the vital corridor in Bhutan.

Figure 26. Wildlife habitat mosaic

Human-wildlife Conflict Management: Top predators and herbivores, considered a pest to the rural farmers, are distributed across the corridor, and the conflict is foreseen. Therefore, strategizing human-wildlife conflict mitigation measures is essential to benefit wildlife and rural farmers. Predators and herbivores have high occupancy in the corridor, and it is evident that human-wildlife conflict is inevitable. Therefore, it is recommended to minimize the conflict through Social Development for Conservation programs (SD4C) which can provide livelihood alternatives to the local farmers. In addition, insurance schemes for livestock depredation and crop damage programs can be initiated to minimize the impact of HWC.

Figure 27. Golden langur killed by vehicle

Awareness and education: Many protected species are protected by the laws and need a strong conservation focus. Local people are the immediate neighbor to these species, and many rural people get associated with killing wildlife due to a lack of awareness of rules and regulations for protecting such species under our law. Making local communities aware of their conservation significance will help strengthen our effort toward conserving such essential species.

Patrolling and enforcement: The division management must carry out patrolling and enforcement activities against illegal extraction of timber, NWFP, and wildlife poaching by the local communities and poachers. The corridor is a breeding habitat for Royal Bengal Tiger, and poaching is risky. Hence SMART patrolling should be enhanced inside its habitat. Patrolling has to be focused within edges of settlements, around temporary labor camps of contractors carrying out developmental works and herding grounds. Fishing patrolling, especially during the winter, should be carried out as the critically endangered White-bellied Heron is best seen feeding during the season. Enforcement of the existing laws should be made stringent since the corridor is the habitat of many threatened species of mammals, birds, plants, and many more taxa.

Ecotourism: The corridor is home to diverse bird species and has very suitable bird-watching trails; therefore, it is recommended to develop and market bird-watching tourism products in the corridor. Moreover, wildlife sightings along roads are frequent, and it has a high potential for developing night wildlife safari, especially from Buli to Therang bridge.

Improve and increase human resource development: We are now gearing towards the scientific management of the corridor. The independent staff responsible for BC4 management with enough strength must be instituted for better corridor management. Natural resources management is also based

on a scientific framework, and it is vital to enhance the knowledge and skills of the staff by providing short and long-time training, refresher courses, and in-house knowledge-sharing seminars. It is also crucial to train the field staff on species taxonomy and field identification, wildlife photography, wildlife survey methods, data analysis, and reporting to enhance the scientific knowledge of the corridor further and cater to its conservation value.

5 Limitation

The RBA was conducted only in the winter months, and the information across other months is underrepresented. Camera traps were installed for six months, from January to June, and it excludes the status of wildlife in the autumn and winter months. The bird survey was conducted only during the day, and nocturnal birds are significantly less represented in the diversity. Most species inventory listings are based on opportunistic observation, and most species could have been excluded. Hence, sampling effort can be increased for all three taxa (plant, mammal, and bird), which is suggested as the result of the species accumulation curve.

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Annexures

Annexure 1: An annotated flora checklist for BC 4 from 2006 to 2021

Sl.no	Scientific name	Family	Habit	IUCN status	CITES	Remarks	0 @2006, x @2016, X@2021
1	*Abies densa*	Pinaceae	Tree	LC			0 X
2	*Acanthocalyx nepalensis*	Caprifoliaceae	Herb	LC			X
3	*Acer campbellii*	Sapindaceae	Tree	LC			0 x X
4	*Acer hookeri*	Sapindaceae	Tree	DD			0 X
5	*Acer oblongum*	Sapindaceae	Tree	LC			X
6	*Acer sikkimense*	Sapindaceae	Tree	LC			X
7	*Acer sterculiaceum*	Sapindaceae	Tree	LC			X
8	*Acer thomsonii*	Sapindaceae	Tree	LC			X
9	*Actinodaphne obovata*	Lauraceae	Tree	LC			0
10	*Aeschynanthus hookeri*	Gesneriaceae	Herb	LC			X
11	*Aesculus indica*	Hippocastanaceae	Tree	LC			0
12	*Agapetes smithiana*	Ericaceae	Herb	LC			0
13	*Agapetes variegata*	Ericaceae	Shrub	LC			X
14	*Ageratina adenophora*	Asteraceae	Shrub	LC			0 x X
15	*Ageratum conyzoides*	Asteraceae	Herb	LC			x X
16	*Aglaia edulis*	Meliaceae	Tree	NT			X
17	*Ailanthus integrifolia*	Simaroubaceae	Tree	LC			X
18	*Ainsliaea latifolia*	Compositae	Grass	LC			X
19	*Albizia chinensis*	Leguminosae	Tree	LC			0 X
20	*Albizia julibrissin*	Leguminosae	Tree	LC			X
21	*Albizia lebbeck*	Leguminosae	Tree	LC			x X
22	*Albizia procera*	Leguminosae	Tree	LC			x X
23	*Alcimandra cathcartii*	Magnoliaceae	Tree	LC			X
24	*Alingium alpinum*	Cornaceae	Shrub	LC			X
25	*Alingium chinensis*	Cornaceae	Shrub	LC			X
26	*Allium caesium*	Alliaceae	Herb	LC			0
27	*Alnus nepalensis*	Betulaceae	Tree	LC			0 x X
28	*Altingia excelsa*	Altingiaceae	Tree	LC			X
29	*Anaphalis busua*	Asteraceae	Herb	LC			0 X
30	*Anaphalis margaritacea*	Compositae	Herb	LC			X

31	*Anaphalis triplenervus*	Asteraceae	Herb	LC			0
32	*Anisodus luridus*	Solanaceae	Shrub	LC			X
33	*Anisomeles indica*	Lamiaceae	Shrub	LC			X
34	*Aphanamixis polystachya*	Meliaceae	Tree	LC			X
35	*Aquilaria malaccensis*	Thymelaeaceae	Tree	CR	Appendix II		0
36	*Ardisia macrocarpa*	Primulaceae	Shrub	LC			0 X
37	*Ardisia thyrsiflora*	Primulaceae	Shrub	LC			0
38	*Arisaema consanguineum*	Araceae	Herb	LC			X
39	*Arisaema galeatum*	Araceae	Herb	LC			X
40	*Arisaema griffithii*	Araceae	Herb	LC			0
41	*Arisaema jacquemontii*	Araceae	Herb	LC			X
42	*Arisaema tortuosum*	Araceae	Herb	LC			X
43	*Arisaema triphyllum*	Araceae	Herb	LC			X
44	*Artemisia bhutanica*	Asteraceae	Shrub	LC		Endemic	X
45	*Artemisia maritima*	Asteraceae	Shrub	LC			x
46	*Artemisia roxburghii*	Asteraceae	Shrub	LC			0
47	*Artemisia vulgaris*	Asteraceae	Shrub	LC			X
48	*Asparagus racemosus*	Asparagaceae	Shrub	LC			X
49	*Astilbe rivularis*	Saxifragaceae	Shrub	LC			0 X
50	*Balanophora sp*	Balanophoraceae	Herb	LC			X
51	*Barleria cristata*	Acanthaceae	Shrub	LC			X
52	*Bauhinia variegata*	Fabaceae	Tree	LC			x X
53	*Begonia bhutanensis*	Begoniaceae	Herb	LC			X
54	*Begonia flaviflora hara*	Begoniaceae	Herb	LC			X
55	*Begonia gemmipara*	Begoniaceae	Herb	LC			X
56	*Begonia hatacoa*	Begoniaceae	Herb	LC			X
57	*Begonia megaptera*	Begoniaceae	Herb	LC			X
58	*Beilschmiedia gammieana*	Lauraceae	Tree	LC			X
59	*Benthamedia capitata*	Cornaceae	Tree	LC			X
60	*Berberis angulosa*	Berberidaceae	Shrub	LC			x
61	*Berberis asiatica*	Berberidaceae	Shrub	LC			0 x X
62	*Berberis hookeri*	Berberidaceae	Shrub	LC			X
63	*Berberis insignis*	Berberidaceae	Shrub	LC			X

64	*Berberis praecipua*	Berberidaceae	Shrub	LC			X
65	*Bergenia ciliata*	Saxifragaceae	Herb	LC			X
66	*Betula alnoides*	Betulaceae	Tree	LC			0 X
67	*Betula utilis*	Betulaceae	Tree	LC			0 X
68	*Bidens pilosa*	Asteraceae	Herb	LC			0 X
69	*Bischofia javanica*	Phyllanthaceae	Tree	LC			X
70	*Bistorta affinis*	Polygonaceae	Herb	LC			0 X
71	*Boehmeria macrophylla*	Urticaceae	Herb	LC			x
72	*Boehmeria platanifolia*	Urticaceae	Shrub	LC			X
73	*Boehmeria platyphylla*	Urticaceae	Shrub	LC			X
74	*Bombax ceiba*	Bombacaceae	Tree	LC			0 X
75	*Borinda grossa*	Poaceae	Bamboo	LC			X
76	*Boschniakia himalaica*	Orobanchaceae	Herb	LC			X
77	*Brassaiopsis hainla*	Araliaceae	Tree	LC			X
78	*Brassaiopsis mitis*	Araliaceae	Tree	LC			0 X
79	*Bridelia retusa*	Phyllanthaceae	Shrub	LC			0 X
80	*Buddleja asiatica*	Buddlejaceae	Shrub	LC			0
81	*Bupleurum candollei*	Apiaceae	Herb	LC			X
82	*Caesalpinia decapetala*	Leguminosae	Shrub	LC			0
83	*Callicarpa arborea*	Lamiaceae	Shrub	LC			0 X
84	*Canarium strictum*	Burseraceae	Tree	LC			0 X
85	*Cannabis sativa*	Cannabaceae	Shrub	LC			x X
86	*Canthium angustifolium*	Rubiaceae	Shrub	LC			X
87	*Cardamine impatiens*	Brassicaceae	Herb	LC			X
88	*Cardiocrinum giganteum*	Liliaceae	Herb	LC			X
89	*Caryota urens*	Arecaceae	Tree	LC			x
90	*Casearia glomerata*	Flacourtiaceae	Shrub	LC			X
91	*Cassiope fastigiata*	Ericaceae	Herb	LC			0
92	*Castanopsis hystrix*	Fagaceae	Tree	LC			0 X
93	*Castanopsis indica*	Fagaceae	Tree	LC			0 X
94	*Castanopsis tribuloides*	Fagaceae	Tree	LC			X
95	*Celtis tetrandra*	Ulmaceae	Tree	LC			0 X
96	*Chimonobambusa callosa*	Poaceae	Bamboo	LC			X

97	*Chirita urticifolia*	Urticaceae	Shrub	LC			0 x
98	*Chlorophytum nepalense*	Asparagaceae		LC			X
99	*Chromolaena odorata*	Asteraceae	Shrub	LC			0 x X
100	*Chukrasia tabularis*	Meliaceae	Tree	LC			x X
101	*Cinnamomum bejolghota*	Lauraceae	Tree	LC			x X
102	*Cinnamomum glaucescens*	Lauraceae	Tree	LC			X
103	*Cinnamomum impressinervium*	Lauraceae	Tree	LC			X
104	*Cinnamomum tamala*	Lauraceae	Tree	LC			0 x
105	*Cirsium falconeri*	Asteraceae	Herb	LC			0 X
106	*Cirsium verutum*	Asteraceae	Herb	LC			0 X
107	*Clematis acuminata*	Ranunculaceae	Climber	LC			X
108	*Clematis montana*	Ranunculaceae	Climber	LC			0 x X
109	*Clerodendrum colebrookianum*	Lamiaceae	Shrub	LC			X
110	*Clerodendrum infortunatum*	Lamiaceae	Shrub	LC			0 x
111	*Clerodendrum serratum*	Lamiaceae	Shrub	LC			X
112	*Clintonia udensis*	Liliaceae	Herb	LC			X
113	*Colocasia esculenta*	Araceae	Herb	LC			x
114	*Corydalis elatum*	Fumariaceae	Herb	LC			0
115	*Corylopsis himalayana*	Hamamelidaceae	Shrub	LC			X
116	*Cotoneaster intregrifolia*	Rosaceae	Herb	LC			0
117	*Cotoneaster microphylla*	Rosaceae	Shrub	LC			x
118	*Cotoneaster rotundifolius*	Rosaceae	Shrub	LC			X
119	*Crassocephalum crepidioides*	Asteraceae	Herb	LC			0 X
120	*Crawfurdia speciosa*	Gentianaceae	Climber	LC			X
121	*Cremanthodium reniforme*	Asteraceae	Herb	LC			0
122	*Crotolaria bracteata*	Leguminosae	Shrub	LC			X
123	*Cyanotis vaga*	Commelinaceae	Herb	LC			X
124	*Cyathula capitata*	Amaranthaceae	Herb	LC			X
125	*Cynoglossum amabile*	Boraginaceae	Shrub	LC			X
126	*Cynoglosum furcatum*	Asteraceae	Herb	LC			0
127	*Daphne bholua*	Thymelaeaceae	Shrub	LC			0 X
128	*Daphne sureil*	Thymelaeaceae	Shrub	LC			X

129	*Daphniphyllum himalense*	Daphniphyllaceae	Tree	LC			0 X
130	*Datura stramonium*	Solanaceae	Shrub	LC			X
131	*Debregeasia longifolia*	Urticaceae	Shrub	LC			0 X
132	*Dendrocalamus hamiltonii*	Poaceae	Bamboo	LC			X
133	*Dendrocnide sinuata*	Urticaceae	Shrub/Tree	LC			X
134	*Deutzia compacta*	Philadelphaceae	Shrub	LC			0
135	*Dichroa febrifuga*	Hydrangeaceae	Shrub	LC			0 x X
136	*Dioscora bulbifera*	Dioscoreaceae	Climber	LC			X
137	*Dioscorea deltoidea*	Dioscoreaceae	Climber	LC	Appendix II		0
138	*Dioscorea hamiltonii*	Dioscoreaceae	Climber	LC			x
139	*Diploknema butyracea*	Sapotaceae	Tree	LC			0 x X
140	*Dipsacus inermis*	Caprifoliaceae	Herb	LC			X
141	*Disporum cantoniense*	Liliaceae	Herb	LC			X
142	*Dobinia vulgaris*	Anacardiaceae	Shrub	LC			X
143	*Docynia indica*	Rosaceae	Tree	LC			0 X
144	*Dodecadenia grandiflora*	Lauraceae	Tree	LC			X
145	*Drepanostachyum intermedium*	Poaceae	Bamboo	LC			x
146	*Drimycarpus racemosus*	Anacardiaceae	Tree	LC			X
147	*Drymaria cordata*	Caryophyllaceae	Herb	LC			X
148	*Duabanga grandiflora*	Lythraceae	Tree	LC			0 x X
149	*Dufrenoya platyphylla*	Santalaceae	Herb	LC			X
150	*Duhaldea cappa*	Asteraceae	Herb	LC			0 X
151	*Edgeworthia gardneri*	Thymelaeaceae	Shrub	LC			X
152	*Ekianthus deflexus*	Ericaceae	Shrub	LC			X
153	*Elaeagnus parviflora*	Elaeagnaceae	Shrub	LC			X
154	*Elaeocarpus lanceifolius*	Elaeocarpaceae	Tree	LC			X
155	*Elaeocarpus sikkimensis*	Elaeocarpaceae	Tree	LC			X
156	*Elastostema lineolatum*	Urticaceae	Herb	LC			0
157	*Elatostema pusila*	Urticaceae	Herb	LC			0
158	*Elatostema sessile*	Urticaceae	Herb	LC			0 x X
159	*Elsholtzia ciliata*	Labiatae	Herb	LC			X
160	*Elsholtzia strobilifera*	Lamiaceae	Herb	LC			X

161	*Elsholzia flava*	Urticaceae	Herb	LC			0
162	*Elsholzia fruiticosa*	Urticaceae	Herb	LC			0
163	*Emblica officinalis*	Phyllanthaceae	Shrub	LC			0 X
164	*Engelhardia spicata*	Juglandaceae	Tree	LC			0 x X
165	*Eriobotyra hookeriana*	Rosaceae	Tree	LC			X
166	*Erythrina arborescens*	Fabaceae	Tree	LC			0 X
167	*Erythrina stricta*	Fabaceae	Tree	LC			X
168	*Euonymous tingens*	Celastraceae	Tree	LC			X
169	*Euphorbia pulcherrima*	Euphorbiaceae	Shrub	LC			X
170	*Eurya acuminata*	Pentaphylaceae	Tree	LC			0 x X
171	*Eurya cerasifolia*	Pentaphylaceae	Tree	LC			0 X
172	*Evodia fraxinifolia*	Rutaceae	Shrub	LC			X
173	*Exbucklandia populnea*	Hamamelidaceae	Tree	LC			0 x X
174	*Ficus auriculata*	Moraceae	Tree	LC			0 X
175	*Ficus elastica*	Moraceae	Tree	LC			0
176	*Ficus heterophylla*	Moraceae	Shrub	LC			X
177	*Ficus hispida*	Moraceae	Shrub	LC			X
178	*Ficus hookeriana*	Moraceae	Tree	LC			x
179	*Ficus oligodon*	Moraceae	Tree	LC			x
180	*Ficus semicordata*	Moraceae	Tree	LC			0 X
181	*Flemingia macrophylla*	Fabaceae	Shrub	LC			X
182	*Fluggea virosa*	Phyllanthaceae	Shrub	LC			0 X
183	*Fragaria nubicola*	Rosaceae	Herb	LC			0 x X
184	*Galinsoga parviflora*	Asteraceae	Herb	LC			X
185	*Galium elegans*	Rubiaceae	Herb	LC			X
186	*Gaultheria fragrantissima*	Ericaceae	Shrub	LC			0 x X
187	*Gaultheria griffithiana*	Ericaceae	Shrub	LC			X
188	*Gaultheria nummularioides*	Ericaceae	Shrub	LC			X
189	*Gaultheria semi-infera*	Ericaceae	Shrub	LC			0 X
190	*Geranium nepalense*	Geraniaceae	Herb	LC			X
191	*Geum elatum*	Rosaceae	Herb	LC			0
192	*Girardina diversifolia*	Urticacea	Herb	LC			0 X
193	*Glochidion heyneanum*	Euphorbiaceae	Tree	LC			X

194	*Gmelina arborea*	Verbenaceae	Tree	LC			x
195	*Gnaphalium affine*	Asteraceae	Herb	LC			0 X
196	*Gnaphalium hypoleucum*	Compositae	Herb	LC			X
197	*Gordonia excelsa*	Theaceae	Tree	LC			X
198	*Grewia optiva*	Tiliaceae	Tree	LC			0
199	*Hedera helix*	Araliaceae	Climber	LC			X
200	*Hedera nepalensis*	Araliaceae	Climber	LC			X
201	*Hedychium aruncullata*	Zingiberaceae	Herb	LC			0
202	*Hedychium densiflorum*	Zingiberaceae	Herb	LC			x
203	*Hedychium ellipticum*	Zingiberaceae	Herb	LC			X
204	*Hedyotis scandens*	Rubiaceae	Herb	LC			X
205	*Helicia nilagirica*	Proteaceae	Shrub	LC			X
206	*Helwingia himalaica*	Cornaceae	Shrub	LC			X
207	*Hemidesmus indicus*	Apocynaceae	Climber/ Shrub	LC			X
208	*Hemiphragma heterophyllum*	Scrophulariaceae	Herb	LC			X
209	*Heracleum lalli*	Apiaceae	Herb	LC			X
210	*Holmskioldia sanguinea*	Verbenaceae	Shrub	LC			X
211	*Hovenia acerba*	Rhamnaceae	Tree	LC			X
212	*Hoya lanceolata*	Apocynaceae	Herb	LC			X
213	*Hoya polyneura*	Apocynaceae	Herb	LC			X
214	*Hydrangea aspera*	Hydrangeaceae	Shrub	LC			X
215	*Hydrocotyle nepalensis*	Araliaceae	Herb	LC			X
216	*Hypericum hookerianum*	Hypericaceae	Shrub	LC			X
217	*Hypericum uralum*	Hypericaceae	Shrub	LC			X
218	*Ilex dipyrena*	Aquifoliaceae	Tree	LC			X
219	*Ilex intricata*	Aquifoliaceae	Tree	LC			X
220	*Ilex sikkimensis*	Aquifoliaceae	Tree	LC			X
221	*Illex fragilis*	Aquifoliaceae	Tree	LC			0 X
222	*Impatiens latiflora*	Balsaminaceae	Herb	LC			X
223	*Impatiens arguta*	Balsaminaceae	Herb	LC			X
224	*Impatiens jurpia*	Balsaminaceae	Herb	LC			X
225	*Impatiens pseudolavigata*	Balsaminaceae	Herb	LC			X
226	*Impatiens racemosa*	Balsaminaceae	Herb	LC			X

227	*Impatiens radiata*	Balsaminaceae	Herb	LC			X
228	*Impatiens sikkimensis*	Balsaminaceae	Herb	LC			X
229	*Impatiens spirifer*	Balsaminaceae	Herb	LC			X
230	*Impatiens stenanthe*	Balsaminaceae	Herb	LC			X
231	*Impatiens tripetala*	Balsaminaceae	Herb	LC			X
232	*Indigofera dosua*	Leguminosae	Shrub	LC			0 X
233	*Ipomea purpurea*	Convolvulaceae	Herb	LC			0
234	*Isodon lopanthoides*	Labiatae	Herb	LC			X
235	*Jasminum dispermum*	Jasminaceae	Climber	LC			X
236	*Juglans regia*	Juglandaceae	Tree	LC			0 x X
237	*Juniperus squamata*	Cupressaceae	Shrub	LC			0
238	*Justicia adhatoda*	Acanthaceae	Shrub	LC			0 x X
239	*Koenigia mollis*	Polygonaceae	Shrub	LC			0 x X
240	*Koenigia polystachya*	Polygonaceae	Shrub	LC			X
241	*Lagatis kunawarensis*	Asteraceae	Herb	LC			0
242	*Lagerstroemia sp.*	Lythraceae	Tree	LC			X
243	*Lagerstroemia speciosa*	Lythraceae	Tree	LC			x
244	*Laggera pterodonta*	Asteraceae	Herb	LC			X
245	*Lantana camara*	Verbenaceae	Shrub	LC			X
246	*Laportea bulbifera*	Urticaceae	Herb	LC			X
247	*Laportea terminalis*	Urticaceae	Herb	LC			X
248	*Leucas ciliata*	Labiatae	Herb	LC			X
249	*Leycester gracilis*	Caprifoliaceae	Shrub	LC			X
250	*Ligularia amplexicaulis*	Asteraceae	Herb	LC			0
251	*Ligularia przewalskii*	Asteraceae	Herb	LC			X
252	*Ligustrum compactum*	Oleaceae	Shrub	LC			X
253	*Lindenbergia muraria*	Scrophulariaceae	Herb	LC			X
254	*Lindera neesiana*	Lauraceae	Tree	LC			X
255	*Lindera pulcherrima*	Lauraceae	Tree	LC			0 X
256	*Lithocarpus elegans*	Fagaceae	Tree	LC			0 x X
257	*Lithocarpus fenestratus*	Fagaceae	Tree	LC			0
258	*Lithocarpus sp.*	Fagaceae	Tree	LC			X
259	*Litsea cubeba*	Lauraceae	Tree	LC			X

260	*Litsea monopetala*	Lauraceae	Tree	LC			X
261	*Litsea Sericea*	Lauraceae	Tree	LC			0
262	*Lobelia nubigena*	Campanulaceae	Herb	LC		Endemic	0
263	*Lobelia pyramidalis*	Campanulaceae	Shrub	LC			X
264	*Lobelia senguinii*	Campanulaceae	Shrub	LC			X
265	*Loranthus elasticus*	Loranthaceae	Tree	LC			x
266	*Lucas aspera*	Lamiaceae	Herb	LC			X
267	*Lyonia ovalifolia*	Ericaceae	Shrub	LC			0 X
268	*Lysionotus serratus*	Gesneriaceae	Shrub	LC			X
269	*Macaranga denticulata*	Euphorbiaceae	Tree	LC			0 X
270	*Macaranga grandifolia*	Euphorbiaceae	Tree	VU			x
271	*Macaranga peltata*	Euphorbiaceae	Tree	LC			X
272	*Maddenia himalaica*	Rosaceae	Shrub	LC			X
273	*Maesa chisia*	Primulaceae	Shrub	LC			0 X
274	*Maesa rugosa*	Myrsinaceae	Shrub	LC			X
275	*Magnolia campbellii*	Magnoliaceae	Tree	LC			0
276	*Magnolia champaca*	Magnoliaceae	Tree	LC			x
277	*Mahonia nepaulensis*	Berberidaceae	Shrub	LC			0 X
278	*Mallotus philippensis*	Euphorbiaceae	Tree	LC			0 X
279	*Mangifera indica*	Anacardiaceae	Tree	LC			x
280	*Mangifera sylvatica*	Anacardiaceae	Tree	LC			X
281	*Maytenus hookeri*	Celastraceae	Shrub	LC			X
282	*Mazus scurrularia*	Mazaceae	Herb	LC			X
283	*Meconopsis grandis*	Papaveraceae	Herb	LC			0
284	*Meizotropis buteiformis*	Fabaceae	Shrub	LC			X
285	*Michelia doltsopa*	Magnoliaceae	Tree	LC			0 X
286	*Michelia kisopa*	Magnoliaceae	Tree	LC			0
287	*Michelia velutina*	Magnoliaceae	Tree	LC			X
288	*Microtropis discolor*	Celastraceae	Shrub	LC			X
289	*Mikania micrantha*	Asteraceae	Herb	LC			0 X
290	*Morus laevigata*	Moraceae	Tree	LC			X
291	*Murraya koenigii*	Rutaceae	Shrub	LC			X
292	*Musa sikkimensis*	Musaceae	Herb	LC			0

293	*Mussenda roxburghii*	Rubiaceae	Shrub	LC			X
294	*Myosotis scorpioides*	Boraginaceae	Herb	LC			X
295	*Myrica esculenta*	Myricaceae	Tree	LC			X
296	*Myrsine semiserrata*	Myrsinaceae	Shrub	LC			x X
297	*Nasturtium officinale*	Tropaeolaceae	Herb	LC			X
298	*Nicandra physalodes*	Solanaceae	Herb	LC			X
299	*Nicotiana tabacum*	Solanaceae	Shrub	LC			X
300	*Ophiopogon japonicus*	Asparagaceae	Grass	LC			X
301	*Oreoseris maxima*	Asteraceae	Herb	LC			X
302	*Oroxyllum indicum*	Bignoniaceae	Tree	LC			0 x X
303	*Osbeckia stellata*	Melastomataceae	Shrub	LC			x X
304	*Ostodes paniculata*	Euphorbiaceae	Tree	LC			0 x X
305	*Osyris lanceolata*	Santalaceae	Shrub	LC			X
306	*Oxyspora paniculata*	Melastomataceae	Shrub	LC			0 X
307	*Panax pseudoginseng*	Araliaceae	Herb	LC			X
308	*Pandanus furcatus*	Pandanaceae	Shrub	LC			x
309	*Pandanus nepalensis*	Pandanaceae	Shrub	LC			0
310	*Parasassafras confertiflora*	Lauraceae	Tree	LC			X
311	*Paris polyphylla*	Melanthiaceae	Herb	VU			X
312	*Peperomia tetraphylla*	Piperaceae	Herb	LC			X
313	*Persea bootanica*	Lauraceae	Tree	LC			0 x
314	*Persea clarkaena*	Lauraceae	Tree	LC			0 X
315	*Persea duthiei*	Lauraceae	Tree	LC			0 x
316	*Persea fructifera*	Lauraceae	Tree	LC			X
317	*Phlogocanthus pubinervius*	Acanthaceae	Shrub	LC			0
318	*Phoebe lanceolata*	Lauraceae	Tree	LC			X
319	*Phoenix humilis*	Arecaceae	Tree	LC			x
320	*Phoenix rupicola*	Arecaceae	Tree	NT			X
321	*Phytolacca acinosa*	Phytolaccaceae	Herb	LC			X
322	*Pieris formosa*	Ericaceae	Shrub	LC			X
323	*Pilea umbrosa*	Urticaceae	Herb	LC			x X
324	*Pinus roxburghii*	Pinaceae	Tree	LC			0 X
325	*Pinus wallichiana*	Pinaceae	Tree	LC			0 X

326	*Piper attenuatum*	Piperaceae	Climber	LC			x
327	*Piper betle*	Piperaceae	Climber	LC			x X
328	*Piper longum*	Piperaceae	Climber/ Shrub	LC			x
329	*Piper pedicilliatum*	Piperaceae	Shrub	LC			X
330	*Plantago erosa*	Plantaginaceae	Herb	LC			0
331	*Plectocomia himalayana*	Arecaceae	Climber	LC			0 X
332	*Polygonatum punctatum*	Asparagaceae	Herb	LC			X
333	*Polytrichum spp.*	Polytrichaceae	Herb	LC			x
334	*Potentilla atrosanguinea*	Rosaceae	Herb	LC			X
335	*Potentilla peduncularis*	Rosaceae	Herb	LC			x X
336	*Pothos cathcartii*	Araceae	Herb	LC			X
337	*Pouzolzia hirta*	Urticaceae	Shrub	LC			X
338	*Pouzolzia sanguinea*	Urticaceae	Shrub	LC			X
339	*Primula boothi*	Primulaceae	Herb	LC			0
340	*Primula capitata*	Primulaceae	Herb	LC			X
341	*Primula concinna*	Primulaceae	Herb	LC			X
342	*Primula gracilipes*	Primulaceae	Herb	LC			X
343	*Primula sikkimensis*	Primulaceae	Herb	LC			0
344	*Prunella vulgaris*	Lamiaceae	Herb	LC			X
345	*Prunus cerasoides*	Rosaceae	Tree	LC			0
346	*Prunus nepalensis*	Rosaceae	Tree	LC			X
347	*Pseudocaryopteris paniculata*	Lamiaceae	Shrub	LC			X
348	*Pterospermum acerifolium*	Sterculiaceae	Tree	LC			x
349	*Quercus glauca*	Fagaceae	Tree	LC			0 X
350	*Quercus griffithii*	Fagaceae	Tree	LC			0 x X
351	*Quercus lamellosa*	Fagaceae	Tree	NT			0 X
352	*Quercus lanata*	Fagaceae	Tree	LC			0 X
353	*Quercus oxyodon*	Fagaceae	Tree	LC			X
354	*Quercus semecarpifolia*	Fagaceae	Tree	LC			0
355	*Rhaphidophora decursiva*	Araceae	Climber	LC			X
356	*Rhaphidophora grandiflora*	Araceae	Climber	LC			X
357	*Rheum acuminatum*	Polygonaceae	Herb	LC			0 X
358	*Rhodiola himalensis*	Crassulaceae	Herb	LC			0

359	*Rhododendron anthopogon*	Ericaceae	Herb	LC			0
360	*Rhododendron arboreum*	Ericaceae	Shrub	LC			0 x X
361	*Rhododendron barbatum*	Ericaceae	Shrub	LC			0 x X
362	*Rhododendron bhutanense*	Ericaceae	Shrub	LC		Endemic	0
363	*Rhododendron dalhousiae*	Ericaceae	Shrub	VU			X
364	*Rhododendron edgeworthii*	Ericaceae	Shrub	LC			0 X
365	*Rhododendron falconeri*	Ericaceae	Shrub	LC			0 x X
366	*Rhododendron flinkii*	Ericaceae	Shrub	LC			0
367	*Rhododendron grande*	Ericaceae	Shrub	LC			0 X
368	*Rhododendron hodgsonii*	Ericaceae	Tree	LC			0 x
369	*Rhododendron kendrickii*	Ericaceae	Shrub	LC			X
370	*Rhododendron kesangiae*	Ericaceae	Tree	LC		Endemic	x
371	*Rhododendron keysii*	Ericaceae	Shrub	LC			0 X
372	*Rhododendron maddenii*	Ericaceae	Shrub	LC			X
373	*Rhododendron setosum*	Ericaceae	Herb	LC			0
374	*Rhododendron thomsonii*	Ericaceae	Shrub	LC			0 X
375	*Rhus chinensis*	Anacardiaceae	Tree	LC			0 x X
376	*Rhus wallichi*	Anacardiaceae	Tree	LC			0
377	*Ribes griffithii*	Grossulariaceae	Shrub	LC			X
378	*Ribes laciniatum*	Grossulariaceae	Shrub	LC			X
379	*Ricinus communis*	Euphorbiaceae	Shrub	LC			0 X
380	*Rohdea nepalensis*	Asparagaceae	Herb	LC			X
381	*Rosa sericea*	Rosaceae	Shrub	LC			X
382	*Roscoea alpina*	Zingiberaceae	Herb	LC			X
383	*Rubia cordifolia*	Rubiaceae	Climber	LC			0 X
384	*Rubia sikkimensis*	Rubiaceae	Shrub	LC			X
385	*Rubus calycinoides*	Rosaceae	Shrub	LC			X
386	*Rubus calycinus*	Rosaceae	Shrub	LC			0 X
387	*Rubus ellipticus*	Rosaceae	Shrub	LC			0 x X
388	*Rubus lineatus*	Rosaceae	Shrub	LC			X
389	*Rubus nievus*	Rosaceae	Shrub	LC			X
390	*Rubus paniculatus*	Rosaceae	Shrub	LC			0 X
391	*Rubus pentagonus*	Rosaceae	Shrub	LC			X

392	*Rubus rugosus*	Rosaceae	Shrub	LC			X
393	*Rubus sengorensis*	Rosaceae	Shrub	LC		Ende mic	X
394	*Rumex nepalensis*	Polygonaceae	Herb	LC			0 X
395	*Salix wallichiana*	Salicaceae	Tree	LC			X
396	*Sambucus adnata*	Adoxaceae	Shrub	LC			X
397	*Sapindus mukorossi*	Sapindaceae	Tree	LC			0 X
398	*Sapium insigne*	Euphorbiaceae	Tree	LC			0 X
399	*Sapria himalayana*	Rafflesiaceae	Herb	EN			X
400	*Sarccococa coriria*	Buxaceae	Herb	LC			0
401	*Sarcococca wallichii*	Buxaceae	Shrub	LC			0 X
402	*Saurauja nepaulensis*	Actinidiaceae	Tree	LC			X
403	*Sausauria gossypiphora*	Compositae	Herb	LC			0
404	*Sausauria nepalensis*	Compositae	Shrub	LC			0
405	*Schefflera impressa*	Araliaceae	Tree	LC			0 X
406	*Schefflera roxburghii*	Araliaceae	Shrub	LC			x
407	*Schefflera velutina*	Araliaceae	Tree	LC			X
408	*Schima khasiana*	Theaceae	Tree	LC			X
409	*Schima wallichii*	Theaceae	Tree	LC			0 x X
410	*Schisandra grandiflora*	Schisandraceae	Climber	LC			X
411	*Scurrula elata*	Loranthaceae	Shrub	LC			X
412	*Scurrula pulverulenta*	Loranthaceae	Shrub	LC			X
413	*Selinum tenuifolium*	Apiaceae	Herb	LC			X
414	*Senecio diversifolius*	Asteraceae	Herb	LC			0 X
415	*Senecio triligulatus*	Asteraceae	Herb	LC			0 X
416	*Sida acuta*	Malvaceae	Shrub	LC			X
417	*Skimmia laureola*	Lauraceae	Shrub	LC			X
418	*Skimmia laureola ssp. multinervia*	Lauraceae	Shrub	LC			X
419	*Smilax aspera*	Smilacaceae	Herb	LC			0
420	*Smilax ferox*	Smilacaceae	Herb	LC			0
421	*Smilax myrtillus*	Smilacaceae	Shrub	LC			X
422	*Smilax orthoptera*	Smilacaceae	Herb	LC			0
423	*Smilex regida*	Smilacaceae	Herb	LC			0
424	*Solanum khasianum*	Solanaceae	Shrub	LC			0 X

425	*Solanum mauritianum*	Solanaceae	Shrub	LC			X
426	*Solanum spirale*	Solanaceae	Shrub	LC			X
427	*Solena amplexicaulis*	Cucurbitaceae	Climber	LC			X
428	*Sophora velutina*	Leguminosae	Shrub	LC			X
429	*Sorbus cuspidata*	Rosaceae	Tree	LC			0 X
430	*Sorbus microphylla*	Rosaceae	Shrub	LC			X
431	*Sorbus rhamnoides*	Rosaceae	Tree	LC			0
432	*Spondias pinnata*	Anacardiaceae	Tree	LC			0
433	*Stephania glabra*	Menispermaceae	Climber	LC			X
434	*Sterculia lanceifolia*	Sterculiaceae	Shrub	LC			x
435	*Sterculia villosa*	Sterculiaceae	Tree	LC			0 x X
436	*Streptopus simplex*	Liliaceae	Herb	LC			X
437	*Strobilanthes maculata*	Acanthaceae	Shrub	LC			X
438	*Strobilanthes wallichii*	Acanthaceae	Shrub	LC			X
439	*Swertia bimauculata*	Gentianaceae	Shrub	LC			X
440	*Swertia petiolata*	Gentianaceae	Herb	LC			0
441	*Symplocos glomerata*	Symplocaceae	Shrub	LC			0 x X
442	*Symplocos racemosa*	Symplocaceae	Tree	LC			x X
443	*Symplocus ramosissima*	Symplocaceae	Tree	LC			X
444	*Synotis alata*	Compositae	Herb	LC			X
445	*Syzygium cumini*	Myrtaceae	Tree	LC			0
446	*Syzygium venosum*	Myrtaceae	Shrub	LC			X
447	*Taraxacum eriopodium*	Asteraceae	Herb	LC			X
448	*Taxus baccata*	Taxaceae	Tree	LC			0 X
449	*Terminalia myriocarpa*	Combretaceae	Tree	LC			0 x X
450	*Tetrastigma serrulatum*	Vitaceae	Climber	LC			X
451	*Thunbergia coccinea*	Acanthaceae	Climber	LC			0 X
452	*Thysanolaena latifolia*	Poaceae	Grass	LC			X
453	*Thysanolaena maxima*	Poaceae	Grass	LC			0 x X
454	*Toona ciliata*	Meliaceae	Tree	LC			0 x X
455	*Toxicodendron succedaneum*	Anacardiaceae	Tree	LC			0 X
456	*Trema sp.*	Cannabaceae	Shrub	LC			X
457	*Trichosanthes lepiniana*	Cucurbitaceae	Climber	LC			X

458	*Trifolium repens*	Leguminosae	Herb	LC			X
459	*Trillium tschonoskii*	Melanthiaceae	Herb	EN			X
460	*Tsuga dumosa*	Pinaceae	Tree	LC			0 X
461	*Tupistra nutans*	Asparagaceae	Herb	LC			X
462	*Tupistra wattii*	Asparagaceae	Herb	LC			X
463	*Ulmus lanceifolia*	Ulmaceae	Tree	LC			X
464	*Urtica ardens*	Urticaceae	Herb	LC			x
465	*Urtica dioica*	Urticaceae	Herb	LC			X
466	*Vaccinium gaultherifolium*	Ericaceae	Shrub	LC			X
467	*Vaccinium nummularia*	Ericaceae	Shrub	LC			X
468	*Vaccinium retusum*	Ericaceae	Shrub	LC			X
469	*Vaccinum nummularia*	Ericaceae	Shrub	LC			0
470	*Vernonia volkameriifolia*	Asteraceae	Shrub	LC			X
471	*Viburnum continifolium*	Ericaceae	Shrub	LC			0
472	*Viburnum cylindricum*	Adoxaceae	Shrub	LC			x X
473	*Viburnum erubescens*	Adoxaceae	Shrub	LC			X
474	*Viburnum nervosum*	Adoxaceae	Shrub	LC			X
475	*Viola betonicifolia*	Violaceae	Herb	LC			X
476	*Viola hookeri*	Violaceae	Herb	LC			X
477	*Viola palustris*	Violaceae	Herb	LC			X
478	*Vitex negundo*	Lamiaceae	Shrub	LC			x
479	*Wallichia densiflora*	Arecaceae		LC			X
480	*Wendlandia speciosa*	Rubiaceae	Shrub	LC			X
481	*Wrightia arborea*	Apocynaceae	Tree	LC			X
482	*Yushania microphylla*	Poaceae	Bamboo	LC			X
483	*Zanthoxyllum oxyphyllum*	Rutaceae	Shrub	LC			X
484	*Zanthoxylum armatum*	Rutaceae	Tree	LC			0 x

Annexure 2: Mammal inventory of BC 4 from 2006 to 2021

Sl.no	Common Name	Scientific Name	Family	IUCN status	CITES	0 @2006, x @2016, X @2021
1	Asiatic Black Bear	*Ursus thibetanus*	Ursidae	VU	Appendix I	0 x X
2	Asiatic Brush-tailed Porcupine	*Atherurus macrourus*	Hystricidae	LC		x X

3	Asiatic Golden Cat	*Catopuma temmincki*	Felidae	NT	Appendix I	x X
4	Assamese Macaque	*Macaca assamensis*	Cercopithecidae	NT		0 x X
5	Barking Deer	*Muntiacus muntjak*	Cervidae	LC		0 x X
6	Bengal Fox	*Vulpes bengalensis*	Canidae	LC		0
7	Capped Langur	*Trachypithecus pileatus*	Cercopithecidae	VU	Appendix I	0 X
8	Clouded Leopard	*Neofelis nebulosa*	Felidae	VU	Appendix I	x X
9	Common House Rat	*Rattus rattus*	Muridae	LC		x
10	Common Jackal	*Canis aureus*	Canidae	LC		0
11	Common Leopard	*Panthera pardus*	Felidae	VU	Appendix I	0 x X
12	Dhole	*Cuon alpinus*	Canidae	EN	Appendix II	0 x X
13	Eurasian Otter	*Lutra Lutra*	Mustelidae	NT	Appendix I	X
14	Five Striped Palm Squirrel	*Funambulus pennantii*	Sciuridae	LC		0
15	Gaur	*Bos gaurus*	Bovidae	VU	Appendix I	X
16	Golden Langur	*Trachypithecus geei*	Cercopithecidae	EN	Appendix I	0 x
17	Grey Langur	*Semnopithecus entellus*	Cercopithecidae	LC	Appendix I	x
18	Himalayan Goral	*Naemorhedus goral*	Bovidae	NT	Appendix I	x X
19	Himalayan Musk Deer	*Moschus leucogaster*	Moschidae	EN	Appendix I	0 x X
20	Himalayan Pika	*Ochotona himalayana*	Ochotonidae			0 x
21	Himalayan Serow	*Capricornis thar*	Bovidae	VU	Appendix I	0 x X
22	Hoary-bellied Squirrel	*Callosciurus pygerythrus*	Sciuridae	LC		0
23	Hodgson's Giant Flying Squirrel	*Petaurista magnificus*	Sciuridae	LC		x
24	Intermediate Horseshoe Bat	*Rhinolophus affinis*	Rhinolophidae	LC		0
25	Jungle Cat	*Felis chaus*	Felidae	LC		0
26	Leopard Cat	*Prionailurus bengalensis*	Felidae	LC	Appendix II	0 x X
27	Malayan Gaint Squirrel	*Ratufa bicolor*	Sciuridae	NT	Appendix II	0 x X
28	Malayan Porcupine	*Hystrix bracyhura*	Hystricidae	LC		x X
29	Marbled Cat	*Pardofelis marmorata*	Felidae	NT	Appendix I	x X
30	Masked Palm Civet	*Paguma larvata*	Viverridae	LC		X
31	Orange-bellied Himalayan Squirrel	*Dremomys lokriah*	Sciuridae	LC		X
32	Particolored Flying Squirrel	*Hylopetes alboniger*	Sciuridae	LC		0

33	Red Fox	*Vulpes vulpes*	Canidae	LC		0
34	Red Panda	*Ailurus fulgens*	Ailuridae	EN	Appendix I	x X
35	Royal Bengal Tiger	*Panthera tigris tigris*	Felidae	EN	Appendix I	0 x X
36	Sambar Deer	*Rusa unicolor*	Cervidae	VU		0 x X
37	Spotted Linsang	*Prionodon pardicolor*	Prionodontidae	LC	Appendix I	X
38	Wild Pig	*Sus scrofa*	Suidae	LC		0 x X
39	Yellow-bellied Weasel	*Mustela kathiah*	Mustelidae	LC		X
40	Yellow-throated Marten	*Martes flavigula*	Mustelidae	LC		x

Annexure 3: An annotated bird checklist for BC 4 from 2006 to 2021

Sl.No	Common name	Scientific name	Family	0 @2006, x @2016, X @2021
1	Abberant Bush Warbler	*Horornis flavolivaceus*	Cettiidae	0
2	Alpine Accentor	*Prunella collaris*	Prunellidae	0 x
3	Ashy Bulbul	*Hemixos flavala*	Pycnonotidae	0
4	Ashy Drongo	*Dicrurus leucophaeus*	Dicruridae	0 x X
5	Ashy-throated Warbler	*Phylloscopus maculipennis*	Phylloscopidae	x X
6	Asian Barred Owlet	*Glaucidium cuculoides*	Strigidae	0 x X
7	Asian Emerald Cuckoo	*Chrysococcyx maculatus*	Cuculidae	x
8	Asian House Martin	*Delichon dasyous*	Hirundinidae	x
9	Bank Myna	*Acridotheres ginginianus*	Sturnidae	x
10	Barred Cuckoo Dove	*Macropygia unchall*	Columbidae	0 x X
11	Bar-throated Siva	*Siva strigula*	Leiothrichidae	0 X
12	Bar-winged Flycatcher-shrike	*Hemipus picatus*	Vangidae	0 X
13	Bar-winged Wren Babbler	*Spalaeornis troglodytoides*	Timaliidae	x
14	Bay Woodpecker	*Blythipicus pyrrhotis*	Picidae	0 x X
15	Beautiful Nuthatch	*Sitta formosa*	Sittidae	0 x
16	Beautiful Rosefinch	*Carpodacus pulcherrimus*	Fringillidae	0
17	Bhutan Laughingthrush	*Trochalopteron imbricatum*	Leiothrichidae	X
18	Black Bulbul	*Hypsipetes leucocephalus*	Pycnonotidae	0 x X
19	Black Drongo	*Dicrurus macrocerus*	Dicruridae	0 x
20	Black Eagle	*Ictinaetus malaiensis*	Accipitridae	0 x X
21	Black Redstart	*Phoenicurus ochruros*	Muscicapidae	0
22	Black throated sunbird	*Aethopyga saturata*	Nectariniidae	x

23	Black-chinned Yuhina	*Yuhina nigrimenta*	Zosteropidae	0 x X
24	Black-crested Bulbul	*Pycnonotus flaviventris*	Pycnonotidae	x X
25	Black-eared Shrike-babbler	*Pteruthius melanotis*	Vireonidae	0 X
26	Black-faced Laughingthrush	*Garrulax affinis*	Leiothrichidae	0 x X
27	Black-faced Warbler	*Abroscopus schisticeps*	Cettiidae	0 X
28	Black-headed Shrike-babbler	*Pteruthius rufiventer*	Vireonidae	0 X
29	Black-tailed Crake	*Porzana bicolor*	Rallidae	0
30	Black-throated Parrotbill	*Suthora nipalensis*	Sylviidae	X
31	Black-throated Prinia	*Prinia atrogularis*	Cisticolidae	X
32	Black-throated Sunbird	*Aethopyga saturata*	Nectariniidae	0 X
33	Black-throated Thrush	*Turdus atrogularis*	Turdidae	0 X
34	Black-throated Tit	*Aegithalos concinnus*	Aegithalidae	0 X
35	Black-winged Cuckooshrike	*Lalage melaschistos*	Campephagidae	0 X
36	Blood Pheasant	*Ithaginis cruentus*	Phasanidae	0 x X
37	Blue Rock Thrush	*Monticola solitarius*	Muscicapidae	0 x X
38	Blue Whistling Thrush	*Myophonus caeruleus*	Muscicapidae	0 x X
39	Blue-bearded Bee-eater	*Nyctyornis athertoni*	Meropidae	X
40	Blue-capped Rock Thrush	*Monticola cinclorhynchus*	Muscicapidae	x X
41	Blue-fronted Redstart	*Phoenicurus frontalis*	Muscicapidae	0 x X
42	Blue-throated Barbet	*Psilopogon asiaticus*	Megalaimidae	0 x X
43	Blue-throated Blue Flycather	*Cyornis rubeculoides*	Muscicapidae	0
44	Blue-winged Laughingthrush	*Trochalopteron squamatum*	Leiothrichidae	0 X
45	Blue-winged Siva	*Siva cyanouroptera*	Leiothrichidae	0 X
46	Blyth's Leaf Warbler	*Phylloscopus reguloides*	Phylloscopidae	0 X
47	Bronzed Drongo	*Dicrurus aeneus*	Dicruridae	0 X
48	Brown Bullfinch	*Pyrrhula nipalensis*	Fringillidae	X
49	Brown Dipper	*Cinclus pallasii*	Cinclidae	0 x X
50	Brown Wood Owl	*Strix leptogrammica*	Strigidae	0
51	Brown-flanked Bush Warbler	*Cettia fortipes*	Cettiidae	0 X
52	Buff-barred Warbler	*Phylloscopus pulcher*	Phylloscopidae	0
53	Chestnut-bellied Nuthatch	*Sitta cinnamoventris*	Sittidae	0 x
54	Chestnut-bellied Rock Thrush	*Monticola rufiventris*	Muscicapidae	X
55	Chestnut-crowned Laughingthrush	*Trochalopteron erythrocephalum*	Leiothrichidae	0 x X

56	Chestnut-crowned Warbler	*Phylloscopus castaniceps*	Phylloscopidae	0 X
57	Chestnut-headed Tesia	*Tesia castaneocoronata*	Cettiidae	0 X
58	Coal Tit	*Periparus ater*	Paridae	0 x
59	Collared Grosbeak	*Mycerobas affinis*	Fringillidae	0
60	Collared Owlet	*Glaucidium brodiei*	Strigidae	0 X
61	Collared Treepie	*Dendricitta frontalis*	Corvidae	x
62	Common Buzzard	*Buteo buteo*	Accipitridae	0
63	Common Emerald Dove	*Chalcophas indics*	Columbidae	x
64	Common Green Magpie	*Cissa chinensis*	Corvidae	0 X
65	Common Hoopoe	*Upupa epops*	Upupidae	x X
66	Common Kestrel	*Falco tinnunculus*	Falconidae	0 X
67	Common Myna	*Acridotheres tristis*	Sturnidae	0 x X
68	Common Rosefinch	*Carpodacus erythrinus*	Fringillidae	x X
69	Common Stonechat	*Saxicola torquatus*	Muscicapidae	X
70	Common Tailorbird	*Orthotomus sutorius*	Cisticolidae	0 X
71	Coppersmith Barbet	*Magalaima haemacephala*	Megalaimidae	x
72	Coral-billed Scimitar Babbler	*Pomatorhinus ferruginosus*	Timaliidae	0 X
73	Crested Bunting	*Melophus lathami*	Emberizidae	0 X
74	Crested Kingfisher	*Megaceryle lugubris*	Alcedinidae	x
75	Crested Serpent Eagle	*Spilornis cheela*	Accipitridae	0 X
76	Crimson Sunbird	*Aethopyga siparaja*	Nectariniidae	0 X
77	Crimson-breasted Woodpecker	*Dendrocopos cathpharius*	Picidae	0 X
78	Crow-billed Drongo	*Dicrurus annectans*	Dicruridae	0
79	Darjeeling Woodpecker	*Dendrocopos darjellensis*	Picidae	0 x X
80	Dark-breasted Rosefinch	*Procarduelis nipalensis*	Fringillidae	0 X
81	Dark-sided Flycatcher	*Muscicapa sibirica*	Muscicapidae	x
82	Dusky Warbler	*Phylloscopus fuscatus*	Phylloscopidae	x
83	Eurasian Cockoo	*Cuculus canorus*	Cuculidae	x
84	Eurasian Eagle Owl	*Bubo Bubo*	Strigidae	X
85	Eurasian Jay	*Garrulus grandarius*	Corvidae	0 X
86	Eurasian Tree Sparrow	*Passer montanus*	Passeridae	0 x X
87	Eurasian Woodcock	*Scolopax rusticola*	Scolopacidae	X
88	Eurasian Wren	*Troglodytes troglodytes*	Troglodytidae	0 X

89	Ferruginuous Flycatcher	*Muscicapa ferruginea*	Muscicapidae	X
90	Fire-breasted Flowerpecker	*Dicaeum ignipectus*	Dicaeidae	0 X
91	Fire-tailed Myzornis	*Myzornis pyrrhoura*	Sylviidae	0 X
92	Fire-tailed Sunbird	*Aethopyga ignicauda*	Nectariniidae	0 x
93	Gold Crest	*Regulus regulus*	Regulidae	0
94	Golden Babbler	*Stachyridopsis chrysaea*	Timaliidae	0
95	Golden Bush Robin	*Tarsiger chrysaeus*	Muscicapidae	X
96	Golden-breasted Fulvetta	*Lioparus chrysotis*	Sylviidae	0 X
97	Golden-throated Barbet	*Psilopogon franklinii*	Megalaimidae	0 x
98	Gould's Shortwing	*Heteroxenicus stellatus*	Muscicapidae	X
99	Great Barbet	*Psilopogon virens*	Megalaimidae	0 x X
100	Great Cormorant	*Phalacrocorax carbo*	Phalacrocoracidae	0 X
101	Great Hornbill	*Buceros bicornis*	Bucerotidae	0 x
102	Great Parrotbill	*Paradoxornis aemodium*	Paradoxornithidae	0
103	Great Tit	*Parus major*	Paridae	x
104	Greater Flameback	*Chrysocolaptes guttacristatus*	Picidae	x
105	Greater Spotted Eagle	*Clanga clanga*	Accipitridae	x
106	Greater Yellownape	*Chrysophlegma flavinucha*	Picidae	0 x X
107	Green Shrike-babbler	*Pteruthius xanthochlorus*	Vireonidae	X
108	Green-backed Tit	*Parus monticolus*	Paridae	0 x X
109	Green-billed Malkoha	*Phaenicophaeus tristis*	Cuculidae	X
110	Greenish Warbler	*Phylloscopus trochiloides*	Phylloscopidae	0 x
111	Green-tailed Sunbird	*Aethopyga nipalensis*	Nectariniidae	0 x X
112	Grey Bushchat	*Saxicola ferreus*	Muscicapidae	0 x X
113	Grey Nightjar	*Caprimulgus jotaka*	Caprimulgidae	0 x X
114	Grey Treepie	*Dendrocitta formosae*	Corvidae	0 x X
115	Grey-backed Shrike	*Lanius tephronotus*	Laniidae	0 x X
116	Grey-bellied Tesia	*Tesia cyaniventer*	Cettiidae	0
117	Grey-capped Pygmy Woodpecker	*Yungipicus canicapillus*	Picidae	0 X
118	Grey-cheeked Warbler	*Phylloscopus poliogenys*	Phylloscopidae	0 x
119	Grey-chinned Minivet	*Pericrocotus solaris*	Campephagidae	0 x X
120	Grey-crested Tit	*Lophophanes dichrous*	Paridae	0 x X
121	Grey-crowned Prinia	*Prinia cinereocapilla*	Cisticolidae	x

122	Grey-headed Canary Flycatcher	*Culicicapa ceylonensis*	Stenostiridae	0 x X
123	Grey-headed Woodpecker	*Picus canus*	Picidae	0 X
124	Grey-hooded Warbler	*Phylloscopus xanthoschistos*	Phylloscopidae	0 X
125	Grey-sided Bush Warbler	*Cettia brunnifrons*	Cettiidae	0 X
126	Grey-sided Laughingthrush	*Garrulax caerulatus*	Leiothrichidae	0 X
127	Grey-throated Babbler	*Stachyris nigriceps*	Timaliidae	0 X
128	Grey-winged Blackbird	*Turdus boulboul*	Turdidae	0 x X
129	Hair-crested Drongo	*Dicrurus hottentottus*	Dicruridae	0 x
130	Hill Patridge	*Arborophila torqueola*	Phasanidae	0 x X
131	Hill Prinia	*Prinia atrogularis*	Cisticolidae	x
132	Himalayan Bluetail	*Tarsiger cyanurus*	Muscicapidae	0 X
133	Himalayan Bulbul	*Pycnonotus leucogenys*	Pycnonotidae	0
134	Himalayan Cuckoo	*Cuculus saturatus*	Cuculidae	X
135	Himalayan Cutia	*Cutia nipalensis*	Leiothrichidae	0 X
136	Himalayan Monal	*Lophophorus impejanus*	Phasanidae	0 x
137	Himalayan Owl	*Strix nivicolum*	Strigidae	X
138	Himalayan Shortwing	*Brachypteryx cruralis*	Muscicapidae	X
139	Himalayan Shrike-babbler	*Pteruthius ripleyi*	Vireonidae	0 x X
140	Hoary throated Barwing	*Actinodura nipalensis*	Leiothrichidae	0 x X
141	Hodgson's Redstart	*Phoenicurus hodgsoni*	Muscicapidae	0 X
142	House Sparrow	*Passer domestica*	Passeridae	x
143	Hume's Warbler	*Phylloscopus humei*	Phylloscopidae	x
144	Indian Cuckoo	*Cuculus micropterus*	Cuculidae	x
145	Indian White-eye	*Zosterops palpebrosus*	Zosteropidae	0 x
146	Kalij Pheasant	*Lophura leucomelanos*	Phasanidae	0 x X
147	Large Hawk-cuckoo	*Cuculus sparverioides*	Cuculidae	x
148	Large Niltava	*Niltava grandis*	Muscicapidae	0 x X
149	Large Woodshrike	*Tephrodornis virgatus*	Vangidae	0 x
150	Large-billed Crow	*Corvus macrorhynchos*	Corvidae	0 x X
151	Large-billed Leaf Warbler	*Phylloscopus magnirostris*	Phylloscopidae	0 X
152	Lemon-rumped Warbler	*Phylloscopus chloronotus*	Phylloscopidae	0 x
153	Lesser Cuckoo	*Cuculus poliocephalus*	Cuculidae	x X
154	Lesser Racket-tailed Drongo	*Dicrurus remifer*	Dicruridae	0 x X

155	Lesser Yellownape	*Picus chlorolophus*	Picidae	0 x
156	Lineated Barbet	*Megalaima lineate*	Megalaimidae	x
157	Little Bunting	*Emberiza pusilla*	Emberizidae	0 X
158	Little Forktail	*Enicurus scouleri*	Muscicapidae	0 X
159	Long-legged Buzzard	*Buteo rufinus*	Accipitridae	0
160	Long-tailed Broadbill	*Psarisomus dalhousiae*	Eurylaimidae	0 x
161	Long-tailed Minivet	*Pericrocotus ethologus*	Campephagidae	0 x
162	Long-tailed Shrike	*Lanius schach tricolor*	Laniidae	0 X
163	Long-tailed Sibia	*Heterophasia picaoides*	Leiothrichidae	0
164	Long-tailed Thrush	*Zoothera dixoni*	Turdidae	0
165	Maroon-backed Accentor	*Prunella immaculata*	Prunellidae	X
166	Mountain Bulbul	*Ixos mcclellandii*	Pycnonotidae	0 X
167	Mountain Hawk Eagle	*Nisaetus nipalensis*	Accipitridae	0 X
168	Mountain Imperial Pigeon	*Ducula badia*	Columbidae	0
169	Mountain Scops Owl	*Otus spilocephalus*	Strigidae	X
170	Mountain Tailorbird	*Phyllergates cucullatus*	Cettiidae	0 X
171	Mrs.Gould's sunbird	*Aethopyga gouldiae*	Nectariniidae	x
172	Nepal Fulvetta	*Alcippe nipalensis*	Pellorneidae	0 X
173	Nepal House Martin	*Delichon nipalense*	Hirundinidae	0 x X
174	Olive-backed Pipit	*Anthus hodgsoni*	Motacillidae	0 x X
175	Orange-bellied Leafbird	*Chloropsis hardwickii*	Chloropseidae	0 x X
176	Orange-headed Thrush	*Geokichla cirtrina*	Turdidae	x
177	Oriental Cuckoo	*Cuculus optatus*	Cuculidae	x
178	Oriental Magpie Robin	*Copsychus saularis*	Muscicapidae	0 x X
179	Oriental Skylark	*Alauda gulgula*	Alaudidae	0
180	Oriental Turtle Dove	*Streptopelia orientalis*	Columbidae	0 x X
181	Paddyfield Pipit	*Anthus rufulus*	Motacillidae	0
182	Pale Blue Flycatcher	*Cyornis unicolor*	Muscicapidae	0
183	Pale-headed Woodpecker	*Gecinulus grantia*	Picidae	0
184	Plain Mountain Finch	*Leucosticte nemoricola*	Fringillidae	0 x X
185	Plain-backed Thrush	*Zoothera mollissima*	Turdidae	0
186	Plumbeous Water Redstart	*Rhyacornis fuliginosa*	Muscicapidae	0 x X
187	Purple Sunbird	*Cinnyris asiaticus*	Nectariniidae	x

188	Red Crossbill	*Loxia curvirostra*	Fringillidae	X
189	Red Junglefowl	*Gallus gallus*	Phasanidae	x X
190	Red-billed Leiothrix	*Leiothrix lutea*	Leiothrichidae	0 X
191	Red-faced Liocichla	*Liocichla phoenicea*	Leiothrichidae	0 X
192	Red-fronted Rosefinch	*Carpodacus puniceus*	Fringillidae	0
193	Red-headed Trogon	*Harpactes erythrocephalus*	Trogonidae	0 X
194	Red-tailed Minla	*Minla ignotincta*	Leiothrichidae	0 X
195	Red-vented Bulbul	*Pycnonotus cafer*	Pycnonotidae	0 x X
196	Rock Pigeon	*Columba livia*	Columbidae	0 x
197	Rosy Pipit	*Anthus roseatus*	Motacillidae	0
198	Rufescent Prinia	*Prinia rufescens*	Cisticolidae	0
199	Rufous Sibia	*Heterophasia capistrata*	Leiothrichidae	0 x X
200	Rufous Treepie	*Dendrocitta vagabunda*	Corvidae	x
201	Rufous Woodpecker	*Micropternus brachyurus*	Picidae	X
202	Rufous-backed Sibia	*Leioptila annectens*	Leiothrichidae	0
203	Rufous-bellied Eagle	*Lophotriorchis kienerii*	Accipitridae	0 X
204	Rufous-bellied Niltava	*Niltava sundara*	Muscicapidae	X
205	Rufous-bellied Woodpecker	*Dendrocopos hyperythrus*	Picidae	0 x X
206	Rufous-breasted Accentor	*Prunella strophiata*	Prunellidae	0 X
207	Rufous-breasted Bush Robin	*Tarsiger hyperythrus*	Muscicapidae	0
208	Rufous-capped Babbler	*Stachyridopsis ruficeps*	Timaliidae	0 x
209	Rufous-chinned Laughingthrush	*Garrulax rufogularis*	Leiothrichidae	X
210	Rufous-faced Warbler	*Abroscopus albogularis*	Cettiidae	X
211	Rufous-fronted Tit	*Aegithalos iouschistos*	Aegithalidae	0
212	Rufous-gorgeted Flycatcher	*Ficedula strophiata*	Muscicapidae	0 x X
213	Rufous-necked Hornbill	*Aceros nipalensis*	Bucerotidae	0 x X
214	Rufous-necked Laughingthrush	*Garrulax ruficollis*	Leiothrichidae	0 x X
215	Rufous-throated Partridge	*Arborophila rufogularis*	Phasanidae	x X
216	Rufous-vented Tit	*Periparus rubidiventris*	Paridae	0 X
217	Rufous-vented Yuhina	*Yuhina occipitalis*	Zosteropidae	0 X
218	Rufous-winged Fulvetta	*Pseudominla castaneceps*	Pellorneidae	0 X
219	Russet Sparrow	*Passer cinnamomeus*	Passeridae	0 X
220	Rusty-cheeked Scimitar Babbler	*Pomatorhinus erythrogenys*	Timaliidae	0 X

221	Rusty-flanked Treecreeper	*Certhia nipalensis*	Certhiidae	0 X
222	Rusty-fronted Barwing	*Actinodura egertoni*	Leiothrichidae	0 x X
223	Salty-backed Forktail	*Enicurus schistaceus*	Muscicapidae	x
224	Sapphire Flycatcher	*Ficedula sapphira*	Muscicapidae	x
225	Satyr Tragopan	*Tragopan satyra*	Phasanidae	0 x X
226	Scaly Laughingthrush	*Trochalopteron subunicolor*	Leiothrichidae	0 X
227	Scaly Thrush	*Zoothera dauma*	Turdidae	X
228	Scaly-breasted Munia	*Lonchura punctulata*	Estrildidae	0
229	Scaly-breasted Wren Babbler	*Pnoepyga albiventer*	Pnoepygidae	0 X
230	Scarlet Finch	*Haematospiza sipahi*	Fringillidae	X
231	Scarlet Minivet	*Pericrocotus speciosus*	Campephagidae	0 x X
232	Short-billed Minivet	*Pericrocotus brevirostris*	Campephagidae	0 x
233	Short-eared Owl	*Asio flammeus*	Strigidae	X
234	Sikkim Treecreeper	*Certhia discolor*	Certhiidae	0 x X
235	Silver-eared Mesia	*Leiothrix argentauris*	Leiothrichidae	X
236	Slaty-backed Forktail	*Enicurus schistaceus*	Muscicapidae	0 X
237	Slaty-bellied Tesia	*Tesia olivea*	Cettiidae	0 X
238	Slaty-blue Flycatcher	*Ficedula tricolor*	Muscicapidae	0
239	Small Niltava	*Niltava macgrigoriae*	Muscicapidae	x X
240	Snow Pigeon	*Columba leuconota*	Columbidae	0 x
241	Snowy-browed Flycatcher	*Ficedula hyperythra*	Muscicapidae	X
242	Speckled Piculet	*Picumnus innominatus*	Picidae	0 X
243	Speckled Wood Pigeon	*Columba hodgsonii*	Columbidae	0 x
244	Spotted Dove	*Spilopelia chinensis*	Columbidae	0 x X
245	Spotted Forktail	*Enicurus maculatus*	Muscicapidae	0 X
246	Spotted Laughingthrush	*Garrulax ocellatus*	Leiothrichidae	x X
247	Spotted Nutcracker	*Nucifraga caryocatactes*	Corvidae	0 x X
248	Spotted Owlet	*Athene brama*	Strigidae	0
249	Spotted Wren Babbler	*Elachura formosa*	Pnoepygidae	0
250	Spot-winged Grosbeak	*Mycerobas melanozanthos*	Fringillidae	X
251	Steppe Eagle	*Aquila nipalensis*	Accipitridae	x X
252	Straited Laughingthrush	*Garrulax striatus*	Leiothrichidae	0
253	Straited Prinia	*Prinia crinigera*	Cisticolidae	0

254	Streak-breasted Scimitar Babbler	*Pomatorhinus ruficollis*	Timaliidae	0 X
255	Streaked Laughingthrush	*Trochalopteron lineatum*	Leiothrichidae	0
256	Streaked Spiderhunter	*Arachnothera magna*	Nectariniidae	0 x X
257	Striated Bulbul	*Pycnonotus striatus*	Pycnonotidae	0 x X
258	Striated Laughingthrush	*Garrulax striatus*	Leiothrichidae	x X
259	Striated Yuhina	*Yuhina castaniceps*	Zosteropidae	0 X
260	Stripe-throated Yuhina	*Yuhina gularis*	Zosteropidae	0 x X
261	Sultan Tit	*Melanochlora sultanea*	Paridae	0 X
262	Tawny Fish Owl	*Ketupa flavipes*	Strigidae	X
263	Tawny Wood Owl	*Strix aluco*	Strigidae	0
264	Tickell's Leaf Warbler	*Phylloscopus affinis*	Phylloscopidae	x X
265	Ultramarine Flycatcher	*Ficedula superciliarius*	Muscicapidae	x
266	Upland Buzzard	*Buteo hemilasius*	Accipitridae	0
267	Verditer Flycatcher	*Eumyias thalassinus*	Muscicapidae	x X
268	Wallcreeper	*Tichodroma muraria*	Tichodromidae	X
269	Ward's Trogon	*Harpactes wardi*	Trogonidae	0 x X
270	Wedge-tailed Green Pigeon	*Treron sphenurus*	Columbidae	0 x X
271	Whiskered Yuhina	*Yuhina flavicollis*	Zosteropidae	0 x X
272	Whistler's Warbler	*Seicercus whistleri*	Phylloscopidae	0 X
273	White Wagtail	*Motacilla alba*	Motacillidae	0 x
274	White-bellied Erpornis	*Erpornis zantholeuca*	Zosteropidae	0 x
275	White-bellied Heron	*Ardea insignis*	Ardeidae	X
276	White-breasted Parrotbill	*Psittiparus ruficeps*	Paradoxornithidae	X
277	White-browed Fulvetta	*Fulvetta vinipectus*	Sylviidae	0 X
278	White-browed Piculet	*Sasia ochracea*	Picidae	X
279	White-browed Rosefinch	*Carpodacus thura*	Fringillidae	0
280	White-browed Scimitar Babbler	*Pomatorhinus schisticeps*	Timaliidae	x
281	White-capped Water Redstart	*Phoenicurus leucocephalus*	Muscicapidae	0 x X
282	White-collared Blackbird	*Turdus albocinctus*	Turdidae	0 x X
283	White-crested Laughingthrush	*Garrulax leucolophus*	Leiothrichidae	0 x X
284	White-gorgeted Flycatcher	*Anthipes monileger*	Muscicapidae	X
285	White-naped Yuhina	*Yuhina bakeri*	Zosteropidae	0 x
286	White-rumped Munia	*Lonchura striata*	Estrildidae	0 X

287	White-spectacled Warbler	*Seicercus affinis*	Phylloscopidae	0
288	White-tailed Nuthatch	*Sitta himalayensis*	Sittidae	0 X
289	White-throated Bulbul	*Alophoixus flaveolus*	Pycnonotidae	0 x X
290	White-throated Dipper	*Cinclus cinclus*	Cinclidae	x
291	White-throated Fantail	*Rhipidura albicollis*	Rhipiduridae	0 x X
292	White-throated Kingfisher	*Halcyon smyrnensis*	Alcedinidae	X
293	White-throated Laughingthrush	*Garrulax albogularis*	Leiothrichidae	0 x X
294	White-throated Redstart	*Phoenicurus schisticeps*	Muscicapidae	0 X
295	White-winged Grosbeak	*Mycerobas carnipes*	Fringillidae	0
296	White-winged Redstart	*Phoenicurus erythrogastrus*	Muscicapidae	0 x
297	Yellow-bellied Fantail	*Chelidorhynx hypoxanthus*	Stenostiridae	0 x X
298	Yellow-bellied Flowerpecker	*Dicaeum melanozanthum*	Dicaeidae	X
299	Yellow-bellied Warbler	*Abroscopus superciliaris*	Cettiidae	0 x
300	Yellow-billed Blue Magpie	*Urocissa flavirostris*	Corvidae	0 x X
301	Yellow-breasted Greenfinch	*Chloris spinoides*	Fringillidae	0 X
302	Yellow-browed Tit	*Sylviparus modestus*	Paridae	0 X
303	Yellow-cheeked Tit	*Parus spilonotus*	Paridae	0 x
304	Yellowish-bellied Bush Warbler	*Horornis acanthizoides*	Cettiidae	0
305	Yellow-rumped Honeyguide	*Indicator xanthonotus*	Indicatoridae	x X

Annexure 4: Mushroom checklist of BC 4 2021

Sl.No	Common name	Scientific name	Family
1		*Oudemensells sp*	Physalacriaceae
2		*Parasola media*	Psathyrellaceae
3	The price	*Agaricus augustus*	Agaricaceae
4	Spiny puff ball	*Lycoperdon echinatum*	Agaricaceae
5	Common puff ball	*Lycoperdon perlatum*	Agaricaceae
6	Wood ear	*Auricularia auricila-judae*	Auriculariaceae
7	Orange Jelly fungus	*Dacrymyces palmatus*	Dacrymycetaceae
8	White-pored chicken of the woods	*Laetiporus cincinnatus*	Fomitopsidaceae
9	White-pored chicken of the woods	*Laetiporus sulphureus*	Fomitopsidaceae
10	Bracket fungus	*Ganoderma applanatum*	Ganodermataceae
11	Reishi mushroom	*Ganoderma lucidum*	Ganodermataceae
12	Earth Star	*Geastrum saccatum*	Geastraceae
13	Old mans beard/lions mane	*Hericium erinaceus*	Hericiaceae
14		*lyophyllum aggregatum*	Lyophyllaceae
15		*lyophyllum shimeji*	Lyophyllaceae
16		*Xeromphalina campanella*	Marasmiaceae
17		*mycena haematopus*	Mycenaceae

18	Clustered bonnet	*Mycena inclinata*	Mycenaceae
19	Lilca bonnet	*Mycena pura*	Mycenaceae
20	Dog stinkhorn	*Mutinus caninus*	Phallaceae
21	Enokitake	*Flammulina velutipes*	Physalacriaceae
22		*Pleurotus citrinopileatus*	Pleurotaceae
23	Hoof fungus	*fomes fomentarius*	Polyporaceae
24		*Microporus affinis*	Polyporaceae
25		*microporus xanthopus*	Polyporaceae
26	Spring polypore	*Polyporus arcularius*	Polyporaceae
27		*Trametes pubescens*	Polyporaceae
28		*Trametes Versicolor*	Polyporaceae
29	Voilet-Pored Bracket Fungus	*Trichaptum abietinum*	Polyporaceae
30		*Trichaptum biforme*	Polyporaceae
31	Orange Peel Fungus	*Aleuria aurantia*	Pyronemataceae
32	Eyelash Pixie Cup	*Scutellinia scutellata*	Pyronemataceae
33	Common Split Gill	*Schizophyllum commune*	Schizophyllaceae
34	False turkey tail	*Stereum ostrea*	Stereaceae
35	Clustered wood lover	*Hypholoma fasciculare*	Strophariaceae
36		*Pholiota nameko*	Strophariaceae
37		*Pholiota squarrosa*	Strophariaceae

Annexure 5: Fern checklist of BC 4 2021

Sl.No	Common name	Scientific name	Family
1		*Hymenophyllum bivalve*	Hymenophyllaceae
2		*Tectaria harlandii*	Tectariaceae
3		*Asplenium delavayi*	Aspleniaceae
4	Bird's Nest Fern	*Asplenium nidus*	Aspleniaceae
5		*Diplazium donianum*	Athyriaceae
6		*Diplazium esculentum*	Athyriaceae
7	Tree fern	*Alsophila spinulosa*	Cyatheaceae
8		*Monachosorum henryi*	Dennstaedtiaceae
9	eagle fern	*Pteridium aquilinum*	Dennstaedtiaceae
10	Spreading Wood Fern	*Dryopteris expansa*	Dryopteridaceae
11	Mountain Male-Fern	*Dryopteris oreades*	Dryopteridaceae
12	common horsetail	*Equisetum arvense*	Equisetidae
13	False staghorn fern	*Dicranopteris linearis*	Gleicheniaceae
14	Forked Ferns	*Diplopterygium giganteum*	Gleicheniaceae
15		*Trichomanes elegans*	Hymenophyllaceae
16	Veined Bristle-Fern	*Trichomanes venosum*	Hymenophyllaceae
17	Fairy Fern	*Odontosoria chinensis*	Lindsaeaceae
18	Chinese Clubmoss	*Huperzia miyoshiana*	Lycopodiaceae
19	Northern Firmoss	*Huperzia selago*	Lycopodiaceae
20	common club moss	*Lycopodium clavatum*	Lycopodiaceae
21		*Lycopodium japonicum*	Lycopodiaceae
22	Fishbone Fern	*Nephrolepis cordifolia*	Nephrolepidaceae

23	Rock-ginger Fern	*Drynaria coronans*	Polypodiaceae
24	Oakleaf Fern	*Drynaria quercifolia*	Polypodiaceae
25	Basket fern	*Drynaria roosii*	Polypodiaceae
26		*Lepisorus excavatus*	Polypodiaceae
27		*Lepisorus heterolepis*	Polypodiaceae
28		*Lepisorus kawakamii*	Polypodiaceae
29	Needle Fern	*Lepisorus mucronatus*	Polypodiaceae
30	Weeping Fern	*Lepisorus thunbergianus*	Polypodiaceae
31	Kangaroo Fern	*Microsorum pustulatum*	Polypodiaceae
32	Golden Polypody	*Phlebodium aureum*	Polypodiaceae
33	Leather-leaf Fern	*Pyrrosia eleagnifolia*	Polypodiaceae
34		*Pyrrosia linearifolia*	Polypodiaceae
35		*Pyrrosia matsudai*	Polypodiaceae
36	Cretan Brake	*Pteris cretica*	Pteridaceae
37	Doederlein's Spikemoss	*Selaginella doederleinii*	Selaginellaceae
38	Willdenow's Spikemoss	*Selaginella willdenowii*	Selaginellaceae

Annexure 6: Herpetofauna checklist of BC 4 2021

Sl. No.	Common name	Scientifice name	Family	IUCN status	CITES
1	Short-nosed Vine Snake	*Ahaetulla prasina*	Colubridae		
2	Orange-collared Keelback	*Rhabdophis himalayanus*	Colubridae		
3	Copper-headed Trinket Snake	*Coelognathus radiatus*	Colubridae		
4	Eastern Trinket Snake	*Orthriophis cantoris*	Colubridae		
5	Banded Trinket Snake	*Oreocrytophis porphyraceus*	Colubridae		
6	Green Rat Snake	*Ptyas nigromarginata*	Colubridae		
7	White-barred Kukri Snake	*Oligodon albocinctus*	Colubridae		
8	Chinese Kukri Snake	*Oligodon chinensis*	Colubridae		
9	Collared Black-headed Snake	*Sibynophis collaris*	Colubridae		
10	Himalayan Keelback	*Herpetoreas platyceps*	Colubridae		
11	Tawny Cat Snake	*Boiga ochracea*	Colubridae		
12	Assamese Slender Snake	*Trachischium Monticola*	Colubridae		
13	Clerk's Keelback	*Hebius clerki*	Colubridae		
14	Striped Trinket Snake	*Orthriophis taeniurus*	Colubridae	VU	
15	Iridescent Snake	*Blythia reticulata*	Colubridae		
16	Large-eyed False Cobra	*Pseudoxenodon macrops*	Colubridae		
17	Macclelland's Coral Snake	*Sinomicrurus macclellandi*	Elapidae		
18	Monocled Cobra	*Naja Kaouthia*	Elapidae		Appendix II
19	King Cobra	*Ophiophagus hannah*	Elapidae	VU	Appendix II
20	Greater Black Krait	*Bungarus niger*	Elapidae		
21	Himalayan Krait	*Bungarus bungaroides*	Elapidae		
22	Short-legged Horned Toad	*Megophrys brachykolos*	Megophryidae	EN	
23	Montane Slug-eating Snake	*Pareas monticola*	Pareidae		
24	Giant Tree Frog	*Rhacophorus maximus*	Rhacophoridae		

25	Bubble-nest Frog	*Raorchestes andersoni*	Rhacophoridae		
26	Mountain Pit Viper	*Ovophis monticola*	Viperidae		

Annexure 7: Orchid checklist of BC 4 from 2006-2021

Sl.no	Scientific name	0 @2006, x @2016, X @2021
1	*Anoectochilus brevilabris*	X
2	*Anthogonium gracile*	X
3	*Arachnanthe clarkei*	X
4	*Arundina graminifolia*	X
5	*Bulbophyllum affine*	X
6	*Bulbophyllum andersonii*	X
7	*Bulbophyllum emarginatum*	X
8	*Bulbophyllum gymnopus*	X
9	*Bulbophyllum hirtum*	X
10	*Bulbophyllum obrienianum*	X
11	*Bulbophyllum odoratissimum*	X
12	*Bulbophyllum parviflorum*	X
13	*Bulbophyllum raskotii*	X
14	*Bulbophyllum reptans*	X
15	*Bulbophyllum retusiusculum*	X
16	*Bulbophyllum sterile*	X
17	*Bulbophylum secundum*	X
18	*Calanthe alismifolia*	X
19	*Calanthe biloba*	X
20	*Calanthe griffithii*	X
21	*Calanthe herbacea*	X
22	*Calanthe mannii*	X
23	*Calanthe plantaginea*	0 X
24	*Calanthe puberula*	X
25	*Calanthe tricarinata*	X
26	*Calanthe triplicata*	X
27	*Calanthe yuksomnensis*	X
28	*Callostylis rigida*	X

29	*Cephalanthera damasonium*	X
30	*Ceratostylis himalaica*	X
31	*Cheirostylis yunnanensis*	X
32	*Chilochista usenoides*	x X
33	*Chrysoglosum ornatum*	X
34	*Cleisostoma paniculatum*	X
35	*Cleisostoma williamsonii*	X
36	*Coelogyne barbata*	X
37	*Coelogyne corymbosa*	X
38	*Coelogyne fimbriata*	X
39	*Coelogyne nitida*	X
40	*Coelogyne occultata*	X
41	*Coelogyne prolifera*	X
42	*Coelogyne schultesii*	X
43	*Coelogyne stricta*	X
44	*Conchidium muscicola*	X
45	*Cremastra appendiculata*	X
46	*Crepidium aphyllum*	X
47	*Cryptochilus lutea*	X
48	*Cryptochilus sanguinea*	X
49	*Cymbidium aloifolium*	X
50	*Cymbidium cyperifolium*	X
51	*Cymbidium erythraeum*	X
52	*Cymbidium iridioides*	X
53	*Dendrobium chrysanthum*	X
54	*Dendrobium densiflorum*	X
55	*Dendrobium denudans*	X
56	*Dendrobium devonianum*	X
57	*Dendrobium fuscescens*	X
58	*Dendrobium heterocarpum*	X
59	*Dendrobium hookerianum*	X

60	*Dendrobium jenkinsii*	X
61	*Dendrobium longicornu*	X
62	*Dendrobium moniliforme*	X
63	*Dendrobium nobile*	X
64	*Dendrobium spatella*	X
65	*Dendrolirium ferrugineum*	X
66	*Epigenium navicularis*	X
67	*Epipogium japonicum*	X
68	*Epipogium roseum*	X
69	*Eria coronaria*	X
70	*Eriodes barbata*	X
71	*Eulophia graminea*	X
72	*Galeola lindleyana*	0 X
73	*Gastrochilus acutifolius*	X
74	*Gastrochilus calceolaris*	X
75	*Gastrochilus disticus*	X
76	*Goodyera procera*	X
77	*Goodyera schlechtendaliana*	X
78	*Herminium lanceum*	X
79	*Herpysma longicaulis*	X
80	*Ione candida*	X
81	*Liparis bootanensis*	X
82	*Liparis cespitosa*	X
83	*Liparis elliptica*	X
84	*Liparis resupinata*	X
85	*Liparis viridiflora*	X
86	*Malaxis acuminata*	X
87	*Malaxis purpurea*	X
88	*Oberonia acaulis*	X
89	*Oberonia falcata*	X
90	*Oberonia maxima*	X

91	*Oberonia mucronata*	x X
92	*Oberonia obcordata*	X
93	*Odontochilus crispus*	X
94	*Odontochilus elwesii*	X
95	*Odontochilus lanceolatus*	X
96	*Odontochilus poilanei*	X
97	*Ornithochilus difformis*	X
98	*Otochilus fuscus*	X
99	*Otochilus lancilabius*	X
100	*Panisea panchaseensis*	X
101	*Panisea tricallosa*	X
102	*Panisea uniflora*	X
103	*Panisea yunnanensis*	X
104	*Papiliolanthe vandarum*	X
105	*Phaius flavus*	X
106	*Phalaenopsis diffformis*	X
107	*Phalaenopsis taenialis*	X
108	*Pholidota articulata*	x X
109	*Pinalia acervata*	X
110	*Pinalia amica*	X
111	*Pinalia spicata*	X
112	*Platanthera aristatus*	X
113	*Plathanthera dunglonggenisis*	X
114	*Pleione hookeriana*	X
115	*Pleione humilis*	X
116	*Pleione maculata*	X
117	*Pleione praecox*	0 X
118	*Satyrium nepalense*	X
119	*Schoenorchis gemmata*	X
120	*Spiranthes hongkongensis*	X
121	*Sunipia bicolor*	X

122	*Sunipia cirrhata*	X
123	*Thunia alba*	X
124	*Vanda alpina*	X
125	*Vanda bicolor*	X
126	*Vanda cristata*	x X
127	*Vanda griffithii*	X
128	*Zeuxine goodyeroides*	X
129	*Zeuxine reflexa*	X

Annexure 8: Butterfly checklist of BC 4 2021

Sl.No.	Common Name	Scientific Name	Family
1	Veined Scrub Hopper	*Aeromachus stigmatus*	Hesperiidae
2	Lucas' Ace	*Sovia lucasii magna*	Hesperiidae
3	Yellow Spot Swift	*Polytremis eltola*	Hesperiidae
4	Tawny Angle	*Ctenoptilum vasava vasava*	Hesperiidae
5	Plain Banded Awl	*Hasora vita indica*	Hesperiidae
6	Tytier's Multispotted flat	*Celaenorrhinius ratna tytleri*	Hesperiidae
7	Bevan's Swift	*Borbo bevani*	Hesperiidae
8	Spotted Demon	*Notocrypta feisthamelii*	Hesperiidae
9	Large-spot Plain Ace	*Thoressa sitala*	Hesperiidae
10	Tyler's White Flat	*Satarupa zulla zulla*	Hesperiidae
11	Common Dartlet	*Oriens gola*	Hesperiidae
12	Green Awlet	*Burara vasutana*	Hesperiidae
13	Common Lineblue	*Prosotas nori*	Lycaenidae
14	Common Cerulean	*Jamides celeno*	Lycaenidae
15	Pale Grass Blue	*Pseudozizeeria maha*	Lycaenidae
16	Common Hedge Blue	*Acytolepis puspa*	Lycaenidae
17	Golden Sapphire	*Heliophorus brahma*	Lycaenidae
18	Dark Grass Blue	*Zizeeria karsandra*	Lycaenidae
19	Swinhoe's Hedge Blue	*Monodontides musina*	Lycaenidae
20	Dark Himalayan Oakblue	*Arhopala rama*	Lycaenidae
21	Blue Tit	*Chliaria kina*	Lycaenidae
22	Common Flash	*Rapla iarbus*	Lycaenidae
23	Bi-spot Royal	*Ancema ctesia*	Lycaenidae
24	Indian Sunbeam	*Curetis thetis*	Lycaenidae
25	Chocolate Royal	*Remelana jangala*	Lycaenidae
26	Angled Sunbeam	*Curetis acuta*	Lycaenidae
27	Himalayan Wonderful Hairstreak	*Thermozephyrus ataxux*	Lycaenidae
28	Euasapa	*Euaspa pavo*	Lycaenidae
29	Forest Quacker	*Pithecops corvus*	Lycaenidae

30	Common Imperial	*Cheritra freja*	Lycaenidae
31	Bright Sunbeam	*Curetis bulis*	Nymphalidae
32	Silver-grey Silverline	*Spindasis nipalicus*	Nymphalidae
33	Green Sapphire	*Heliphorus androcles*	Nymphalidae
34	Powdery Green Sapphire	*Heliphorus tamu*	Nymphalidae
35	Common Beak	*Libythea lepita*	Nymphalidae
36	Glassy Tiger	*Parantica aglea*	Nymphalidae
37	Chestnut Tiger	*Parantica sita*	Nymphalidae
38	Chocolate Tiger	*Parantica melaneus*	Nymphalidae
39	Common Crow	*Euploea core*	Nymphalidae
40	Striped Blue Crow	*Euploea mulciber*	Nymphalidae
41	Common Nawab	*Polyura anthamas*	Nymphalidae
42	Tiger Brown	*Orinona damaris*	Nymphalidae
43	Common Fivering	*Ypthima baldus*	Nymphalidae
44	Himalayan Fivering	*Ypthima sakra*	Nymphalidae
45	Yellow Coster	*Acraea issoria*	Nymphalidae
46	Large Silverstripe	*Argynnis childreni*	Nymphalidae
47	Common Sergeant	*Athyma perius*	Nymphalidae
48	Common Sailor	*Neptis hylas*	Nymphalidae
49	Popinjay	*Stibochiona nicea*	Nymphalidae
50	Common Map	*Cyrestis thyodamas*	Nymphalidae
51	Common Maplet	*Chersonisia risa*	Nymphalidae
52	Tabby	*Pseudergolis wedah*	Nymphalidae
53	Common Jester	*Symbrenthia lilaea*	Nymphalidae
54	Indian Red Admiral	*Vanessa indica*	Nymphalidae
55	Indian Tortoisehell	*Aglais caschmirensis*	Nymphalidae
56	Blue Admiral	*Kaniska canace*	Nymphalidae
57	Blue Pansy	*Junonia orithia*	Nymphalidae
58	Yellow Pansy	*Junonia hiertha*	Nymphalidae
59	Chocolate Pansy	*Junonia iphita*	Nymphalidae
60	Lemon Pansy	*Junonia lemonias*	Nymphalidae
61	Orange Oak Leaf	*Kallima inchus*	Nymphalidae
62	Blue Duchess	*Euthalia duda*	Nymphalidae
63	Red Lacewing	*Cethosia cyana*	Nymphalidae
64	Common Commodore	*Auzakia danava*	Nymphalidae
65	Bicolor Commodore	*Parasarpa zayla*	Nymphalidae
66	Blue-tailed Jester	*Symbrenthia niphanda*	Nymphalidae
67	Indian Fritillary	*Argyreus hyperbius*	Nymphalidae
68	Large Threering	*Ypthima nareda*	Nymphalidae
69	Tamil Yeoman	*Cirrochroa thais*	Nymphalidae
70	Great Yellow Sailer	*Neptis radha*	Nymphalidae
71	Straight-banded Treebrown	*Lethe verma*	Nymphalidae
72	Blackvein Sergeant	*Athyma ranga*	Nymphalidae
73	Blue Duke	*Bassarona durga*	Nymphalidae

74	Bronze Duke	*Euthalia nara*	Nymphalidae
75	Common Bushbrown	*Mycalesis perseus*	Nymphalidae
76	Spotted Palmfly	*Elymnias malelas*	Nymphalidae
77	Great Nawab	*Polyura eudamippus*	Nymphalidae
78	Dark Blue Tiger	*Tirumala septentrionis*	Nymphalidae
79	Green Duke	*Euthalia sahadeva*	Nymphalidae
80	Circe	*Hestina nama*	Nymphalidae
81	Autumn Leaf	*Doleschallia bisaltide*	Nymphalidae
82	Orange Staft Sergeant	*Athyma cama*	Nymphalidae
83	Dark-Branded Bush Brown	*Mycalesis minus*	Nymphalidae
84	Himalayan Sergeant	*Athyma opalina*	Nymphalidae
85	Green Commodore	*Sumalia daraxa*	Nymphalidae
86	Moore's Bushbrown	*Mycalesis heri*	Nymphalidae
87	Grand Duchess	*Euthalia patala*	Nymphalidae
88	Indian Purple Emperor	*Mimathyma ambica*	Nymphalidae
89	Painted Lady	*Vanessa cardui*	Nymphalidae
90	Club Beak	*Libythea myrrha*	Nymphalidae
91	Black Prince	*Rohana parisatis*	Nymphalidae
92	Common Nawab	*Polyura athamas*	Nymphalidae
93	Blue Oakleaf	*Kallima horsfieldii*	Nymphalidae
94	White-edged Blue Baron	*Euthalia phemius*	Nymphalidae
95	Pallid Argus	*Callerebia scanda*	Nymphalidae
96	Common Woodbrown	*Lethe sidonis*	Nymphalidae
97	Lilack Fork	*Lethe dura*	Nymphalidae
98	Common Red Forester	*Lethe mekara*	Nymphalidae
99	Small Woodbrown	*Lethe nicetella*	Nymphalidae
100	Pasha	*Herona marathus*	Nymphalidae
101	Jewel Five-ring	*Ypthima avanta*	Nymphalidae
102	Tailed Red Forester	*Lethe sinorix*	Nymphalidae
103	Chocolate Jungle Queen	*Stichophthalma nourmahal*	Nymphalidae
104	Scarce Evening Brown	*Cyllogenes janetae*	Nymphalidae
105	White Commodore	*Parasarpa dudu*	Nymphalidae
106	Jungle Glory	*Thaumantis diores*	Nymphalidae
107	Common Mormon	*Papilio polytes*	Papilionidae
108	Golden Birdwing	*Troides aeacus*	Papilionidae
109	Common Windmill	*Atrophaneura polyeucts*	Papilionidae
110	Rose Windmill	*Atrophaneura latreillei*	Papilionidae
111	Great Windmill	*Atrophaneura dasarata*	Papilionidae
112	Common Rose	*Atrophaneura aristolochiae*	Papilionidae
113	Red Helen	*Papilio helenus*	Papilionidae
114	Common Bluebottle	*Graphium serpedon*	Papilionidae
115	Glassy Bluebottle	*Graphium cloanthus*	Papilionidae
116	Common Peacock	*Papilio polyctor*	Papilionidae
117	Paris Peacock	*Papilio paris*	Papilionidae

118	Six-bar Swordtail	*Graphium euros*	Papilionidae
119	Spangle	*Papilio protenor*	Papilionidae
120	Krishna Peacock	*Papilio krishna*	Papilionidae
121	Spot Swordtail	*Graphium nomius*	Papilionidae
122	Veined Jay	*Graphium chironides*	Papilionidae
123	Fourbar Swordtail	*Graphium agetes*	Papilionidae
124	Lesser Zebra	*Graphium macareus*	Papilionidae
125	Yellow Helen	*Papilio nephelus*	Papilionidae
126	Tawny Mime	*Papilio agestor*	Papilionidae
127	Brown Gorgon	*Meandrusa sciron*	Papilionidae
128	Tailed Jay	*Graphium agamemnon*	Papilionidae
129	Common Raven	*Papilio castor*	Papilionidae
130	Spectacled Swordtail	*Graphium paphus*	Papilionidae
131	Indian Cabbage White	*Pieris canidia*	Pieridae
132	Large Cabbage White	*Pieris brassicae*	Pieridae
133	Yellow Orange Tip	*Ixias pyrena*	Pieridae
134	White Orange Tip	*Ixias marianne*	Pieridae
135	Red-spot Jezebel	*Delias descombesi*	Pieridae
136	Pale Jezebel	*Delias sanaca*	Pieridae
137	Red-base Jezebel	*Delias pasithoe*	Pieridae
138	Common Grass Yellow	*Eurema hecabe*	Pieridae
139	Spotted Sawtooth	*Prioneris thestylis*	Pieridae
140	Hill Jezebel	*Delias belladonna*	Pieridae
141	Dark Jezebel	*Delias berinda*	Pieridae
142	Plain Surphur	*Dercas lycorias*	Pieridae
143	Dark Clouded Yellow	*Colias fieldii*	Pieridae
144	Dark Judy	*Abisara fylla*	Riodinidae
145	Punchinello	*Zemeros flegyas*	Riodinidae
146	Lesser Punch	*Dodona dipoea*	Riodinidae
147	Tailed Punch	*Dodona eugenes*	Riodinidae
148	Common Punch	*Dodona durga*	Riodinidae
149	Mixed Punch	*Dodona ouida*	Riodinidae
150	Orange Punch	*Dodona egeon*	Riodinidae

Annexure 9: Moths checklist of BC 4 2021

Sl.No.	Common Name	Scientific Name	Family
1	Bob Butterfly Moth	*Callidula attenuata*	Callidulidae
2	Glad-eye Butterfly Moth	*Pterodecta anchora*	Callidulidae
3	Cossid Moth	*Zeuzera multistrigata*	Cossidae
4	Coral Tree Moth	*Agathodes ostentalis*	Crambidae
5	Thunbergia Tear Sucker	*Filodes fulvidorsalis*	Crambidae
6		*Oreta vatama*	Drepanidae
7	Large Bird-dropping Hooktip	*Macrocilix maia*	Drepanidae

8		*Barsine orientalis*	Erebidae
9		*Lygniodes endoleucs*	Erebidae
10		*Palirisa lineosa*	Eupterotidae
11		*Osteosema sp.*	Geometridae
12	Yellow-border Plutodes	*Plutodes costatus*	Geometridae
13	False Tiger Month	*Dysphania militaris*	Geometridae
14		*Percnia ductaria*	Geometridae
15	Iridicolor Emerald	*Iotaphora iridicolor*	Geometridae
16		*Thallasodes* sp.	Geometridae
17		*Limacodidae sp.*	Limacodidae
18		*Tarsolepis fulgida*	Notodontidae
19		*Syntypistis sp.*	Notodontidae
20		*Salassa sp.*	Saturniidae
21	Edward's Atlas Moth	*Archaeoattacus edwardsii*	Saturniidae
22	Rosy Tasar Silk Moth	*Antheraea rubicunda*	Saturniidae
23	Indian Moon Moth	*Actias selene*	Saturniidae
24	Orange-legged Clearwing	*Melittia hampsoni*	Sesiidae
25		*Marumba sp.*	Sphingidae
26	Ochreous Gliding Hawkmoth	*Ambulyx ochracea*	Sphingidae
27		*Sataspes infernalis*	Sphingidae
28	Green-striped Hawkmoth	*Cechetra lineosa*	Sphingidae
29	Broad-bordered Bee Hawk Moth	*Hemaris fuciformis*	Sphingidae
30		*Cerace cyanopyga*	Tortricidae
31	Harlequin Tiger Moth	*Campylotes histrionicus*	Zygaenidae
32		*Sacada sp.*	Pyralidae
33		*Numenes sp.*	Erebidae
34		*Daddala sp.*	Erebidae
35		*Arcte polygrapha*	Noctuidae
36	Hill Fern Moth	*Callopistria repleta*	Noctuidae

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