# Is Down Color in Himalayan Birds Associated With a High Elevation Life History?

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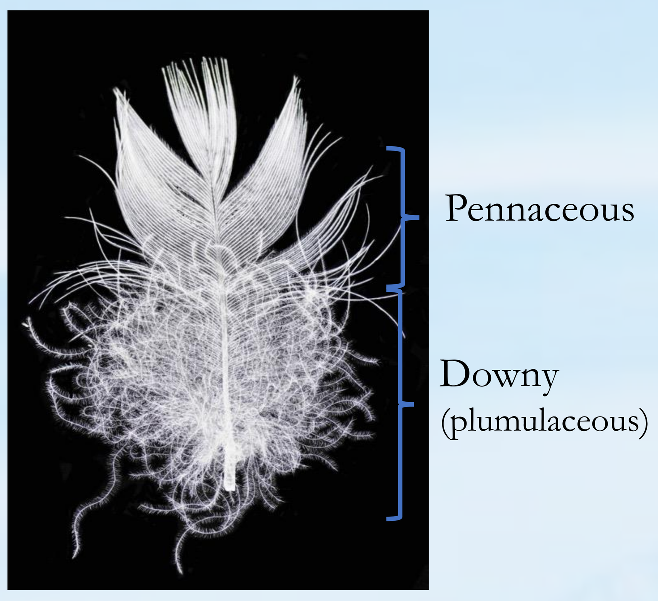
## Introduction




Contour Feather

High elevation habitats have given rise to diverse modifications for cold-tolerance in animals. Small animals tend to lose heat faster than larger organisms and thus small montane animals have significant thermo-insulative adaptations[1].

We explored potential feather adaptations to cold in Himalayan birds. By using microscopy to quantify the down color (intensity) in feathers, we aimed to determine if the intensity of pigment in the downy feather barbules is associated with increasing elevation and body size. We also compared the intensity of color in down feathers with pennaceous pigment coloration (Figure 1.) in feathers from 99 species of passerine birds found across a 4000m Himalayan elevational gradient.

## Questions

1. Is down color intensity associated with elevation in Himalayan birds?
2. Is down color intensity associated with body size in Himalayan birds?
3. Are down color intensity and pennaceous color correlated across species?

## Methods

We analyzed down intensity on museum specimens of 99 species of year-round resident Himalayan birds at the National Museum of Natural History (USNM). For each species, we chose two specimens with known elevation of collection to include specimens with lowest and highest elevation. We photographed a single contour feather using a FSCB 50-400X light and Leica 59i stereo microscope (Leica Microsystems, Wetzlar, Germany) with Leica DFC209 HP camera against a black color standard. We used the software Image J[2] to quantify the brightness of five polygons selected within the downy and pennaceous regions each using a FSB conversion. We then calculated the mean intensity of the downy and pennaceous region for each specimen correcting for the variation in incident light using the color standard. We then used a Phylogenetic Generalized Least Squares analysis[3] to test our three research questions using a phylogeny of our study taxa generated using birdtree.org[4] .

**Blue Rock-Thrush**
*Monticola solitarius*
(2042 meters)

**Spotted Forktail**
*Enicurus maculatus*
(1141 meters)

**Red-vented Bulbul**
*Pycnonotus cafer*
(1104 meters)

**Orange-bellied Leafbird**
*Chloropsis hardwickii*
(1036 meters)

**Black-throated sunbird**
*Aethopyga saturata*
(893 meters)

**Silver-eared Mesia**
*Leiothrix argentauris*
(593 meters)

## Results


Figure 2. Relationship between each variable. From (A-C) the dots represent mean values for 99 study species. The lines represent a relationship between the two variables, based on a linear regression model. (A) There was a negative association between downy color intensity and elevation ($p<0.05$). (B) A positive correlation between down color intensity and body mass. (C) A significant correlation between down color intensity and pennaceous color intensity.

**After controlling for phylogenetic relationships between species we found that:**

- A significant negative association between down color intensity and elevation. High elevation birds have significantly more intense down color ($P<0.05$).
- A significant positive association between down intensity and body size. Small birds have more intense (darker) down than large birds.
- A significant positive relationship between down intensity and pennaceous color intensity. Himalayan birds with more intense (darker) down have more intense pennaceous color.

## Discussion

We found that the intensity (brightness) of down decreases with both, increasing elevation and body size in Himalayan passerines. Our results are similar to Pap et al. (2020)[5] who found that pigmented node density of downy barbules was correlated with cold habitats in European birds. Down provides thermo-insulative advantage to birds by trapping pockets of air close to the body[6]. Melanized feather micro-structures are known to be more resistant to mechanical and ecto-parasite degradation[7,8]. Thus, whether high elevation and small birds have dark down to directly absorb heat by exposing the down to incident radiation, or whether dark down has evolved to resist degradation to maintain its thermo-insulative potential remains to be studied. Nevertheless, our findings suggest a strong selection on the color intensity of downy barbules in Himalayan birds to enhance and maintain the thermoregulatory potential of feathers.

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## References

Bird species images obtained from https://birdsoftheworld.org for this educational purpose.

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