Figure 1. Gomukh.

Butterflies of the Sacred Gangotri Landscape in the Himalaya

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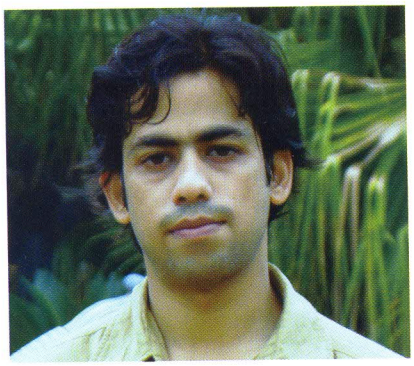

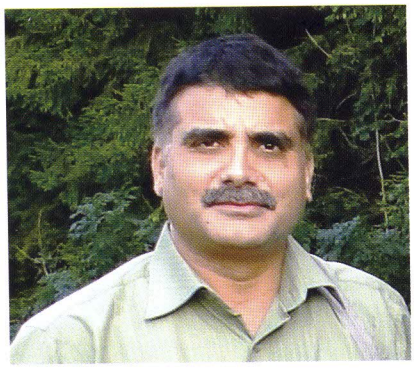

The Himalaya is the world's largest mountain complex, a meeting point of major biogeographical zones, and is a global biodiversity hotspot important for conservation. Extending along the northern fringe of the Indian subcontinent, from the bend of the Indus river in the northwest to the Brahmaputra river in the east, the Himalaya affects the life and livelihood of over 300 million people. The state of Uttarakhand also forms part of this complex Himalayan mountain system and is located in the northern part of the Indian subcontinent, sharing international borders with Tibet and China. Uttarakhand falls in what is termed the biogeographic province 2(B) of the Western Himalaya (Roger & Panwar, 1988). The mountains of Uttarakhand play a key role in supporting the economy, through hydropower, water supply, horticulture, agriculture and tourism. The state also holds significant biological, socio-cultural

Figure 2. Nilang Valley

and ecological wealth. It is, however, also prone to natural disasters like flash floods, cloud bursts, earthquakes and landslides. A lake burst event in Kedarnath in 2013, due to unexpected heavy rain, is an example of one such disaster, taking thousands of lives and devastating the biodiversity of Kedarnath valley all within a few minutes.

An inventory of biodiversity is of primary importance as part of biodiversity conservation efforts and for sustainable development, particularly in threatened and fragmented landscapes like the Western Himalaya, which harbour a unique assemblage of flora and fauna of considerable conservation importance. In comparison with higher plants and larger animals, the inventory of insects in the Western Himalayan landscape is still fragmented and incomplete.

Gangotri Landscape

The Gangotri landscape is an important habitat for high altitude biodiversity in the Western Himalayan region. The area represents large variation in altitude (from 900m to over 6,000m), with a gradient of disturbance regimes from pristine natural Himalayan forests to highly disturbed villages and agricultural lands. Three protected areas (Gangotri National Park, Govind National Park and Govind Wildlife Sanctuary) lie within the current study area. Gomukh, an important holy shrine for Hindus and the source of river Ganges, is in Gangotri National Park and is visited by large numbers of pilgrims (Fig. 1). Gangotri National Park is accessible through two valleys, *viz.* Gangotri and Nilang valley (Fig. 2) and is also visited by large numbers of international tourists for adventure, trekking, camping, mountain climbing, and for spiritual purposes. Despite being home to important high altitude biodiversity, there have been very few scientific studies conducted in the landscape.

Butterflies as indicators

To select and prioritise areas for biodiversity conservation, assessments of diversity and distribution patterns of indicator taxa can be an important, helpful and a cost-effective alternative to generation of more expansive species inventories. By focusing on one biodiversity indicator taxon a large amount of money and time can be saved, and this can be a valuable tool in conservation planning. Several taxa have been tested for their utility as indicators. Butterflies have been suggested as potential indicators of habitat fragmentation and disturbance, and have been successfully tested as surrogate taxa to reflect biodiversity in other taxa as well. Several features of the butterflies make them good candidates for us as indicators, in addition to their potential as charismatic umbrella and/or flagship species. They fulfil many of the criteria proposed to define useful study groups: they have short generation times, are day-flying, diverse, and usually easily identifiable. Furthermore, butterfly taxonomy, distribution, and natural history are better described than many other insect taxa (Vane-Wright & Ackery, 1984).

Keeping this in mind, we studied patterns and processes involved in shaping diversity and distribution of butterflies along elevational gradients in the Gangotri landscape from 2008 to 2011. We sampled four vegetation types, *viz.* mixed riparian and scrub forest, pine forest, broad leaved forest, conifer and alpine forest. Butterfly species richness, abundance and microclimatic data were collected.

Butterfly diversity and composition

A total 189 species of butterflies were recorded, representing 92 genera and 5 families. Analysis suggested that the inventory was almost complete at a regional level (96%). The most abundant species was *Pieris canidia* (503 individuals), and most individuals were recorded in mixed riparian and scrub forest (201 individuals). The highest numbers of species were recorded in mixed riparian and scrub forest, and the lowest in pine forest (Fig. 3).

Comparison of different habitats showed that, on average, species and composition of habitat type was more similar within than among different habitats (Fig. 4). Analysis showed that the greatest differences occurred between mixed riparian scrub forest and pine forest, and mixed riparian scrub forest and conifer and alpine forest. The greatest differences in family composition occurred between sites of pine forest and mixed riparian and scrub forest, with the families Lycaenidae and Nymphalidae contributing most to group differences between pine forests and mixed riparian and scrub forest. Species of family Nymphalidae generally prefer canopy forest with good moisture availability, while species of the family Lycaenidae were found in patches comprising considerable diversity of flowering herbs and shrubs; both such conditions are absent in pine forests. The generalist species observed were Large Cabbage White, Common Brimstone, Indian Cabbage White, Indian Tortoiseshell, Pioneer, Spotless Grass Yellow, Pale Grass Blue, Common Emigrant, Common Copper, Indian Red Admiral, Plain Tiger and Painted Lady.

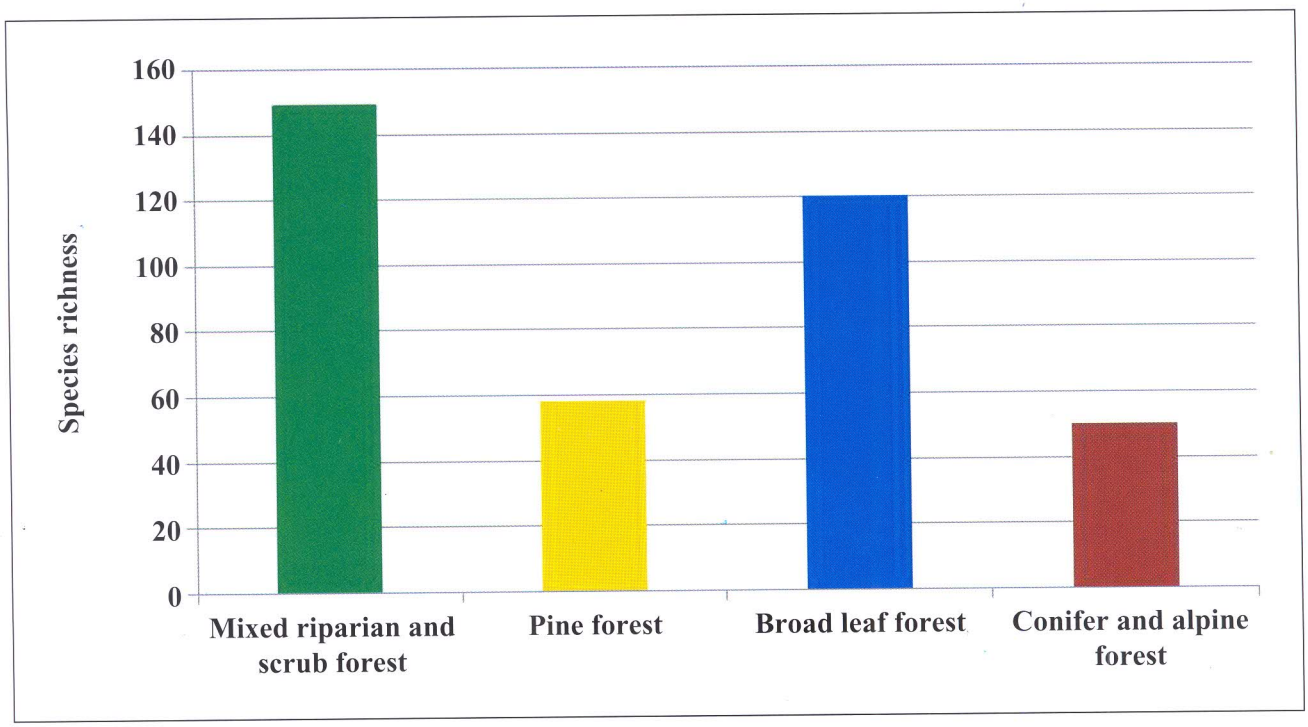

Fig. 3. Butterfly species richness in different habitats.

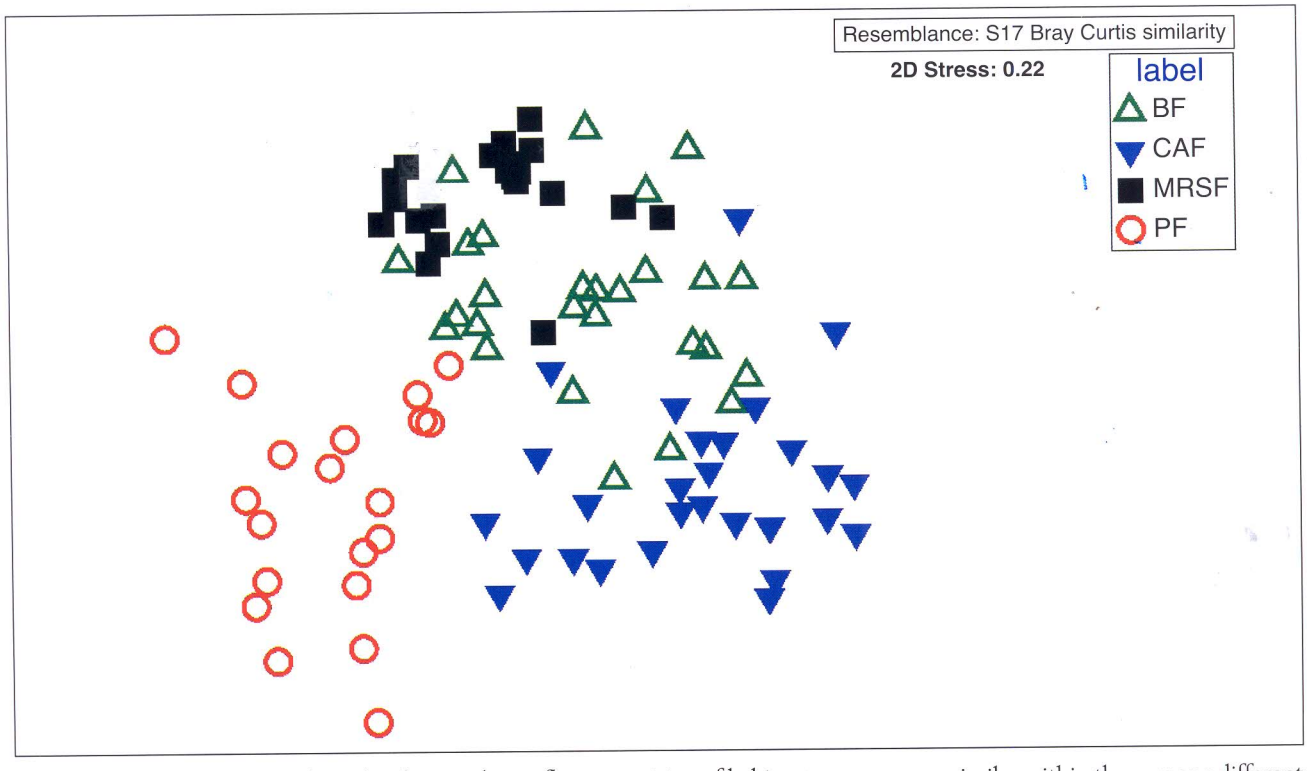

Fig. 4: Multi-Dimensional Scaling plot showing butterfly composition of habitat type was more similar within than among different habitats. BF = Broad leaf forest, CAF = Conifer and alpine forest, MRSF = Mixed riparian and scrub forest, PF = Pine forest.

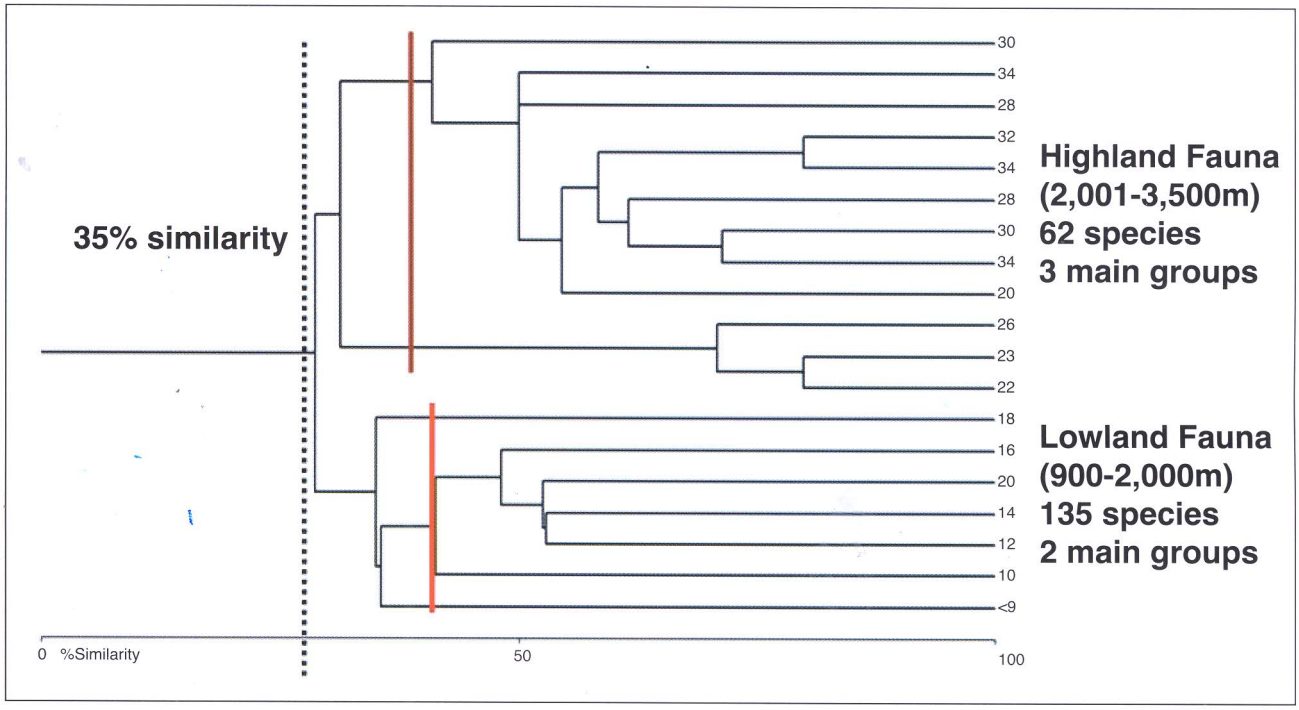

Fig. 5: Two major butterfly assemblage groups structured by altitude.

Role of altitude in shaping butterfly assemblages

Altitude was found to play a major role in governing butterfly composition. Results showed that two major assemblage groups of butterfly (highland and lowland) were found to be structured by altitude (Fig. 5). At a plot level, environmental variables like temperature, plant species richness, shrub and herb density and canopy cover were the main positive predictors of butterfly species diversity, while elevation, relative humidity and disturbance (fire and livestock abundance) variables showed negative relationships to butterfly diversity. Our study also offered support for the 'water energy balance' hypothesis of species richness gradients, which states that the temperature limits the number of species at higher altitude, and rainfall determines species richness at warmer, lower altitudes.

Seasonal patterns were also examined. In general, the main peak in diversity of butterflies was observed at the end of the summer season (dry season) with a second peak in the monsoon season (wet season), while the highest abundance was recorded at the end of wet season. The most abundant butterfly family was Nymphalidae, accounting for more than half of the total individuals of butterflies. Nymphalidae also accounted for the highest number of species occurring every month during the year. Butterfly composition was found to be significantly variable across summer, monsoon and winter seasons, as well as between natural and disturbed sites when grouped separately. Butterflies were seen in congruence at sites where water was available in the landscape at the end of dry season (late May and early June).

Findings

Approximately 9.5% of total species (189) which were recorded from the landscape were listed in the Indian Wildlife (Protection) Act (1972). In conclusion, we observed that despite conducting our survey over a restricted geographic range, the landscape was able to support a high level of butterfly diversity, and that the processes associated with landscape heterogeneity were strong enough to support a unique butterfly assemblage between forests (Fig. 6). Despite enormous pressure from the local communities on these habitats, they supported a considerably high (around 40-50% of the butterfly species expected to be found in Uttarakhand state) butterfly diversity in a relatively small area. This region, along with three protected areas, is important for long term conservation of biodiversity in Gangotri landscape in Western Himalaya.

There have been very few studies on the biogeography and distribution of the Himalayan butterfly fauna during past decades (Mani, 1986). As the forests in the Himalaya are under significant threat from human-induced forest fragmentation and habitat degradation, there is an urgent need for biodiversity studies, especially for taxa which are endemic to the Himalayan region. We expect that results presented and discussed here will help conservation planners and managers by aiding them in the selection of biodiversity rich areas and use of indicator taxa, which will boost biodiversity conservation efforts in the Himalaya.

References

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Common Blue Apollo.

Yellow Swallowtail.

Blue Admiral.

Indian Awlking.

Narrow Banded Satyr.

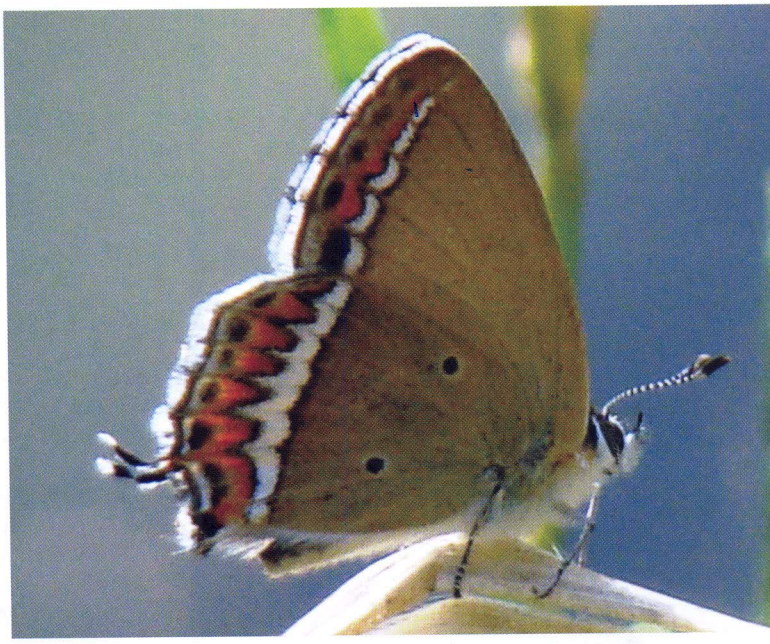

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Fig. 6: Some butterflies reported from Gangotri landscape.