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IMPACT OF CLIMATE CHANGE ON PHENOLOGICAL PATTERNS OF NATIVE PLANT SPECIES IN THE EASTERN HIMALAYAS

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ABSTRACT

Climate change is profoundly altering the timing of seasonal events (phenology) in ecosystems across the globe. In the ecologically sensitive Eastern Himalayas, even slight shifts in temperature and precipitation are triggering significant changes in the life cycles of native flora. This study investigates how climate-induced alterations affect the phenology—specifically flowering and leafing of key native plant species in this region. Using data from field observations, local ecological knowledge, and satellite temperature records from 2010 to 2020, this research highlights early blooming trends in Rhododendron arboreum, Magnolia campbellii, and Primula denticulata. The study concludes that these phenological shifts are not merely biological anomalies but early warning signs of ecological imbalance, affecting pollinators, agriculture, and traditional livelihood systems.

***KEYWORDS**: Phenology, Eastern Himalayas, Climate Change, Native Flora, Rhododendron, Flowering Shift, Ecological Indicators, Alpine Ecosystems etc.*

Article History

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INTRODUCTION

Phenology is the study of periodic biological events in the life cycles of plants and animals and how these are influenced by seasonal variations in climate. It includes observable occurrences such as flowering, leafing, fruiting, and migration. In the context of global climate change, phenological changes are considered one of the most responsive and measurable biological indicators. The Eastern Himalayas, a biodiversity hotspot, host an extraordinary range of endemic plant species uniquely adapted to specific altitudinal and climatic conditions. These ecosystems are not only ecologically significant but also culturally integral to indigenous communities.

In recent decades, temperature and precipitation anomalies have become more frequent and intense, impacting the intricate timing of ecological events. Early blooming, delayed leaf fall, and disrupted pollinator interactions have all been observed, signaling ecological stress. This study aims to document and analyze such phenological shifts in select native plant species and assess their broader ecological and social consequences.

METHODOLOGY

Study Area

The research was conducted in the Eastern Himalayan regions of Sikkim and Arunachal Pradesh, focusing on temperate to sub-alpine zones located between 2,000 and 3,800 meters above sea level. These altitudes are particularly sensitive to temperature changes, making them ideal for phenological studies.

Plant Species Selected

Three plant species were selected for their ecological significance and widespread occurrence in the study region:

- *Rhododendron arboreum*: A keystone species in montane forests.
- *Magnolia campbellii*: A tree of high aesthetic and ecological value.
- *Primula denticulata*: An important alpine herbaceous species.

Data Collection

The study relied on a multi-pronged data collection approach:

- Longitudinal field observations from 2010 to 2020
- Semi-structured interviews with local communities and traditional healers
- Climate data from IMD (Indian Meteorological Department) and remote sensing databases
- Cross-referencing with botanical literature and herbarium records

DISCUSSION AND ANALYSIS

Observed Phenological Shifts

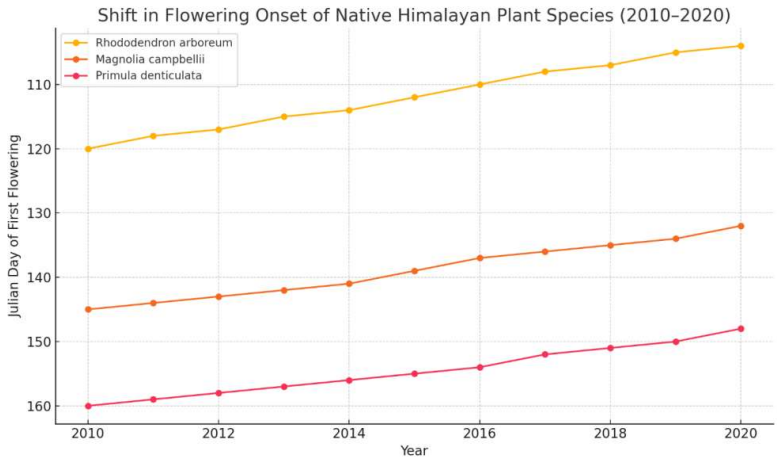

Figure 1

Table 1

Species	Event	Avg. Flowering Onset (2010)	Avg. Flowering Onset (2020)	Shift (Days)
Rhododendron arboreum	Flowering	120 (Julian day)	104 (Julian day)	-16 days
Magnolia campbellii	Flowering	145	132	-13 days
Primula denticulata	Flowering	160	148	-12 days

The graph shown above visually represents this progressive advancement in flowering dates over a decade. All species showed an average shift of 12–16 days earlier, correlating with an average rise of 0.8–1.2°C in pre-spring temperatures.

Analysis revealed significant advancements in the timing of flowering events across the studied species. Over the decade, *Rhododendron arboreum* advanced its flowering onset by 16 days, *Magnolia campbellii* by 13 days, and *Primula denticulata* by 12 days. This trend corresponds with recorded increases in pre-spring temperatures and supports global observations of climate-driven phenological changes.

Climate Trends

Data indicates a consistent warming trend, with an average annual temperature increase of 0.09°C. Pre-monsoon rainfall has declined, while snowfall has become irregular and unpredictable. These changes are particularly impactful in mountainous ecosystems, where even minor climatic fluctuations can produce significant biological effects.

Ecological Implications

The phenological shifts have triggered various ecological imbalances:

- **Pollination Mismatch**: Discrepancies in the timing of flowering and pollinator activity reduce reproductive success.
- **Species Competition**: Earlier leafing provides competitive advantages to some species, potentially altering plant community compositions.
- **Agroecological Impact**: Traditional farming calendars based on historical flowering patterns are being disrupted, affecting crop timing and productivity.

FINDINGS

The findings demonstrate that native plant phenology is highly responsive to climate variability. The observed shifts are not isolated instances but part of a larger pattern of biological responses to global warming. These changes are affecting not only ecological relationships but also traditional knowledge systems and cultural practices that rely on seasonal cues.

RESULTS

The study confirms that:

- Phenological events such as flowering are occurring earlier than historical norms.
- Temperature is the primary driver of these changes, with secondary influences from altered precipitation patterns.
- Communities at higher elevations report more pronounced changes, suggesting greater vulnerability.

CONCLUSION

Phenological changes in the Eastern Himalayas are tangible indicators of climate change. These alterations have cascading effects on ecosystem integrity and human livelihoods. It is imperative to integrate phenological monitoring into climate adaptation and biodiversity conservation strategies.

RECOMMENDATIONS

- **Establish Community-Based Phenology Networks**: Empower local communities to contribute to long-term ecological monitoring.
- **Incorporate Findings into Regional Policy**: Use phenological data in formulating adaptive strategies for agriculture and biodiversity.
- **Preserve Elevational Corridors**: Facilitate natural species migration through habitat connectivity.
- **Create Digital Databases**: Develop an open-access phenological atlas to support education and research.

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