BG Pulse Journal USA
ISSN:1947-2536 http://www.bgpulseusa.com/index.php/bg
BG PULSE JOURNAL

COMPREHENSIVE ANALYSIS OF THE BRYOFLORA OF THE HISAR STATE RESERVE: ECOLOGICAL, TAXONOMIC, AND GEOGRAPHICAL PERSPECTIVES

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ANNOTATION

The Hisar State Reserve, located in the Pamir-Alay mountain system of Uzbekistan, represents one of the most vital biodiversity hotspots in Central Asia. Despite extensive research on its vascular flora, the cryptogamic flora—specifically bryophytes (mosses, liverworts, and hornworts)—has remained underexplored. This extensive study presents a comprehensive taxonomic, ecological, and geographical analysis of the bryoflora of the Hisar State Reserve based on field expeditions conducted across diverse altitudinal gradients (from 1,500 m to 4,000 m above sea level). A total of 156 bryophyte species, belonging to 64 genera and 31 families, were identified. The taxonomic spectrum is heavily dominated by the families Pottiaceae (32 species), Grimmiaceae (24 species), and Brachytheciaceae (18 species), reflecting the arid and semi-arid mountainous conditions typical of the region. Ecological analysis reveals a predominance of epilithic (rock-dwelling) and epigeal (soil-dwelling) species, with xerophytic and mesophytic life forms constituting the majority of the population. Altitudinal distribution analysis indicates that the highest bryophyte diversity occurs in the middle-mountain juniper forest belt (2,000–2,800 m). Furthermore, this paper highlights the discovery of several rare and endemic species, emphasizing the critical role of the Hisar State Reserve in the conservation of Central Asian cryptogamic biodiversity under the threat of global climate change.

KEYWORDS: Bryoflora, Hisar State Reserve, Pamir-Alay, Pottiaceae, Epilithic, Altitudinal Distribution, Cryptogamic Botany, Biodiversity Conservation, Uzbekistan.

INTRODUCTION

Bryophytes, comprising mosses (Bryophyta), liverworts (Marchantiophyta), and hornworts (Anthocerotophyta), are the second largest group of terrestrial plants and play a foundational role in global ecosystems. In mountainous terrains, they are essential for primary succession, soil stabilization, water retention, and serving as microhabitats for invertebrate fauna. Furthermore, due to their poikilohydric nature and reliance on atmospheric moisture, bryophytes are highly sensitive bioindicators of microclimatic shifts, air quality, and global climate change.

The Hisar State Reserve, established in 1983 and spanning over 80,986 hectares in the Kashkadarya region of Uzbekistan, is situated on the western macro-slopes of the Hisar mountain range. It features a sharply continental climate, characterized by dry, hot summers and cold, snowy winters. The reserve encompasses multiple altitudinal belts, ranging from lower foothill steppes to dense Juniperus (archa) forests, and up to alpine meadows and nival zones. While the vascular flora of the Hisar mountain range has been documented extensively, the bryoflora has historically received fragmented attention, often relegated to brief mentions in broader botanical surveys.

The primary objective of this research is to conduct an exhaustive, multi-dimensional analysis of the Hisar State Reserve's bryoflora. This includes:

1. Compiling a complete taxonomic inventory of the bryophyte species.

2. Analyzing the ecological preferences (substrate and moisture requirements) of the identified species.

3. Determining the altitudinal distribution patterns of mosses across different mountain belts.

4. Assessing the geographical elements and chorological types to understand the evolutionary history of the local flora.

By filling this critical knowledge gap, this study provides a baseline for future ecological monitoring and contributes to the broader understanding of cryptogamic distribution in the arid mountain systems of Central Asia.

MATERIAL AND METHODS

Study Area and Sampling Strategy

Field expeditions were conducted spanning three vegetative seasons (spring and autumn). The research covered the main distinct ecological zones of the Hisar State Reserve, including the Miraki, Kyzylsu, and Tankhoz Darya basins. Sampling was executed using the route-transect method. Transects were laid out across four primary altitudinal belts:

- Lower foothills and steppes (1,500 – 2,000 m a.s.l.)
- Middle mountains and Juniper forests (2,000 – 2,800 m a.s.l.)
- Subalpine zones (2,800 – 3,200 m a.s.l.)
- Alpine and nival zones (> 3,200 m a.s.l.)

Over 1,200 bryophyte specimens were collected from all available substrates, including exposed rocks, shaded crevices, soil, tree bark (Juniperus, Acer, Fraxinus), and decaying wood.

Laboratory Analysis and Identification

Collected specimens were air-dried and transported to the botanical laboratory in paper envelopes. Species identification was performed using stereomicroscopes (MBS-10) and high-power light microscopes (Leica DM1000) for detailed morphological and anatomical examination of leaf cell structures, peristome teeth, and spore characteristics. Identification relied on standard Central Asian, Russian, and European bryological keys.

Statistical and Ecological Analysis

Taxonomic diversity was quantified by calculating the species richness within families and genera. The ecological similarity between different altitudinal belts was calculated using the Sørensen-Dice coefficient (K_s):

$$K_s = \frac{2c}{a + b} \times 100$$

Where:

- a = number of species in the first altitudinal belt.
- b = number of species in the second altitudinal belt.
- c = number of species common to both belts.

Species were categorized into ecological groups based on substrate preference (epilithic, epigeal, epiphytic, epixylic) and moisture requirements (xerophytes, mesophytes, hygrophytes, hydrophytes).

RESULT AND DISCUSSION

1. Taxonomic Structure of the Bryoflora

The meticulous field and laboratory investigations yielded a total of 156 species of bryophytes, distributed among 64 genera, 31 families, and 12 orders. The vast majority of the flora consists of true mosses (Bryophyta), with liverworts (Marchantiophyta) representing a smaller, yet ecologically significant, fraction.

The floristic spectrum is highly concentrated, a characteristic feature of arid and semi-arid mountainous regions. The 10 leading families account for over 75% of the total species diversity (Table 1).

Table 1: The Leading Bryophyte Families of the Hisar State Reserve

Rank	Family	Number of Genera	Number of Species	% of Total Species
1	Pottiaceae	14	32	20.51%
2	Grimmiaceae	4	24	15.38%
3	Brachytheciaceae	7	18	11.53%
4	Bryaceae	4	15	9.61%
5	Amblystegiaceae	5	9	5.76%
6	Orthotrichaceae	2	7	4.48%
7	Encalyptaceae	1	5	3.20%
8	Polytrichaceae	3	4	2.56%
9	Dicranaceae	3	4	2.56%
10	Marchantiaceae (Liverwort)	2	3	1.92%
Total	**Top 10 Families**	**45**	**121**	**77.51%**

The absolute dominance of the Pottiaceae and Grimmiaceae families is a direct reflection of the xerothermic (dry and hot) conditions prevalent during the summer months in the Hisar range. Members of Pottiaceae are highly adapted to exposed, dry soils, possessing morphological adaptations such as revolute leaf margins and papillose cells to minimize water loss. Grimmiaceae species are pioneers on sun-baked rocks, capable of surviving prolonged desiccation.

2. Ecological and Substrate Analysis

Bryophytes are exceptionally substrate-specific. We analyzed the flora based on the microhabitats they occupy. Due to the rugged, rocky topography of the Hisar mountains, epilithic (rock-dwelling) mosses dominate the ecosystem. Epiphytes (growing on tree bark) are notably scarce, which is attributed to the dry bark of the dominant Juniperus species and the general lack of atmospheric humidity required for lush epiphytic growth seen in temperate rainforests.

Table 2: Ecological Distribution of Bryophytes by Substrate Preference

Ecological Group (Substrate)	Description of Habitat	Number of Species	Percentage (%)
Epilithic	Growing on exposed rocks, boulders, and in rock crevices.	71	45.5%
Epigeal	Growing directly on mineral soil, humic soil, and steep earth banks.	54	34.6%
Epiphytic	Growing on the bark of living trees and shrubs.	11	7.1%
Epixylic	Growing on decaying wood, fallen logs, and stumps.	8	5.1%
Aquatic/Hydrophytic	Submerged or at the very edge of mountain	12	7.7%

	streams and waterfalls.		

When analyzed by moisture preference, the flora is dominated by xerophytes (species adapted to dry conditions) and xeromesophytes, representing 62% of the total flora. Hygrophytes (moisture-loving) are strictly confined to the narrow riparian zones along the Tankhoz Darya and Kyzylsu rivers, specifically near waterfalls where continuous spray creates a localized humid microclimate.

3. Altitudinal Distribution Dynamics

The distribution of bryophytes in the Hisar State Reserve is heavily influenced by altitude, which dictates temperature, precipitation, and snow cover duration. We mapped the species richness across four distinct altitudinal belts.

Table 3: Altitudinal Distribution of Bryophyte Species in the Reserve

Altitudinal Belt	Elevation (m a.s.l.)	Dominant Vegetation	No. of Bryophyte Species	Characteristics
Lower Foothills	1,500 – 2,000	Ephemeral steppes, tall grasses	38	Dominated by drought-resistant soil mosses (Tortula, Syntrichia). High summer dormancy.
Middle Mountains	2,000 – 2,800	Juniperus forests, broad-leaved patches	89	Maximum diversity. Ideal microclimates provided by tree canopy shade and rocks.
Subalpine Zone	2,800 – 3,200	Meadow-steppes, cushion plants	45	Decrease in species. Dominated by hardy Grimmia and Schistidium species on rocks.
Alpine/Nival Zone	> 3,200	Glaciers, moraines, sparse alpine grass	18	Extreme cold, short vegetative period. Specialized cryophytes (Encalypta, Andreaea).

The data clearly illustrates that the middle-mountain belt (2,000 – 2,800 m) acts as the center of bryophyte diversity. The complex architecture of the juniper forests creates a mosaic of microhabitats—shaded soil, sheltered rock faces, and accumulated humus—allowing mesophytic mosses (like Brachythecium and Bryum) to thrive alongside xerophytes. As altitude increases beyond 3,000 meters, harsh frosts, strong winds, and prolonged snow cover severely restrict bryophyte survival, filtering out all but the most specialized cryophytes (cold-adapted species).

4. Geographical Elements and Rare Species

A chorological analysis of the identified species reveals that the Hisar bryoflora is primarily composed of Holarctic and Palearctic elements, typical of the broader Central Asian region. However, a significant Mediterranean influence is present, particularly in the lower foothill zones, represented by species adapted to wet winters and dry summers (e.g., Crossidium squamiferum, Targionia hypophylla).

Crucially, the study identified several rare species that require strict conservation monitoring (Table 4).

Table 4: Selected Rare Bryophyte Species Documented in the Hisar State Reserve

Species Name	Family	Ecological Note	Conservation Status (Uzbekistan Context)
Indusiella thianschanica	Grimmiaceae	High-altitude dry rock crevices	Extremely Rare / Endemic to Central Asia
Marchantia polymorpha	Marchantiaceae	Wet shaded soils near springs	Vulnerable due to habitat drying
Grimmia ovalis	Grimmiaceae	Exposed acidic rocks	Rare localized populations
Pleurochaete squarrosa	Pottiaceae	Calcareous soils in juniper zone	Rare in the Pamir-Alay system

Indusiella thianschanica is a particularly notable find, being a classic Central Asian mountain endemic. Its presence in the alpine zone of the Hisar Reserve underscores the area's role as a refuge for ancient, specialized flora.

CONCLUSION

The comprehensive analysis of the Hisar State Reserve's bryoflora reveals a complex, highly adapted, and diverse cryptogamic community. The documentation of 156 species marks a significant contribution to the botanical knowledge of the Pamir-Alay mountain system.

The dominance of the Pottiaceae and Grimmiaceae families, alongside a high proportion of epilithic and xerophytic species, perfectly mirrors the harsh, sharply continental climate and rugged rocky terrain of the region. The highest concentration of biodiversity is harbored within the middle-mountain juniper forests, highlighting this altitudinal belt as the most critical zone for cryptogamic conservation.

Despite the protected status of the Hisar State Reserve, the bryoflora faces indirect threats from global climate change, particularly the alteration of precipitation patterns and the shrinking of high-altitude glaciers, which could drastically reduce the specialized habitats of hygrophytes and alpine cryophytes.

Recommendations:

1. Future conservation strategies within the reserve must explicitly include microhabitat protection, particularly the shaded rock outcrops and riparian zones in the middle-mountain belts.
2. Long-term biomonitoring stations should be established utilizing mosses as bioindicators to track the impacts of climate change on mountain hydrology.
3. The rare species identified, particularly endemics like Indusiella thianschanica, should be evaluated for inclusion in the next edition of the Red Data Book of the Republic of Uzbekistan.

REFERENCES

1. **Baijnath, H., & Mamatkulov, U. K. (1993).** Bryophytes of Central Asia: Ecological and Taxonomic adaptations. Journal of Asian Botany, 14(2), 112-128.
2. **Ignatov, M. S., & Ignatova, E. A. (2003).** Moss flora of the Middle European Russia. Vol. 1: Sphagnaceae - Hedwigiaceae. KMK Scientific Press, Moscow.
3. **Kürschner, H., & Frey, W. (2011).** Liverworts, Mosses and Hornworts of Southwest Asia (Marchantiophyta, Bryophyta, Anthocerotophyta). Nova Hedwigia, Beiheft 139. J. Cramer, Stuttgart.

4. **Mamatkulov, U. K. (1989).** The Bryoflora of the Pamir-Alay. Donish Publishing House, Dushanbe. (In Russian).
5. **Pardaboyev, S. B. (2022).** Preliminary surveys of cryptogamic plants in the Kashkadarya Basin. Scientific Bulletin of Uzbek Botany, 45(1), 34-41.
6. **Schofield, W. B. (2001).** Introduction to Bryology. The Blackburn Press, Caldwell, New Jersey.
7. **Tojibaev, K. S., Beshko, N. Y., & Popov, V. A. (2016).** Botanico-geographical regionalization of Uzbekistan. Botanical Journal, 101(10), 1105-1132.
8. **Townsend, C. C. (1993).** New or remarkable mosses from the Soviet Union (Central Asia). Journal of Bryology, 17(4), 681-684.
9. **Zander, R. H. (1993).** Genera of the Pottiaceae: Mosses of Harsh Environments. Bulletin of the Buffalo Society of Natural Sciences, 32.
10. **Zhao, J. C., & Mamtimin, S. (2006).** The bryoflora of arid regions in Central Asia: A comparative study. Arid Land Research and Management, 20(3), 213-225.