

**PREPRINT**

*Author-formatted, not peer-reviewed document posted on 18/05/2026*

DOI: <https://doi.org/10.3897/arphapreprints.e200143>

---

# **Macrofungal diversity of Bhutan: A specimen-based assessment**

Sabitra Pradhan,  Michael Thomas

# Macrofungal diversity of Bhutan: A specimen-based assessment

Sabitra Pradhan<sup>‡</sup>, Michael B. Thomas<sup>§</sup>

<sup>‡</sup> National Mushroom Centre, DoA, MoAL, Wanchutaba, Bhutan

<sup>§</sup> Affiliate Researcher, National Mushroom Centre, DoA, MoAL, Wanchutaba, Bhutan

Corresponding author: Sabitra Pradhan ([sabitrapp@moal.gov.bt](mailto:sabitrapp@moal.gov.bt)), Michael B. Thomas ([michaelbthomas@gmail.com](mailto:michaelbthomas@gmail.com))

## Abstract

### Background

A study was undertaken including systematic field surveys and specimen-based documentation of macrofungi across Bhutan to address longstanding inventory gaps in national fungal knowledge. Despite Bhutan's position within the biologically rich Himalayan region, fungal diversity has remained underrepresented in both regional checklists and global biodiversity databases. To establish a reliable baseline, surveys were conducted across diverse habitats and elevational gradients, including temperate broadleaf forests, coniferous forests, alpine zones, and subtropical regions. Standardized collection protocols were followed to ensure high-quality voucher specimens, detailed field metadata, and accurate georeferencing.

All specimens were curated, identified using current taxonomic literature, and deposited in national mushroom centre Fungarium collection. Throughout the project, particular emphasis was placed on verifying nomenclature, updating synonymy, and documenting precise locality data to enhance long-term research value. This sustained effort has resulted in one of the most comprehensive specimen-based datasets of Bhutanese macrofungi assembled to date.

To promote transparency, accessibility, and global collaboration, the complete specimen dataset is now being published through an openly accessible biodiversity data portal. The dataset follows internationally recognized biodiversity informatics standards to ensure interoperability with global repositories. By mobilizing these occurrence records, we aim to provide a robust foundation for future taxonomic, ecological, conservation, and biogeographic studies, while supporting national biodiversity assessment and long-term monitoring initiatives in the Himalayan region.

## New information

The dataset of the Bhutan National Fungarium comprises 2,500 macrofungal specimen records, of which 100% are georeferenced, providing strong spatial resolution for distributional analysis. Taxonomic coverage includes 104 families, 270 genera, and 816 species, with 1,990 records (80%) identified to species level. In total, the dataset documents 824 taxa, including subspecies and varieties, representing the most comprehensive specimen-based fungal datasets available for Bhutan.

District-level (Dzongkhag) sampling reveals a strong concentration of collections in Thimphu (1,454 records), followed by Tsirang (273) and Punakha (225). Moderate sampling has occurred in Bumthang (149), Sarpang (116), and Paro (105). Several districts remain minimally sampled, including Chukha (83), Haa (81), Trashiyangtse (7), Trongsa (3), Gasa (2), and Samtse (2).

Notably, the following eight districts have not yet been sampled: Dagana, Lhuentse, Mongar, Pema Gatshel, Samdrup Jongkhar, Trashigang, Wangdue Phodrang, and Zhemgang. These geographic gaps highlight priority areas for future macrofungal surveys to improve national coverage and better represent Bhutan's fungal diversity across the Himalayan landscape.

## Keywords

Fungal diversity, Himalayas Bhutan, Ascomycota, Basidiomycota, Species richness, specimens, fungarium

## Introduction

### Background

Bhutan lies within the [Eastern Himalayan biodiversity hotspot](#) and supports exceptional biological diversity across a wide range of elevational gradients known for its intact forest cover, and strong national commitment to environmental conservation (Myers et al. 2000). Spanning subtropical lowlands to alpine peaks above 7,500 meters, the country supports an exceptional diversity of ecosystems within a relatively compact geographic area. More than 70% of the country remains forested, and national policy mandates maintaining at least 60% forest cover in perpetuity (Royal Government of Bhutan 2008). Recent biodiversity syntheses estimate that more than 11,000 species have been recorded from Bhutan, although many taxonomic groups remain poorly documented (National Biodiversity Centre 2019, Gyeltshen and Prasad 2022). The country's flora has been documented extensively through the Flore of Bhutan (Grierson and Long 1983, Grierson and Long 1991, Nolfie 1994) and subsequent national biodiversity initiatives such as the Endemic Plants of Butan (Yangzom and Long 2015). The national herbarium

maintains a well curated collection with thousands of vascular plant species documented through sustained botanical exploration and herbarium development.

In contrast, fungal diversity historically remained significantly under-documented. The single most important historical specimen-based legacy monograph for Bhutan fungi (excluding lichens) (Prasher 1999a, Prasher 1999b), based on approximately 1,500 fungal collections (collected from 1979–1983) and treating 306 species in 138 genera. Earlier research by Kashiwadani (1988) and Upreti and Ranjan (1988) focused primarily on economically important fungal species. Not surprisingly, members of the family Ophiocordycipitaceae have attracted the greatest research attention (Cannon et al. 2009, Choden et al. 2021, Wu et al. 2016). More recently, ethnomycological studies have expanded this perspective by documenting the cultural and subsistence importance of wild edible mushrooms in Bhutan (Tshering and Verma 2024).

In addition, two colorful field guides and posters published by the National Mushroom Centre have become important resources for fungal identification, particularly for distinguishing edible and poisonous mushrooms (Mata et al. 2010, Nagasawa et al. 2021). The latter publication was developed to support an educational campaign aimed at rural communities that frequently harvest wild edible mushrooms, with the goal of reducing potentially fatal mushroom poisoning incidents. The National Mushroom Centre's records reveal over 100 cases of mushroom poisoning and more than 30 recorded deaths between 1994 and 2020 (Nagasawa et al. 2021, Bhutan Broadcasting Service 2023). These field guides have since been digitized, linked to specimen records, and made available online to improve data accessibility and public engagement (Mata et al. 2020). The growth of tourism and biodiversity conservation (Brooks 2010) in Bhutan has also contributed to increased awareness of the country's fungal diversity, with popular articles promoting fungal forays across Bhutan's diverse landscapes (Winkler 2009, Winkler 2026).

Bhutan's "Fungi checklist" is not always used in a strict modern taxonomic sense. Bhutan's institutional fungi checklists and summaries may also present lichen-forming fungi and insect-associated fungi together with other fungal groups, and may also reference oomycetes alongside fungi in checklist contexts. While other published works are regional in scope, in these Himalayan works sometimes Bhutan species and specimens are explicitly included (Atri et al. 2019, Prasher 2015).

For lichens (and lichenicolous fungi), the foundational national synthesis remains (Aptroot and Feijen 2002), an annotated checklist of 287 lichens and lichenicolous fungi, with a strong primary-collection basis (c. 800 collections) and extensive new country records. Earlier Bhutan-specific lichen literature exists but is comparatively sparse (Kashiwadani 1988, Upreti and Ranjan 1988, Söchting 1999). The most Bhutan-relevant peer-reviewed primary literature outside inventories is concentrated in (a) economically important fungi (notably *Ophiocordyceps sinensis*) and (b) plant pathology (pathogen presence/first reports and outbreaks) (Cannon et al. 2009).

Although fungi play critical ecological roles in forest dynamics, nutrient cycling, and traditional food systems, systematic inventories of macrofungi and microfungi have only recently gained momentum. The disparity between plant and fungal knowledge reflects both historical research focus and logistical challenges associated with mycological surveys in mountainous terrain. Recognizing these gaps, Bhutan has strengthened national efforts to document fungi biodiversity across all taxa. Through coordinated initiatives under the National Biodiversity framework and associated institutions, specimen collection, databasing, and digitization efforts are expanding. These programs aim to improve baseline knowledge, enhance conservation planning, and ensure that Bhutan's rich biological heritage—plants, fungi, and other organisms alike—is systematically recorded and made accessible for research, policy, and sustainable development (Kumata et al. 2025). This has led to a preliminary desk reviews checklists being published by the National Biodiversity Centre (2019) and Gyeltshen and Prasad (2022), however these lists were incomplete and not specimen-based.

The Myco-diversity Program is a specialized component of the [National Mushroom Center](#) under the Department of Agriculture, dedicated to documenting and preserving Bhutan's macrofungal diversity (Thiers 2026). The fungarium was unofficially launched in 2009 when the first specimens were collected. For the first 5 years, specimen collecting was primarily opportunistic and a labor of love by a few young emerging mycologists, led by Sabitra Pradhan. Since then, specimen collecting has been prioritized as part of the Mushroom Centre's mandate to systematically collect wild mushrooms across the country, identify specimens, and preserve them through standardized drying and curation methods (Wu et al. 2004). One of the primary activities of the Mushroom Centre is the development of a national fungarium to support biodiversity research, conservation, and sustainable utilization of edible, medicinal, and poisonous fungi.

In 2017, the [National Herbarium \(THIM\)](#) received technical support through a partnership with the [U.S. Fulbright Program](#), led by Dr. Michael B. Thomas. This collaboration facilitated the development of specimen databasing systems, workflow protocols, and the establishment of the fungi specimen collection in a collections-based biodiversity data portal. Since that time, Dr. Thomas has continued to serve as Data Curator, supporting data portal management, capacity building, and training in collection management to strengthen long-term institutional sustainability of a curated dataset of Bhutan fungal records.

To date, more than 2500 fungal specimens have been accessioned from the diverse ecological regions of Bhutan (Table 1). Each dried specimen is databased, digitally imaged, and curated according to standardized protocols, with specimen records published through a publicly accessible specimen data portal to promote transparency and scientific collaboration. The collection continues to expand through ongoing field expeditions and coordinated collecting efforts by the Myco-diversity Program of the National Mushroom Centre. At the moment, the national fungarium ([BNF](#)) maintains the largest specimen collection of Bhutanese fungi.

## Sampling methods

### Description: Study Area

The field surveys were conducted in various habitats, ranging from different types of forests from the subtropical belt in Sarpang to alpine forests in Chelela, Haa. The study sites were chosen to cover environmental heterogeneity in vegetation composition in different types of farm lands in Gelephu to virgin forests in [Phrumshingla National Park](#), insitu conservation site in [Royal Botanical Garden](#) in Serbithang, Thimphu, etc. This environmental heterogeneity has been reported to affect fungal diversity and distribution in different gradients.

### Sampling Design and Survey Methods

Wild mushrooms were collected through walk-through survey and opportunistic sampling methods. The walk-through survey method was conducted by traversing through the study area, following existing trails, forest paths, and natural environmental gradients. The survey was conducted at a slow and constant pace, allowing for intensive visual inspection of all possible sites for wild mushrooms, such as leaf litters, decaying woods, tree stumps, and exposed soil surfaces.

In addition to this, opportunistic sampling was conducted to collect all species that were encountered during the course of the study, beyond the main survey route. This includes species that are scattered, patchily distributed, or infrequently encountered during surveys, which may be beyond the scope of walk-through surveys. The opportunistic sampling method is particularly applicable for this study because, due to the irregular distribution and ephemeral nature of fruiting bodies, opportunistic sampling is particularly applicable.

### Sampling Period

For field collections, the collections were made during peak fruiting seasons, mainly during the monsoon and post-monsoon periods, when conditions are most favorable for fungi to emerge in most areas. However, for surveys in Royal Botanical Garden in Serbithang the surveys were carried out weekly for 3 consecutive years from 2019 to 2021 and four distinct seasons in Bhutan in Gelephu Mindfulness City Area.

### Specimen Collection and Field Handling

For collecting specimens, mushroom harvesting sticks/knives were used to collect fruiting bodies encountered during surveys. The harvesting sticks/knives were used to ensure that the entire specimen was collected, including the stipe base. When available, multiple specimens at different developmental stages were collected to capture morphological variation. Each specimen was handled individually and wrapped in wax paper to avoid moisture buildup and cross-contamination. The specimens were placed in a firm basket

while in the field and while transporting them from the field to the laboratory to avoid degradation of specimens.

### Field Data Recording

For each specimen, detailed metadata were recorded, including date, geographic coordinates (latitude, longitude, and elevation), habitat description, substrate types (e.g., soil, wood, and leaf litter), and associated vegetation. Additional data recorded include abundance (solitary, scattered, clustered), and ecological context. Macromorphological features such as cap shape, size, color, surface texture, gill attachment, stipe features, odor, and color change upon bruising were recorded in situ as well as in the laboratory. Photographs were taken using a digital camera from multiple angles: pileus, lamellae, stipe, and habitat in the field and with the individual fungarium number in the laboratory.

### Specimen Processing and Identification

In the laboratory, specimens were examined for detailed macroscopic features, which included measuring the pileus diameter and stipe length. In the microscopic examination, thin sections were prepared from the structures to be examined, and then they were examined using a compound microscope to determine various features such as spore size, basidia, and cystidia. Spore prints were prepared by allowing mature specimens to set on sterile surfaces to determine spore color, which is one of the identifying features.

### Preservation and Storage

Specimens were dried at 40-50°C until completely desiccated. The dried specimens were stored in containers with desiccants and labeled with unique collection codes and details of the specimens. All specimens were curated and stored at the Bhutan National Fungarium for future reference and preservation.

### Molecular Analysis

For specimens that could not be identified using conventional methods, molecular analyses were performed. The internal transcribed spacer (ITS) region was sequenced to identify the species and to carry out phylogenetic analysis to confirm the species.

**Data Management** The data including the detail information on the specimens and the photographs of the specimens are published in the [Bhutan Biodiversity Specimen Portal](#) and the Google drive of the [National Mushroom Centre](#).

### Geographic coverage

**Description:** Bhutan is administratively divided into 20 districts (dzongkhags), spanning a remarkable range of ecological zones from subtropical lowlands to alpine Himalayan environments above 4,500 meters. The current fungal dataset includes records from 12 districts, with particularly strong representation in Thimphu (1,454 specimens, 64%), followed by Tsirang (273), Punakha (225), Bumthang (149), Sarpang (116), and Paro

(105) (Table 2). More limited sampling has occurred in Chukha (83), Haa (81), Trashiyangtse (7), Trongsa (3), Gasa (2), and Samtse (2). Ninety-four percent of the specimens are collected from five districts.

Eight districts remain unsampled to date including: Dagana, Lhuentse, Mongar, Pema Gatsel, Samdrup Jongkhar, Trashigang, Wangdue Phodrang, and Zhemgang. These geographic gaps largely reflect logistical and financial constraints rather than ecological absence. Many of these districts are remote, rugged, and characterized by limited road access, requiring extended travel times and significant field resources. The concentration of specimens in Thimphu and adjacent districts is inextricably linked to the professional activities and field leadership of Sabitra Pradhan, whose work and institutional base were centered in the capital region. As a result, areas most accessible from Thimphu have received the greatest collecting effort.

Expanding fungal exploration into the unsampled districts remains a priority but is constrained by limited funding and shortage of human resources in the Myco-diversity Program. High-elevation fieldwork involves steep terrain, unpredictable weather, seasonal road closures, and physically demanding conditions. Rapid climatic shifts, landslides, and altitude-related health risks further complicate survey efforts. Despite these challenges, the ecological diversity of Bhutan's montane and alpine systems suggests that substantial undocumented fungal diversity likely remains in these underexplored regions.

Description: Bhutan, entire country,

Coordinates: 88.7°E and 92.1°E Latitude; 28.3°N and 26.7°N Longitude.

## Taxonomic coverage

**Description:** The dataset encompasses both wild and native macrofungi collected across diverse habitats in Bhutan, as well as a smaller number of cultivated species, particularly from the Thimphu region where institutional cultivation and demonstration activities occur. The majority of records represent naturally occurring forest fungi gathered through systematic field surveys, reflecting Bhutan's rich ecological gradients and forest ecosystems.

The dataset currently comprises 2,500 specimen records, of which all specimens are georeferenced, providing strong spatial integrity for distributional analyses. Taxonomic coverage includes 104 families, 270 genera, and 816 species, with 1,990 records (80%) identified to species level. In total, the dataset documents 824 taxa, including subspecies and varieties. This represents one of the most comprehensive specimen-based fungal resources assembled for Bhutan to date. The top 16 families account for approximately 64% of all specimen records in the dataset (Table 1).

Until 2010, the taxonomic backbone used for specimen identification was primarily based on available regional floras and standard mycological reference literature. In some

instances, taxonomic determinations reflected the specialized expertise of individual collectors, which could lead to minor deviations in nomenclatural interpretation. Since 2011, online references such as MushroomExpert have provided updated information and detailed descriptions, while systematic revision of fungal names has been undertaken using MycoBank as the authoritative nomenclatural reference. MycoBank is an online database serving the global mycological community by documenting nomenclatural novelties and providing updated taxonomic information. The adoption of MycoBank has strengthened nomenclatural consistency, improved alignment with international standards, and enhanced interoperability of the dataset with global biodiversity platforms.

## Temporal coverage

**Data range:** 2009-1-01 - 2025-5-26.

**Notes:** The temporal distribution of specimen collection spans 2009–2025 and reflects both the gradual establishment and subsequent expansion of systematic mycological surveys in Bhutan. Early collecting efforts were modest, with 21 specimens recorded in 2009 and annual totals remaining below 120 specimens through 2012. A notable increase occurred in 2013 (208 specimens), followed by fluctuating but sustained activity between 2014 and 2018. Collection intensity accelerated significantly beginning in 2019 (315 specimens), peaking in 2020 with 598 specimens—the most productive year in the dataset. This surge corresponds to expanded fieldwork, improved institutional coordination, and strengthened specimen workflow and databasing. Following 2020, collecting levels stabilized at moderate levels (65–149 specimens annually), indicating continued but more targeted survey efforts. Overall, the dataset demonstrates a clear transition from exploratory and capacity-building phases to more systematic and intensive documentation, resulting in a robust multi-year temporal specimen baseline for macrofungal diversity in Bhutan.

## Usage licence

**Usage licence:** Other

**IP rights notes:** This work is licensed under a Creative Commons Attribution (CC-BY) 4.0 Licence (<http://creativecommons.org/licenses/by/4.0/>). The licence covers images of the specimens deposited in <http://bhutanbiodiversity.net/> and available in GBIF, as well as their metadata.

## Data resources

**Data package title:** Bhutan National Fungarium Specimens

**Resource link:** <https://doi.org/10.15468/88qx9z>

**Number of data sets: 1**

**Data set name:** Bhutan National Fungarium

**Character set:** UTF-8 (unicode)

**Download URL:** <https://zenodo.org/records/19862518>

**Data format:** CSV

**Data format version:** version 1

**Description:** This is a data download of the accessioned Bhutan National Fungarium specimen records.

Column label	Column description
basisOfRecord	A specimen that has been preserved.
institutionCode	The name (or acronym) in use by the institution having custody of the object(s) or information referred to in the record.
collectionCode	The name, acronym, coden, or initialism identifying the collection or data set from which the record was derived.
ownerInstitutionCode	The name (or acronym) in use by the institution having ownership of the object(s) or information referred to in the record.
occurrenceID	An identifier for the dwc:Occurrence (as opposed to a particular digital record of the dwc:Occurrence). In the absence of a persistent global unique identifier, construct one from a combination of identifiers in the record that will most closely make the dwc:occurrenceID globally unique.
catalogNumber	An identifier (preferably unique) for the record within the data set or collection.
kingdom	The full scientific name of the kingdom in which the dwc:Taxon is classified.
phylum	The full scientific name of the phylum or division in which the dwc:Taxon is classified.
class	The full scientific name of the class in which the dwc:Taxon is classified.
order	The full scientific name of the order in which the dwc:Taxon is classified.
family	The full scientific name of the family in which the dwc:Taxon is classified.
scientificName	The full scientific name, with authorship and date information if known.
scientificNameAuthorship	The authorship information for the dwc:scientificName formatted according to the conventions of the applicable dwc:nomenclaturalCode.
genus	The full scientific name of the genus in which the dwc:Taxon is classified.
specificEpithet	The name of the first or species epithet of the dwc:scientificName.
taxonRank	The taxonomic rank of the most specific name in the dwc:scientificName.

infraspecificEpithet	The name of the lowest or terminal infraspecific epithet of the dwc:scientificName, excluding any rank designation.
identifiedBy	A list (concatenated and separated) of names of people, groups, or organizations who assigned the dwc:Taxon to the subject.
dateIdentified	The date on which the subject was determined as representing the dwc:Taxon.
identificationQualifier	A brief phrase or a standard term ("cf.", "aff.") to express the determiner's doubts about the dwc:Identification.
recordedBy	A list (concatenated and separated) of names of people, groups, or organizations responsible for recording the original dwc:Occurrence.
recordNumber	An identifier given to the dwc:Occurrence at the time it was recorded. Often serves as a link between field notes and a dwc:Occurrence record, such as a specimen collector's number.
eventDate	The date-time or interval during which a dwc:Event occurred.
occurrenceRemarks	Comments or notes about the dwc:Occurrence.
habitat	A category or description of the habitat in which the dwc:Event occurred.
substrate	The substrate on which the specimen was collected.
associatedTaxa	A list (concatenated and separated) of identifiers or names of dwc:Taxon records and the associations of this dwc:Occurrence to each of them.
country	The name of the country or major administrative unit in which the dcterms:Location occurs.
stateProvince	The name of the next smaller administrative region than country (state, province, canton, department, region, etc.) in which the dcterms:Location occurs.
county	The full, unabbreviated name of the next smaller administrative region than stateProvince (county, shire, department, etc.) in which the dcterms:Location occurs.
municipality	The full, unabbreviated name of the next smaller administrative region than county (city, municipality, etc.) in which the dcterms:Location occurs.
locality	Less specific geographic information can be provided in other geographic terms (dwc:higherGeography, dwc:continent, dwc:country, dwc:stateProvince, dwc:county, dwc:municipality, dwc:waterBody, dwc:island, dwc:islandGroup).
decimalLatitude	The geographic latitude (in decimal degrees, using the spatial reference system given in dwc:geodeticDatum) of the geographic center of a dcterms:Location.
decimalLongitude	The geographic longitude (in decimal degrees, using the spatial reference system given in dwc:geodeticDatum) of the geographic center of a dcterms:Location.
geodeticDatum	The ellipsoid, geodetic datum, or spatial reference system (SRS) upon which the geographic coordinates given in dwc:decimalLatitude and dwc:decimalLongitude are based.

coordinateUncertaintyInMeters	The horizontal distance (in meters) from the given dwc:decimalLatitude and dwc:decimalLongitude describing the smallest circle containing the whole of the dcterms:Location.
georeferencedBy	A list (concatenated and separated) of names of people, groups, or organizations who determined the georeference (spatial representation) for the dcterms:Location.
georeferenceSources	A list (concatenated and separated) of maps, gazetteers, or other resources used to georeference the dcterms:Location, described specifically enough to allow anyone in the future to use the same resources.
georeferenceRemarks	Comments or notes about the spatial description determination, explaining assumptions made in addition or opposition to the those formalized in the method referred to in dwc:georeferenceProtocol.
minimumElevationInMeters	The lower limit of the range of elevation (altitude, usually above sea level), in meters.
maximumElevationInMeters	The upper limit of the range of elevation (altitude, usually above sea level), in meters.
verbatimElevation	The original description of the elevation (altitude, usually above sea level) of the Location.
disposition	The current state of a dwc:MaterialEntity with respect to a collection.
references	A related resource that is referenced, cited, or otherwise pointed to by the described resource.

## Additional information

The complete list of collectors consists of 110 individuals. The list of the top collectors is given in Table 3. The dataset is overwhelmingly shaped by Sabitra Pradhan, who contributed 40.3% of all recorded collector occurrences, demonstrating long-term leadership. International collaboration is evident through significant contributions from Kentaro Hosaka, Takashi Nakayama, and Kazuo Watanabe, along with organized institutional teams. Additional substantial contributions were made by Dawa Penjor (5.8%), Dorji (4%), L.B. Tamang (2%), and Hem Kumar Newar (3%). The top 5 collectors contributed 61.2% of all records. Fifteen collectors contributed more than 50 specimens, collectively representing the majority of the dataset, while 18 contributors are represented by single collections. This distribution demonstrates both the critical role of dedicated long-term collectors and the importance of national and international collaboration in building Bhutan's national fungi collection. The collectors were always accompanied by associate collators as the collection were mostly in forest with possibility of encountering the wild animals and often needed assistance in difficult terrains and thick forest. Mr. Dawala has contributed as the top most associate collectors followed by Hem Kumar Newar.

## Acknowledgements

We gratefully acknowledge the dedicated staff of the National Mushroom Center for their sustained support of this work, with special thanks to both Program Directors, Mr. Dawa Penjor and Mr. Chenchu Dukpa, for their leadership, guidance, and commitment to advancing fungal research in Bhutan. We also extend our sincere appreciation to the staff of the Royal Botanical Garden, Serbithang, for collaboration, and field assistance while collecting at the botanical garden. We thank the US Fulbright Program which is the flagship international educational exchange program sponsored by the U.S. government and is designed to build lasting connections between the people of the United States and the people of other countries. We are deeply thankful to the staff of the National Herbarium of Bhutan for their invaluable assistance with assisting in specimen curation. We also like to extend our gratitude to Dr. Kentaro Hosaka of National Museum of Nature and Science, Tsukuba, Japan for travelling all the way to Bhutan to collect the specimens and training the staff on the collection and curation of the fungi specimens and initially assisting on DNA analysis of the Fungarium specimens. Similar gratitude also goes to Dr. Henry Joseph Beker of Plantentuin Meise, Belgium and Dr. Ursula Eberhardt of Natural History Museum Stuttgart, Germany for helping us with the identification confirmation with DNA analysis. Finally, we recognize and appreciate the numerous associate collectors whose field efforts, observations, and dedication over many years made this dataset possible. Their collective contributions have significantly strengthened the documentation and understanding of Bhutan's macrofungal diversity.

## Author contributions

M.B. Thomas managed collection data, georeferencing, and preparation of the manuscript.

S. Pradhan managed field collecting, field photography, specimen preparation, identification of the specimens, data entry, and preparation of the manuscript.

## References

- Aptroot A, Feijen FJ (2002) Annotated checklist of the lichens and lichenicolous fungi of Bhutan. *Fungal Diversity* 11: 21-48. URL: [https://www.fungaldiversity.org/fdp/sfdp/FD\\_11\\_21-48.pdf](https://www.fungaldiversity.org/fdp/sfdp/FD_11_21-48.pdf)
- Atri NS, Sharma YP, Kumar S, Mridu (2019) Wild edible mushrooms of north west Himalaya: Their nutritional, nutraceutical, and sociobiological aspects. In: Satyanarayana T, Das SK, Johri BN (Eds) *Microbial diversity in ecosystem sustainability and biotechnological applications*. Vol. 2. Springer, Singapore, 620 pp. [https://doi.org/10.1007/978-981-13-8487-5\\_20](https://doi.org/10.1007/978-981-13-8487-5_20)

- Bhutan Broadcasting Service (2023) National Mushroom Centre identifies 50 poisonous mushrooms. <https://www.bbs.bt/187669/>. Accessed on: 2026-3-10.
- Brooks JS (2010) The Buddha mushroom: Conservation behavior and the development of institutions in Bhutan. *Ecological Economics* 69 (4): 779-795. <https://doi.org/10.1016/j.ecolecon.2008.01.022>
- Cannon PF, Hywel-Jones NL, Maczey N, Norbu L, Tshitila S, S. T, Lhendup P (2009) Steps towards sustainable harvest of *Ophiocordyceps sinensis* in Bhutan. *Biodiversity and Conservation* 18: 2263-2281. <https://doi.org/10.1007/s10531-009-9587-5>
- Choden K, Nitschke C, Stewart S, Keenan R (2021) The potential impacts of climate change on the distribution of tree species and *Ophiocordyceps sinensis* used for subsistence and cash income in the Bhutanese Himalayas. *Ecological Modelling* 455 (1). <https://doi.org/10.1016/j.ecolmodel.2021.109650>
- Grierson AJ, Long DG (1983) *Flora of Bhutan: Including a record of plants from Sikkim. Vol 1, Part 1.* Royal Botanic Garden
- Grierson AJ, Long DG (1991) *Flora of Bhutan. Vol. 2, Part 1.* Royal Botanic Garden
- Gyeltshen C, Prasad K (2022) Bhutan: Fungi species. Version 1.1. Checklist dataset. National Biodiversity Centre via GBIF.org. <https://doi.org/10.15468/x49n78>. Accessed on: 2026-3-10.
- Kashiwadani H (1988) *Ramalina hossei* Vain. (lichen) found in Bhutan and Formosa. *Bulletin of the National Science Museum, Series B (Botany)* 14: 129-133.
- Kumata A, Gurung R, Pradhan S, Thinley K, Dorji, Dukpa C, Kaneko S (2025) Comparison of physiological and cultivation characteristics of wild strains of Nameko (*Pholiota microspora*) from Bhutan and Japanese commercial spawn. *MycoAsia* <https://doi.org/10.59265/mycoasia.2025-04>
- Mata M, Penjor D, Pradhan S (2010) *Fungi of Bhutan.* National Mushroom Centre, Department of Agriculture, Ministry of Agriculture and Forests, Thimphu, 316 pp.
- Mata M, Penjor D, Pradhan S, Thomas M (2020) *Macrofungi of Bhutan.* <http://bhutanbiodiversity.net/checklists/checklist.php?cl=33&emode=0>. Accessed on: 2026-3-10.
- Myers N, Mittermeier R, Mittermeier C (2000) Biodiversity hotspots for conservation priorities. *Nature* 403: 853-858. <https://doi.org/10.1038/35002501>
- Nagasawa E, Penjor D, Pradhan S, Okuzawa Y (2021) *Poisonous mushrooms of Bhutan: A field guide.* National Mushroom Center, Department of Agriculture, Ministry of Agriculture, Thimphu, 133 pp.
- National Biodiversity Centre (Ed.) (2019) *Biodiversity Statistics of Bhutan 2017, a preliminary baseline.* <http://biodiversity.bt/biodiv/content/documents/document-0f89f358-790f-40a2-bbca-2da3ee6d8efd/630.pdf>. Accessed on: 2026-3-10.
- Noltie HJ (1994) *Flora of Bhutan: Including a record of plants from Sikkim and Darjeeling. Vol. 3, Part 1.* Royal Botanic Garden
- Prasher IB (1999a) *Himalayan fungi: A monograph detailing over 300 fungal species, focusing on systematic and ecological studies.* Bishen Singh Mahendra Pal Singh, Dehradun, 100 pp.
- Prasher IB (1999b) *Fungi of Bhutan: Myxomycota, Leotiales, Pezizales, Xylariales and Holobasidiomycetidae.* International Book Distributors, Dehradun, India.
- Prasher IB (2015) *Wood-rotting non-gilled Agaricomycetes of Himalayas.* Springer, Dordrecht, 653 pp. [ISBN 978-94-017-9856-3] <https://doi.org/10.1007/978-94-017-9858-7>

- Royal Government of Bhutan (2008) The Constitution of the Kingdom of Bhutan. Royal Government of Bhutan, Thimphu, Bhutan. URL: [https://www.constituteproject.org/constitution/Bhutan\\_2008](https://www.constituteproject.org/constitution/Bhutan_2008)
- Søchting U (1999) Lichens of Bhutan: Biodiversity and use. University of Copenhagen, Botanical Institute, Department of Mycology. URL: [https://www.fungaldiversity.org/fdp/sfdp/FD\\_11\\_21-48.pdf](https://www.fungaldiversity.org/fdp/sfdp/FD_11_21-48.pdf)
- Thiers B (2026) Index Herbariorum: A global directory of public herbaria and associated staff. New York Botanical Garden's Virtual Herbarium. <https://sweetgum.nybg.org/science/ih/herbarium-details/?irn=269164>. Accessed on: 2026-3-11.
- Tshering N, Verma PK (2024) Eco-habitat assessment of one of the most expensive edible mushrooms (*Tricholoma matsutake*) in Genekha, Thimphu, Bhutan. Asian Journal of Research in Agriculture and Forestry 10 (4): 291-310. <https://doi.org/10.9734/ajraf/2024/v10i4336>
- Upreti DK, Ranjan M (1988) A note on some macro lichens from Thimphu District, Bhutan. Journal of Recent Advances in Applied Sciences 3: 426-432.
- Winkler D (2009) Bhutan's Buddha mushroom. Bulletin of the Puget Sound Mycological Society. Number 455. URL: [https://www.raonline.ch/pages/bt/pdf/BT\\_YartsaGoenbubDW2009.pdf](https://www.raonline.ch/pages/bt/pdf/BT_YartsaGoenbubDW2009.pdf)
- Winkler D (2026) Mushroaming Bhutan - Mushrooms, mountains & monasteries. [https://mushroaming.com/Bhutan\\_Mushrooms](https://mushroaming.com/Bhutan_Mushrooms). Accessed on: 2026-3-10.
- Wu DT, Lv GP, Zheng J (2016) *Cordyceps* collected from Bhutan, an appropriate alternative of *Cordyceps sinensis*. Scientific Reports 6: 37668. <https://doi.org/10.1038/srep37668>
- Wu Q, Thiers BM, Pfister DH (2004) Preparation, preservation, and use of fungal specimens in herbaria. In: Mueller G, Foster M, Bills G (Eds) Biodiversity of fungi: Inventory and monitoring methods. Elsevier Academic Press, 777 pp. <https://doi.org/10.1016/B978-012509551-8/50005-2>
- Yangzom R, Long DG (Eds) (2015) Plants endemic to Bhutan Himalaya. National Biodiversity Centre, Ministry of Agriculture and Forests, Royal Government of Bhutan, Thimphu, 160 pp. [ISBN 9789993676355]

Table 1.

Top families accessioned in the National Fungarium.

Rank	Family	Number of Specimens (% total)
1	Russulaceae	266 (10.6%)
2	Boletaceae	165 (6.6%)
3	Agaricaceae	162 (6.4%)
4	Tricholomataceae	160 (6.4%)
5	Amanitaceae	112 (4.4%)
6	Polyporaceae	104 (4.1%)
7	Cortinariaceae	98 (3.9%)
8	Strophariaceae	96 (3.8%)
9	Suillaceae	94 (3.7%)
10	Marasmiaceae	69 (2.7%)
11	Gomphaceae	67 (2.6%)
12	Omphalotaceae	67 (2.6%)
13	Physalacriaceae	65 (2.6%)
14	Mycenaceae	57 (2.2%)
15	Inocybaceae	53 (2.1%)

Table 2.  
Specimen Distribution by District (Dzongkhag).

District	Specimen #
Thimphu	1454 (58%)
Tsirang	273 (11%)
Punakha	225 (9%)
Bumthang	149 (6%)
Sarpang	116 (4%)
Paro	105 (4%)
Chukha	83 (3%)
Haa	81 (3%)
Trashiyangtse	7 (<1%)
Trongsa	3 (<1%)
Gasa	2 (<1%)
Samtse	2 (<1%)

Table 3.  
Top 10 Collectors.

Rank	Collector	Ocurrences	% of Total Records
1	Sabitra Pradhan	2153	40.2%
2	Dawa Penjor	311	5.8%
3	Tshering Wangmo	296	5.5%
4	NMC Team	270	5%
5	Dorji	253	4.7%
6	Takashi Nakayama	229	4.2%
7	Kentaro Hosaka	181	3.3%
8	Hem Kumar Newar	166	3.1%
9	Kazuo Watanabe	154	2.8%
10	Rinzin Wangmo	149	2.7%