



***Ganoderma* in Central Asia: a provenance-based review of ethnomycological evidence, medicinal relevance, and occurrence records**

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Review

Abstract

Background: Knowledge of *Ganoderma* in Central Asia is dispersed among regional literature, herbarium and voucher records, sequence repositories, biodiversity databases, and secondary accounts of vernacular terminology and medicinal relevance. These sources document different phenomena and cannot be combined uncritically as equivalent evidence of distribution, species identity, or cultural practice.

Methods: A provenance-based critical review was conducted for Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan. Comparable searches were undertaken in Uzbek, Kazakh, Kyrgyz, Tajik, Turkmen, and Russian. Vernacular terms and use-related statements were classified by source geography and participant provenance; occurrence representations were linked to independent evidence units and assessed with literature, herbarium, voucher, and sequence data. Only source-supplied specimen, observation, or sampling-event coordinates were used; unresolved sampling context was displayed separately from species-occurrence evidence.

Results: No participant-based ethnobiological study of *Ganoderma* was identified. Uzbekistan-focused sources provided secondary Uzbek names and labelled *G. adspersum* and *G. applanatum* as medicinal, but their detailed indications and preparation statements were drawn mainly from non-Central Asian comparative literature or web sources rather than documented Uzbek practice. A Kazakhstan cadaster classified *G. applanatum* as medicinal without recording an indication or preparation; Kyrgyz, Tajik, and Turkmen searches mainly recovered scientific or modern commercial reishi terminology. The occurrence audit retained 62 independent evidence units from 73 raw GBIF representations plus non-GBIF sources. Seventeen independent units had source-supplied coordinates suitable for mapping. Taxonomic support was strongest for *G. applanatum* and for sequence-linked Uzbek *G. adspersum* and *G. resinaceum*; wild Central Asian records under *G. lucidum* remained unresolved without voucher-linked molecular evidence.

Conclusions: Central Asian *Ganoderma* knowledge is best understood as a layered and provenance-dependent evidence base rather than as a uniform regional tradition or distribution dataset. The review distinguishes regionally supported ethnomycological evidence from non-regional medicinal comparisons and commercial terminology, and separates database representations from independent, taxonomically evaluated units. The five-country scope is retained to compare documentation systems and verification needs, not to rank countries by fungal richness, abundance, or prevalence of use.

Keywords: *Ganoderma*; Central Asia; ethnomycology; medicinal relevance; provenance; vernacular terminology; occurrence records; voucher specimens; DNA barcoding; GBIF; reishi terminology.

Background

Wood-inhabiting macrofungi connect fungal biodiversity with tree health, woody-substrate use, medicinal narratives, and cultural interpretations of forest and managed landscapes. Persistent bracket fungi are conspicuous on living trees, exposed roots, dead trunks, stumps, and fallen wood, but ecological visibility alone does not demonstrate that a fungus is locally named, collected, or used. Such relationships require independently documented ethnobiological evidence (Dai *et al.* 2009; Gafforov 2014; Baby *et al.* 2015; Bishop *et al.* 2015; Tayjanov *et al.* 2021; Li *et al.* 2023; Gafforov *et al.* 2023b).

Within this group, *Ganoderma* P. Karst. is one of the most conspicuous and culturally prominent genera of lignicolous basidiomycetes. Its laccate and non-laccate species colonise living trees, roots, trunks, stumps, fallen logs, and buried woody substrates, where they cause white rot and contribute to tree-decay processes. Their persistent bracket-like basidiomata, frequent association with mature broadleaved trees, and long-standing representation in medicinal-mushroom traditions have also made them central to reishi- and lingzhi-related scientific and commercial discourse (Ryvarden & Gilbertson 1993; Ryvarden 2004; Paterson 2006; Gafforov 2014; Baby *et al.* 2015; Bishop *et al.* 2015; Hapuarachchi *et al.* 2018; Cör *et al.* 2018; Bernicchia & Gorjón 2020; Lin 2019; Wang *et al.* 2020; Gafforov *et al.* 2023b; Karunarathna *et al.* 2025a; Plosca *et al.* 2025).

In this review, “medicinal relevance” is an analytical label used when a source associates a *Ganoderma* taxon or name with a medicinal classification, ethnomedicinal narrative, pharmacological discourse, or reishi/lingzhi commerce. It does not mean that a use occurred in Central Asia. A statement is treated as regional medicinal-use evidence only when its source identifies the Central Asian country or locality and the provenance of the practice. The label does not imply therapeutic efficacy, safety, or confirmed taxonomic identity of historical, local, or commercial material (Cao *et al.* 2012; Zhou *et al.* 2015; Hennicke *et al.* 2016; Loyd *et al.* 2018; Wang *et al.* 2020; Gafforov *et al.* 2023a, 2023b; Harnpicharnchai *et al.* 2023).

Taxonomic reliability is therefore fundamental to ethnobiological interpretation. Historical publications, herbarium labels, regional checklists, and commercial sources have used names such as *Fomes applanatus*, *Polyporus applanatus*, *Elfvigia applanata*, *Ganoderma lipsiense*, *G. australe* sensu auct., and broadly applied *G. lucidum*. Although these names remain useful for tracing older records and source traditions, they cannot automatically be accepted as currently valid species identifications. Molecular studies have demonstrated that several geographically and phylogenetically distinct laccate taxa were historically grouped under *G. lucidum*, making voucher-linked morphological and molecular evidence necessary for reliable species-level interpretation (Donk 1969; Ryvarden & Gilbertson 1993; Cao *et al.* 2012; Zhou *et al.* 2015; Hennicke *et al.* 2016; Loyd *et al.* 2018; Bernicchia & Gorjón 2020; Pecoraro *et al.* 2020; Luangharn *et al.* 2021).

Acceptance of a historical, commercial, or locally reported name without adequate supporting evidence may associate medicinal narratives with the wrong taxon, distort host relationships, or exaggerate regional distributions. Reliable interpretation therefore requires consideration of locality, host or substrate, ecological context, voucher or herbarium material, photographs, sequence data, and the distinction among wild, cultivated, imported, and commercially processed material (Cao *et al.* 2012; Zhou *et al.* 2015; Hennenke *et al.* 2016; Loyd *et al.* 2018; Gafforov *et al.* 2020, 2023a, 2023b; Shakarbaev *et al.* 2025; Turemuratova *et al.* 2025).

This distinction is especially important in Central Asia, defined here as Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan. The region encompasses deserts, riparian forests, foothills, and the Western Tien Shan and Pamir-Alay Mountain systems, yet fungal documentation remains uneven among countries, repositories, languages, and periods of collection. Regional differences in available records therefore reflect research and documentation histories as well as biological occurrence (Khassanov 2015; Gafforov 2017; Gafforov *et al.* 2017, 2020, 2025a, 2025b, 2025c; Lestari *et al.* 2021; Cazabonne *et al.* 2022; Khojimatov *et al.* 2023; Kulymbet *et al.* 2023; Gafforov *et al.* 2024, 2026a, 2026b; Gafforov 2026; Khusanov *et al.* 2026).

Regional fungal identification has frequently relied on names transferred from better-studied regions or inherited from older floristic traditions. Subsequent morphological and molecular investigations across different fungal groups have shown that Central Asian collections may represent distinct lineages, overlooked taxa, or previously unrecognised species. Wood-inhabiting basidiomycetes remain less systematically investigated than vascular plants and many plant-associated microfungi, increasing the likelihood of both underreporting and misapplied names (Varma 1995; Stutz *et al.* 2000; Gafforov *et al.* 2014, 2017, 2019; Gafforov & Hoshino 2015; Gafforov & Rakhimov 2017; Yatsiuk *et al.* 2016; Antonin *et al.* 2017; Kan *et al.* 2017; Yuan *et al.* 2017; Samarakoon *et al.* 2018; Pem *et al.* 2018, 2019a, 2019b, 2025; Liu *et al.* 2019; Abdurazakov *et al.* 2021; Appadoo *et al.* 2021; Htet *et al.* 2021; Aluthmuhandiram *et al.* 2022; Wang *et al.* 2022; Bradshaw *et al.* 2023; Senwana *et al.* 2024; Cao *et al.* 2025; Peng *et al.* 2025a, 2025b; Urinboev *et al.* 2026).

Evidence concerning Central Asian *Ganoderma* is distributed across Soviet-era and post-Soviet taxonomic literature, regional floras and cadastres, herbarium catalogues, GBIF occurrences, GenBank- and ENA-linked sequences, and secondary accounts of terminology and medicinal relevance. Some screened regional sources provide contextual mycological history but no verifiable *Ganoderma* record. A defensible synthesis must therefore identify the precise role, source geography, and limitations of every source (Shvartsman 1964; Elchibaev 1968, 1969; Gafforov 2014; Cho *et al.* 2019; Gafforov *et al.* 2020, 2023a, 2023b, 2026a, 2026b; Mosolova *et al.* 2021, 2023; Rakhimova *et al.* 2023; GBIF.org 2026).

The assessed sources associate *Ganoderma* with medicinal narratives, teas, water extracts, tinctures, powders, commercial products, and material or artistic applications. Provenance screening showed, however, that most specific therapeutic indications and preparation descriptions were drawn from non-Central Asian comparative literature or web sources. They are therefore evidence of broader medicinal relevance, not of Central Asian ethnomedicinal practice. Because *Ganoderma* basidiomata are generally woody, corky, and bitter, food-related statements are treated as processed, flavouring, beverage, or product contexts rather than ordinary edibility (Dai *et al.* 2009; Baby *et al.* 2015; Bishop *et al.* 2015; Yalcin *et al.* 2020; Wang *et al.* 2020; Gafforov *et al.* 2023a, 2023b; Dong *et al.* 2023, 2025).

Chemical and biological studies provide comparative context for medicinal narratives but cannot substitute for regional taxonomic verification. Research on *Ganoderma* has reported polysaccharides, β -glucans, triterpenoids, ganoderic acids, phenolics, sterols, fatty acids, proteins, nucleosides, and a wide range of experimental bioactivities. Most of this evidence, however, derives from non-Central Asian material, cultivated strains, or commercial products. Its relevance to wild regional collections can be assessed only when the studied material is supported by reliable vouchers, confirmed taxonomic identification, and preferably molecular evidence (Paterson 2006; Boh *et al.* 2007; Kozarski *et al.* 2012; Baby *et al.* 2015; Bishop *et al.* 2015; Zengin *et al.* 2015; Rašeta 2016; Rašeta *et al.* 2016, 2020, 2021, 2023, 2026; Taofiq *et al.* 2017; Cör *et al.* 2018; Bulam *et al.* 2019; Wang *et al.* 2020; Biswal *et al.* 2022; Lin *et al.* 2022; Karaman *et al.* 2022; Sułkowska-Ziaja *et al.* 2023; Plosca *et al.* 2025; Karunarathna *et al.* 2025b, 2025c; Gafforov *et al.* 2023b, 2026a; Krupodorova *et al.* 2025).

The central analytical problem is that four distinct questions are often conflated: whether a database entry represents an independent specimen or event; whether the taxon name is supported by a voucher or sequence; whether a coordinate belongs to the underlying record; and whether a name or use statement derives from participants, secondary literature, or commercial discourse. Conflating these layers can inflate both distributional and cultural conclusions (Gafforov *et al.* 2020, 2023a, 2023b; Haelewaters *et al.* 2022; Rakhimova *et al.* 2023; Hongsanan *et al.* 2025; GBIF.org 2026).

This review therefore examines *Ganoderma* across the five Central Asian countries as a provenance-based synthesis. Its objectives are to: (1) identify vernacular terminology and use-related statements and classify them by source geography and participant provenance; (2) distinguish regionally supported ethnomycological evidence from non-regional medicinal comparisons and modern commercial reishi terminology; (3) link repeated occurrence representations to independent evidence units; (4) evaluate taxonomic and spatial reliability using explicit voucher, sequence, locality, and coordinate criteria; and (5) determine how these limitations affect ethnobiological interpretation. Host, habitat, and chemical information are retained only as supporting context.

Materials and Methods

Review design, scope, and terminology

This study was designed as a critical review and evidence audit rather than a formal systematic review, field ethnography, or taxonomic revision. The geographical scope comprised Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan. No interviews, participant observation, questionnaires, or other primary data collection with human participants were conducted. For methodological comparison, participant-based ethnobiological research obtains primary use reports through documented approaches such as group conversations, semi-structured interviews, and on-site observation (Amin *et al.* 2024).

Evidence was separated into four provenance layers: (1) occurrence and taxonomic evidence from specimens, vouchers, observations, and sequences; (2) historical regional literature and cadastres; (3) secondary literature records of vernacular terminology or use-related statements; and (4) modern commercial or non-regional comparative information. The expression ethnobiological evidence therefore refers to the provenance and interpretation of source records, not to newly collected participant-based evidence.

Literature and source identification

Electronic literature and metadata were identified or verified through Google Scholar, Crossref, PubMed, journal and publisher websites, GBIF, NCBI GenBank, ENA, Index Fungorum, and MycoBank. Reference lists were screened backward for Soviet-era floras, monographs, cadastres, and locally distributed sources. Searches were updated on 22 August 2026.

A comparable multilingual protocol was applied across Uzbek, Kazakh, Kyrgyz, Tajik, Turkmen, and Russian. Each national-language search combined *Ganoderma* or a focal species name with local terms for mushroom or fungus, bracket or polypore, reishi or lingzhi, folk name, medicine, use, tea, extract, and the relevant country or locality. Original scripts, Latin/Cyrillic variants, spelling variants, and Russian historical taxonomic terms were screened. Search strings, URLs, source type, language, and inclusion outcome were logged in Table S4.

Representative terms included Uzbek *ganoderma*, po'kak/pukak, ayiq noni, and reyshi qo'ziqorini; Kazakh *ганодерма*, рейши саңырауқұлағы, ағаш саңырауқұлағы, and трутовик; Kyrgyz *ганодерма*, рейши козу карыны, жыгач козу карыны, and трутовик; Tajik *ганодерма*, занбӯруғи рейши, занбӯруғи дарахт, and трутовик; Turkmen *ganoderma*, Reishi kömelegi, ağaç kömelegi, and Russian-language трутовик; and Russian трутовик плоский, трутовик лакированный, and трутовые грибы. Commercial and machine-translated pages were logged as contemporary terminology but were not accepted as traditional vernacular or local-use evidence. (Donk 1969; Ryvarden & Gilbertson 1993; Bernicchia & Gorjón 2020; Table S4)

Historical evidence was verified against accessible source text whenever possible. Kazakhstan records were traced to Shvartsman (1964), Kalymbetov (1969), and Rakhimova *et al.* (2023); the latter was also screened for explicit use descriptors. Kyrgyzstan occurrence support was retained from voucher- and ITS-linked material in Cho *et al.* (2019) and catalogued H records; assessed historical and recent checklists that did not contain a verifiable *Ganoderma* record were not used as occurrence sources. Uzbekistan evidence came from published studies, TASM-linked material, and the GBIF-published aphyllorphoroid dataset. Tajikistan evidence included TAAM records. No verified *Ganoderma* record from Turkmenistan was recovered. (Shvartsman 1964; Kalymbetov 1969; Elchibaev 1968, 1969; Cho *et al.* 2019; Gafforov 2014; Gafforov *et al.* 2020, 2023a, 2023b; Mosolova *et al.* 2021, 2023; Rakhimova *et al.* 2023)

GBIF, herbarium, and sequence-linked evidence

GBIF was used as an aggregator of representations, not as the main or final authority for regional distribution. The five-country download was audited together with literature, herbarium, voucher, and sequence evidence. Each GBIF row was retained in Table S1, while analytical counts and Figure 2 used independent evidence units after duplicate resolution (Gafforov & Ordynets 2022; GBIF.org 2026).

Potential duplicates were evaluated using occurrenceID, institution and catalog number, voucher or sample code, sequence accession, event date, coordinates, locality, source dataset, and taxon name. Repeated GBIF, GenBank, ENA, UNITE, and publisher representations of the same specimen or sampling event were linked to one evidence unit. A representation count was never treated as a specimen count; cross-repository links and deduplication decisions are provided in Table S8.

Technical identifiers, unranked sequence labels, genus-level identifications, and taxonomically sensitive names were retained but not interpreted as accepted species. In particular, 22 rows labelled SH1217207.09FU represented two coordinate pairs and were collapsed to two unresolved units. Records labelled *G. lucidum* were treated as *G. lucidum* s.l. or unresolved laccate *Ganoderma* unless supported by voucher-linked molecular evidence. This conservative treatment is further justified by evidence that public fungal sequences may remain misidentified or retain outdated synonymous labels, emphasising the need for sequence verification against voucher-supported taxonomic concepts (Cho *et al.* 2021).

Sequence-linked evidence required an explicit connection among taxon name, voucher or specimen code, sequence marker, and country or locality. A sequence with incomplete locality or voucher linkage was retained as molecular support but not as a confirmed georeferenced occurrence. Kyrgyzstan KA vouchers from Cho *et al.* (2019) were accepted as strong taxonomic evidence, but they were not plotted because voucher-specific coordinates were not provided.

Publicly accessible herbarium information was searched for TAAM, TASM-linked records, H, and KNA/KA material. The available public AA and FRU resources did not expose comprehensive searchable fungal specimen catalogues. Failure to retrieve a record online was therefore treated as a catalogue-access limitation, not evidence that the physical collections lack *Ganoderma*. Historical AA/FRU-related statements remained literature-supported and voucher-unverified unless a catalogue number and specimen metadata were independently accessible.

Record linkage, georeferencing, and data extraction

For each representation, available data were extracted for taxon and original name, country, locality, supplied coordinates and uncertainty, host or substrate, event date, institution and catalogue number, voucher or sample code, sequence marker and accession, source type, vernacular terminology, use-related statement, source geography, and participant provenance. The master evidence register (Table S6) preserves raw representations, independent evidence units, duplicate links, exclusions, and map status.

Coordinates were accepted only when explicitly supplied for the underlying specimen, observation, or sampling event. No coordinates were assigned from country centroids, institution locations, regional centroids, or unverified locality interpretations. Literature and voucher records lacking exact coordinates were retained as country- or locality-level evidence but were not plotted.

Names and use-related statements were classified by provenance as participant-based primary records, secondary literature records, non-regional comparative information, historical scientific terminology, or modern commercial terminology. No participant-based primary record was identified in the assessed sources. Host and habitat statements were analysed as ecological evidence only and were not used to infer those fungi were observed, named, collected, or used by people.

Evidence classification and synthesis

Evidence classes were applied at the independent-unit level: C1, sequence-linked voucher with usable locality; C2, catalogued voucher with usable locality; C3, published historical or literature record with locality but without an accessible verified voucher; C4, observation-only record; M1, molecular evidence with incomplete locality or voucher linkage; U1, genus-level or species-complex record; U2, environmental, unranked, or technical identifier; and X, duplicate representation, non-target taxon, or unsupported record. Only C1 and C2 were described as voucher-confirmed occurrences.

Historical names and synonyms were search pathways rather than separate taxa. Commercial reishi/lingzhi terminology was culturally relevant but taxonomically insufficient. Product pages, imported goods, and machine-translated commercial text were not accepted as evidence of a traditional local name, wild occurrence, local harvesting, or therapeutic efficacy.

The audit produced five linked outputs: raw source tables (Tables S1-S5), independent evidence registers (Table S6), the exact Figure 2 point dataset (Table S7), representation links (Table S8), and a country-level evidence-gap audit (Table S9). Figure 2 separates 17 core occurrence units from three coordinate-bearing context units and pairs the map with evidence-class profiles for all 62 independent units. C3, M1, and coordinate-poor C2 records remain in the register and country profiles but are not assigned inferred map points.

The analytical contribution of the review is the explicit separation of representation, independence, taxonomic support, spatial precision, and ethnobiological provenance. This framework permits a regional synthesis without treating uneven database coverage as biological distribution or secondary terminology as primary ethnographic evidence.

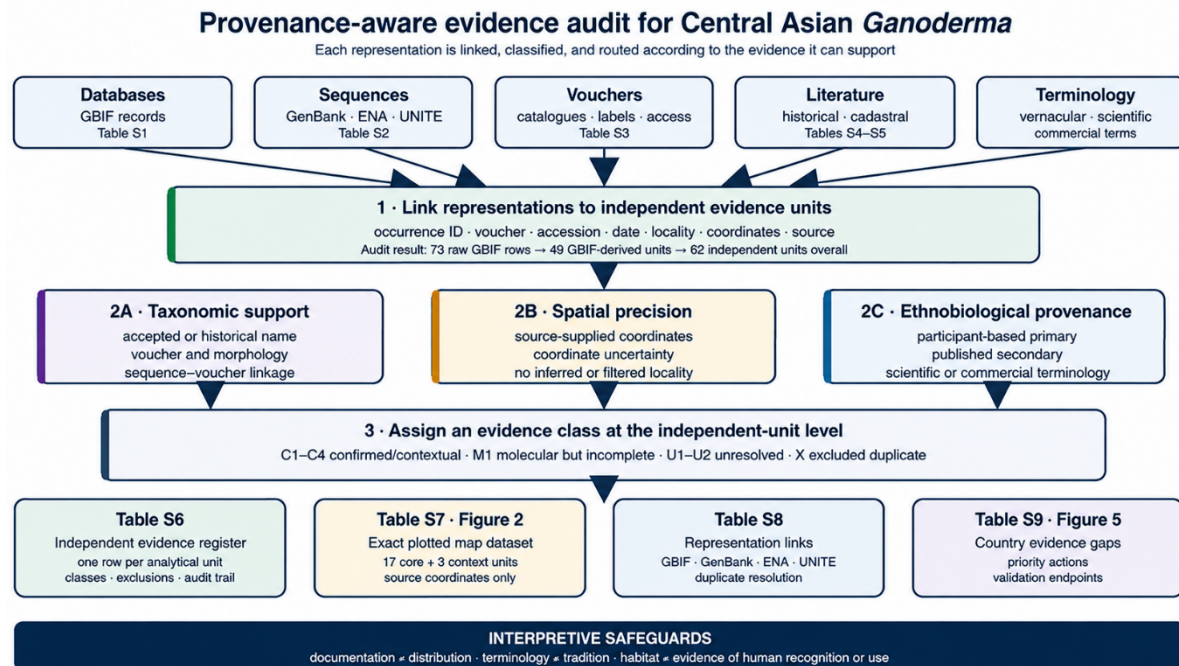


Figure 1. Provenance-aware workflow for Central Asian *Ganoderma* evidence. Source representations are linked to independent evidence units, assessed for taxonomic support, spatial precision, and ethnobiological provenance, and assigned evidence classes before entering Tables S1–S9 or Figure 2. Counts refer to this revision: 73 raw GBIF representations, 49 GBIF-derived independent units, 62 total independent units after addition of 13 non-GBIF units, 17 core mapped occurrence units, and three coordinate-bearing context units.

Limitations

The evidence base remains uneven. Historical literature may refer to inaccessible vouchers; AA and FRU lack comprehensive public fungal catalogues; several sequence vouchers lack specimen-level coordinates; and secondary terminology or use-related statements rarely document their original participant provenance. Absence from a public portal or national GBIF subset was not interpreted as biological absence.

The review does not estimate abundance, ecological frequency, complete species richness, prevalence of use, or cultural importance. Map points represent documented evidence units, and multilingual web hits represent source availability and contemporary terminology, not the frequency of local knowledge.

Results and Discussion

Evidence base and focal taxonomic units

Four focal taxonomic units were retained: *G. applanatum*, *G. adspersum*, *G. resinaceum*, and *G. lucidum* s.l. Their status differs. The first three have varying combinations of voucher, sequence, historical, and host evidence; *G. lucidum* s.l. remains a deliberately unresolved medicinal-mushroom label unless linked to diagnostic vouchers and sequences. (Gafforov 2014; Gafforov *et al.* 2020, 2023a, 2023b; GBIF.org 2026)

Ganoderma applanatum had the broadest regional support. Uzbekistan included published and voucher-linked records; Kazakhstan had detailed historical locality and host reports; Kyrgyzstan had five ITS-linked KNA/KA vouchers and catalogued H material; and Tajikistan had TAAM and GBIF-linked evidence. Historical synonyms were used only to trace records. (Shvartsman 1964; Kalymbetov 1969; Cho *et al.* 2019; Gafforov *et al.* 2020, 2023a, 2023b; Rakhimova *et al.* 2023; TAAM herbarium data; GBIF.org 2026)

Ganoderma adspersum was supported in Uzbekistan by morphology, host information, and ITS/LSU-linked material. Older names related to *G. australe* sensu auct. or *G. europaeum* were not automatically reassigned and remain dependent on

voucher reassessment. (Gafforov *et al.* 2020, 2023a, 2023b) (Donk 1969; Ryvarden & Gilbertson 1993; Bernicchia & Gorjón 2020)

Ganoderma resinaceum was represented by sequence-linked Uzbek material and historical Kazakhstan records, including reports on *Quercus robur*. These records support regional investigation of a resinous/laccate unit but do not justify assigning additional laccate observations without voucher-based morphology and molecular verification. (Shvartsman 1964; Gafforov *et al.* 2020, 2023b)

Ganoderma lucidum s.l. was retained because the label is prominent in reishi/lingzhi and commercial discourse but has been applied to multiple laccate lineages. Central Asian records bearing this name were not accepted as wild *G. lucidum* s. str. without voucher-linked molecular evidence. (Cao *et al.* 2012; Zhou *et al.* 2015; Hennicke *et al.* 2016; Loyd *et al.* 2018) Genus-level vouchers, technical identifiers, historical combinations, and incompletely linked molecular records were retained as traceable evidence but did not increase species-level diversity. Table 1 summarises the working units and their evidential limits.

Vernacular terminology and source provenance

No participant-based ethnomycological study of *Ganoderma* was identified. The Uzbek terms in the evaluated literature are therefore classified as secondary literature records unless supported by an identifiable primary participant source. The Kazakhstan cadastre provides a separate secondary medicinal classification for *G. applanatum*, but no verifiable participant-based local-use dataset was identified in any of the five countries (Gafforov *et al.* 2023b; Rakhimova *et al.* 2023).

For *G. adspersum*, the reported Uzbek terms Pogʻanasimon ganoderma and xilma-xil poʻkak have the literal glosses ‘step-like/tiered *Ganoderma*’ and ‘variegated/diverse cork [bracket] fungus’. These glosses are linguistically informative, but the terms remain secondary literature records and cannot alone verify species identity or cultural prevalence.

For *G. applanatum*, Tugʻri pukak is glossed literally as “straight/true cork [bracket] fungus,” and ayiq noni as “bear bread.” The latter is culturally distinctive, but the reviewed source does not document original participants, interview context, frequency, or geographical distribution. (Gafforov *et al.* 2023b)

The comparable Kyrgyz search retrieved the modern commercial expression рейши козу карыны (‘reishi mushroom’). Elchibaev (1968, 1969) and Mosolova *et al.* (2021, 2023) were screened as regional sources but did not provide a verifiable *Ganoderma* name or use record; Russian трутовик плоский (‘flat polypore’) was therefore retained only as scientific/common search terminology. (Elchibaev 1968, 1969; Mosolova *et al.* 2021, 2023; Table S4)

For unresolved laccate *Ganoderma*, Reshi ganoderma is a reishi loan expression and laklangan pukak is glossed “lacquered cork [bracket] fungus.” These terms may refer to scientific descriptions, cultivated strains, imported products, or processed material; they do not confirm wild *G. lucidum* s. str. (Cao *et al.* 2012; Zhou *et al.* 2015; Hennicke *et al.* 2016; Loyd *et al.* 2018; Wang *et al.* 2020; Gafforov *et al.* 2023b)

For *G. resinaceum*, Qatronsimon ganoderma is glossed “tar-like/resin-like *Ganoderma*.” Its descriptive fit with a resinous basidiome does not replace voucher-linked identification or establish participant-based use. (Gafforov *et al.* 2020, 2023b)

Kazakh рейши саңырауқұлағы, Tajik занбӯруғи рейши, and Turkmen Reishi kömelegi all literally mean “reishi mushroom” in the retrieved modern web context. They were logged as contemporary commercial terminology, not as traditional names, primary ethnobiological evidence, or proof of local wild occurrence.

The multilingual result therefore strengthens, rather than removes, the geographical limitation: Uzbekistan has secondary local terminology in an Uzbekistan-focused source, Kazakhstan has a secondary medicinal classification, and the Kyrgyz, Tajik, and Turkmen searches primarily recovered scientific or commercial vocabulary. Absence of primary documentation is treated as a research gap, not absence of knowledge (Gafforov *et al.* 2026b).

Table 2 provides each term's reported form, literal English gloss, provenance, and evidential limit. Complete search strings and screened sources are provided in Table S4.

Table 1. *Ganoderma* taxa and working units used for evidence assessment in Central Asia

Taxon/working unit	Main countries with evidence	Main evidence basis	Interpretation in this review	Taxonomic treatment	Key references
<i>Ganoderma applanatum</i> (Pers.) Pat.	Uzbekistan, Kazakhstan, Kyrgyzstan, Tajikistan	Voucher/sequence evidence, historical locality-host literature, TAAM/H records, and georeferenced observations	Broadest regional support, but individual units retain separate evidence classes and map status	Older records under <i>Fomes applanatus</i> , <i>Polyporus applanatus</i> , <i>Elfvingia applanata</i> , <i>Phaeoporus applanatus</i> , and <i>Ganoderma lipsiense</i> were treated as historical pathways rather than separate accepted taxa	Shvartsman 1964; Kalymbetov 1969; Cho <i>et al.</i> 2019; Gafforov <i>et al.</i> 2020, 2023a, 2023b; Rakhimova <i>et al.</i> 2023; GBIF.org 2026
<i>Ganoderma adspersum</i> (Schulzer) Donk	Uzbekistan	Uzbek voucher, morphology, host, ITS, and LSU evidence	Supported in Uzbekistan; older <i>G. australe</i> /adspersum-complex names remain revision-dependent	Records under <i>G. australe</i> sensu auct., <i>G. europaeum</i> , or related names require reassessment using morphology, host, voucher, and molecular data	Donk 1969; Ryvarden & Gilbertson 1993; Gafforov 2014; Bernicchia & Gorjón 2020; Gafforov <i>et al.</i> 2020; Gafforov <i>et al.</i> 2023a, 2023b; GBIF.org 2026
<i>Ganoderma resinaceum</i> Boud.	Uzbekistan, Kazakhstan	Uzbek sequence-linked material and historical Kazakhstan host-locality reports	Supported working unit; additional laccate records require voucher and molecular verification	Regional records require host, voucher, and sequence verification because related laccate taxa may be confused under broad historical names	Shvartsman 1964; Ryvarden & Gilbertson 1993; Torres-Torres & Guzmán-Dávalos 2012; Cabarroi-Hernández <i>et al.</i> 2019; Gafforov <i>et al.</i> 2020; Luangharn <i>et al.</i> 2021; Gafforov <i>et al.</i> 2023b
<i>Ganoderma lucidum</i> (Curtis) P. Karst. s.l. / unresolved laccate <i>Ganoderma</i>	Uzbekistan, Kazakhstan, commercial or unresolved regional records	Historical, commercial, and incompletely linked laccate records	Unresolved medicinal-mushroom label, not a confirmed wild regional species	Not accepted as wild <i>G. lucidum</i> s. str. without voucher-linked molecular evidence; commercial reishi/lingzhi terminology was not treated as wild occurrence evidence	Shvartsman 1964; Ryvarden & Gilbertson 1993; Cao <i>et al.</i> 2012; Zhou <i>et al.</i> 2015; Hennicke <i>et al.</i> 2016; Loyd <i>et al.</i> 2018; Gafforov <i>et al.</i> 2020; Gafforov <i>et al.</i> 2023b
Historical <i>G. applanatum</i> f. <i>australe</i>, broadly applied <i>G. australe</i>, and related non-laccate records	Kazakhstan, Kyrgyzstan, unresolved regional records	Historical literature, GBIF entries, and records under broad or inconsistent names	Historical name retained as a search and revision pathway; not counted as an additional species	Requires voucher reassessment and, where possible, DNA barcoding before species-level interpretation	Shvartsman 1964; Bernicchia & Gorjón 2020; GBIF.org 2026

<i>Ganoderma</i> sp., technical identifiers, and unresolved molecular/material-sample records	Kyrgyzstan, Tajikistan, and other under-documented areas	Genus-level records, herbarium entries, GBIF material samples, observation-based records, and technical identifiers such as SH1217207.09FU	Traceable sampling evidence only; no species-level interpretation without voucher, sequence, and locality linkage	Not raised to species level without supporting voucher, morphology, sequence metadata, or phylogenetic placement	Cho <i>et al.</i> 2019; TAAM herbarium data; GBIF.org 2026; Table S3
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Note: Historical names and synonyms were used as search pathways for older literature, herbarium labels, GBIF records, and regional checklists (Table S4). They were not treated as separate accepted taxa unless supported by modern taxonomic evidence

Table 2. Local-language and commercial terminology associated with *Ganoderma* in Central Asia, classified by provenance. None of the entries represents newly collected participant-based evidence.

Taxon/working unit	Country/region	Reported name or terminology	Provenance type	Literal English gloss and evidential limit	Key references
<i>Ganoderma adspersum</i>	Uzbekistan	Pogʻanasimon ganoderma; xilma-xil poʻkak	Secondary literature record (Uzbek terminology)	Pogʻanasimon ganoderma = ‘step-like/tiered <i>Ganoderma</i> ’; xilma-xil poʻkak = ‘variegated/diverse cork [bracket] fungus.’ No original participant provenance demonstrated.	Gafforov <i>et al.</i> 2023b
<i>Ganoderma applanatum</i>	Uzbekistan	Tugʻri pukak; ayiq noni	Secondary literature record (Uzbek terminology)	Tugʻri pukak = ‘straight/true cork [bracket] fungus’; ayiq noni = ‘bear bread.’ Descriptive/cultural glosses do not establish species identity or prevalence.	Gafforov <i>et al.</i> 2023b
<i>Ganoderma lucidum</i> s.l. / commercial reishi	Kyrgyzstan online context	рейши козу карыны	Modern Kyrgyz commercial terminology	‘Reishi mushroom.’ Imported commercial wording; not traditional or participant-based evidence.	Multilingual search audit for the present review (Tables S4 and S8; updated 22 August 2026).
<i>Ganoderma lucidum</i> s.l. / unresolved laccate <i>Ganoderma</i>	Uzbekistan and regional commercial contexts	Reshi ganoderma; laklangan pukak; reishi; lingzhi	Secondary literature terminology plus reishi loanword	Reshi ganoderma = ‘Reishi <i>Ganoderma</i> ’; laklangan pukak = ‘lacquered cork [bracket] fungus.’ Does not confirm wild <i>G. lucidum</i> s. str.	Cao <i>et al.</i> 2012; Zhou <i>et al.</i> 2015; Hennicke <i>et al.</i> 2016; Loyd <i>et al.</i> 2018; Wang <i>et al.</i> 2020; Gafforov <i>et al.</i> 2023b
<i>Ganoderma resinaceum</i>	Uzbekistan	Qatronsimon ganoderma	Secondary literature record (Uzbek terminology)	Qatronsimon ganoderma = ‘tar-like/resin-like <i>Ganoderma</i> .’ Descriptive gloss; no participant provenance demonstrated.	Gafforov <i>et al.</i> 2023b
<i>Ganoderma lucidum</i> s.l. / commercial reishi	Kazakhstan online/academic context	рейши саңырауқұлағы	Modern Kazakh scientific/commercial terminology	‘Reishi mushroom.’ Logged as contemporary terminology, not a traditional name, local wild occurrence, or participant-based use record.	Multilingual search audit for the present review (Tables S4 and S8; updated 22 August 2026).
<i>Ganoderma lucidum</i> s.l. / commercial reishi	Tajikistan online context	занбӯруғи рейши	Modern Tajik commercial or machine-translated terminology	‘Reishi mushroom.’ Logged as contemporary terminology, not a traditional name, local wild occurrence, or participant-based use record.	Multilingual search audit for the present review (Tables S4 and S8; updated 22 August 2026).
<i>Ganoderma lucidum</i> s.l. / commercial reishi	Turkmenistan online context	Reishi kömelegi	Modern Turkmen commercial terminology	‘Reishi mushroom.’ Logged as contemporary terminology, not a traditional name, local wild occurrence, or participant-based use record.	Multilingual search audit for the present review (Tables S4 and S8; updated 22 August 2026).

Note: Literal glosses describe words, not verified folk classifications or species identities. Commercial reishi terminology is separated from secondary Uzbek terminology and from Russian scientific/common terminology.

Medicinal relevance: regional evidence and comparative context

No participant-based primary medicinal-use record was identified. The Uzbekistan-focused sources label *G. adspersum* and *G. applanatum* as medicinal, but their detailed indications and preparation statements are synthesised mainly from non-Central Asian literature and web pages. A source focused on Uzbekistan is not, by itself, evidence that every use it summarises occurs in Uzbekistan. The Kazakhstan cadastre separately marks *G. applanatum* as medicinal but gives no preparation, indication, participant source, or frequency (Gafforov *et al.* 2023a, 2023b; Rakhimova *et al.* 2023).

Accordingly, the regional evidence supports medicinal classification and medicinal relevance, not a demonstrated Central Asian ethnomedical practice. The review does not infer prevalence, continuity, cultural importance, efficacy, or country-wide practice.

Specific preparation examples - including tea or water extracts, dried powder incorporated into food, and tea or alcoholic tincture - are retained in Table 3 only as non-Central Asian comparative context. Internet-derived recipes and dosage instructions are not treated as ethnographic or clinical evidence and are not reproduced as practical guidance. Woody *Ganoderma* basidiomata are not presented as ordinary edible mushrooms (Dai *et al.* 2009; Wang *et al.* 2020; Gafforov *et al.* 2023a, 2023b).

Commercial reishi/lingzhi products and medicinal narratives were most often linked to *G. lucidum* s.l. Because product labels may represent cultivated strains, imported material, or different laccate taxa, they were excluded from evidence of wild Central Asian occurrence and traditional local use (Cao *et al.* 2012; Zhou *et al.* 2015; Hennicke *et al.* 2016; Loyd *et al.* 2018; Wang *et al.* 2020).

Material, artistic, culinary, and flavouring statements associated with *G. applanatum* or reishi products were also traced to comparative or web-based sources. Marking or drawing on the pale pore surface, dyeing, flavouring, beverages, and processed products remain ethnomycological relevant topics, but the assessed sources do not document Central Asian participants, frequency, precise locality, or continuity. They are therefore retained as comparative context rather than demonstrated regional traditions (Dai *et al.* 2009; Gafforov *et al.* 2023b).

Table 3 separates regional medicinal classifications, Uzbekistan-focused secondary syntheses, non-Central Asian comparative medicinal information, and modern commercial or material-use contexts. The table identifies where each statement was reported, whether a preparation or application was specified, its provenance class, and the conclusion that the evidence can support.

Occurrence evidence as documentation context

The raw GBIF file contained 73 *Ganoderma*-related representations: 36 from Uzbekistan, 29 from Kyrgyzstan, four from Kazakhstan, and four from Tajikistan; none was retrieved for Turkmenistan. After linking duplicates and repeated repository representations, these became 49 independent GBIF-derived units. Thirteen additional literature or herbarium units produced a master register of 62 independent evidence units (Tables S1, S6, and S8; Gafforov 2014; Gafforov & Ordynets 2022; Gafforov *et al.* 2020, 2023a, 2023b; GBIF.org 2026).

Raw national counts were not compared as distributional density. The Kyrgyzstan subset illustrates why: 22 rows under SH1217207.09FU represented two coordinate pairs and two unresolved sampling units. Uzbekistan also contained repeated GBIF, ITS, and LSU representations of the same vouchers. Such repetitions were retained for traceability but collapsed analytically.

Evidence class and spatial precision varied independently. Voucher or sequence support did not guarantee usable coordinates, and a coordinate did not guarantee species-level identification. Therefore, records were summarised simultaneously by evidence class, duplicate status, and map status rather than by basisOfRecord or country count alone.

Figure 2 distinguishes 17 core units with source-supplied coordinates—11 voucher- or sequence-supported units, four observation-only units, and two unresolved genus-level vouchers—from three coordinate-bearing context units that are not counted as species occurrences. The context layer comprises one Kazakhstan *G. lucidum* s.l. context record with a stated 10-km uncertainty and two Kyrgyzstan UNITE sampling units. Coordinates were not jittered, and broad literature or voucher localities were not assigned inferred points. Table S7 provides the exact plotted records, point role, source identifier, evidence class, coordinate uncertainty, and inclusion decision.

Table 3. Medicinal and other use-related information associated with *Ganoderma* in the assessed sources, classified by taxon, source geography, preparation or application, and provenance.

Taxon or label	Country or source context	Use category	Preparation or application (where stated)	Provenance classification and interpretation	Key references
<i>Ganoderma adspersum</i> ; <i>G. applanatum</i>	Uzbekistan	Medicinal classification and summarised medicinal relevance	Both taxa are labelled medicinal. No Uzbekistan-specific preparation is documented; the tea/water-extract statement for <i>G. applanatum</i> comes from comparative literature.	Secondary synthesis. Detailed indications are compiled mainly from non-Central Asian sources; no Uzbek participants, use locality, frequency, or knowledge-transmission context is provided.	Gafforov <i>et al.</i> 2023a, 2023b; Dai <i>et al.</i> 2009
<i>Ganoderma applanatum</i>	Kazakhstan (Almaty-region cadastre)	Medicinal classification	Not stated	Secondary cadastral attribute; no indication, preparation, participant source, frequency, or therapeutic evidence is provided.	Rakhimova <i>et al.</i> 2023
<i>G. applanatum</i> ; <i>G. lucidum</i> s.l.; <i>G. resinaceum</i>	China, India, Nigeria, Cameroon, Serbia, and other non-Central Asian contexts	Comparative ethnomedicinal reports	Tea or water extract; dried powder incorporated into food; tea or alcoholic tincture; other source-specific preparations.	Non-Central Asian comparative evidence only. It explains medicinal relevance but does not establish Central Asian practice, regional taxon identity, safety, or efficacy.	Dai <i>et al.</i> 2009; Gafforov <i>et al.</i> 2023b
<i>G. applanatum</i> ; <i>G. lucidum</i> s.l. / commercial reishi	Global comparative and modern Central Asian online contexts	Material, culinary/flavouring, and processed-product context	Marking or drawing on the pore surface; dyes; flavouring or beverages; teas, powders, capsules, and extracts.	Comparative or commercial context only. Internet recipe and dosage statements are excluded as regional ethnographic or clinical evidence.	Dai <i>et al.</i> 2009; Cao <i>et al.</i> 2012; Zhou <i>et al.</i> 2015; Hennicke <i>et al.</i> 2016; Loyd <i>et al.</i> 2018; Wang <i>et al.</i> 2020; Gafforov <i>et al.</i> 2023b

Note: Source-reported categories do not demonstrate therapeutic efficacy, safety, prevalence, participant-based practice, or transferability to taxonomically unverified Central Asian material. Internet recipe and dosage statements are not presented as guidance.

Uzbekistan contributed ten map-ready units, including TASM-linked and sequence-associated records. Additional published records with 10-km uncertainty or repeated representations remain in the register but were not used to imply fine-scale distribution or abundance. (Gafforov *et al.* 2020, 2023a, 2023b)

Kyrgyzstan contributed strong voucher and ITS evidence but no core species-occurrence point because the accessible KA and H records lacked voucher-specific coordinates. The 22 SH1217207.09FU rows collapsed to two unresolved sampling units at two source coordinate pairs. Figure 2 shows them as open contextual symbols, but they are not counted as species occurrences. (Cho *et al.* 2019; H/GBIF records; GBIF.org 2026)

Kazakhstan contributed three georeferenced independent units and a substantially richer historical literature. Kalymbetov (1969) documented *G. applanatum* and *G. resinaceum* with hosts and Almaty-region localities, while Shvartsman (1964) and Rakhimova *et al.* (2023) provided additional cadastral context and explicitly classified *G. applanatum* as medicinal (Russian: лекарственный). Records without exact coordinates were not placed on the map.

Tajikistan contributed four georeferenced units, including three TAAM vouchers from the Kondara area and one observation. Two TAAM vouchers remained *Ganoderma* sp. and were mapped as unresolved genus-level evidence rather than assigned to *G. applanatum*.

No verified *Ganoderma* s. str. occurrence from Turkmenistan was identified in the assessed GBIF, literature, or TAAM evidence. Records of other Ganodermataceae were excluded as non-target contextual material; this is a documentation outcome, not evidence of biological absence. (GBIF.org 2026)

Thus, Figure 2 is a paired evidence audit rather than a distribution model. Panel A separates exact core occurrence points from explicitly labelled unresolved context, while panel B summarises the evidence-class structure of all 62 independent units, including non-georeferenced literature and molecular records. Neither point density nor bar length is interpreted as abundance, richness, prevalence, or survey completeness.

Host and habitat context

Host and habitat data were evaluated as ecological metadata, not as evidence of human recognition or use. The strongest host-associated evidence concerned *G. applanatum*, followed by Uzbek records of *G. adspersum* and *G. resinaceum*; host claims attached to *G. lucidum* s.l. were retained only as unresolved laccate *Ganoderma* unless voucher-linked molecular evidence was available. (Shvartsman 1964; Cao *et al.* 2012; Zhou *et al.* 2015; Hennicke *et al.* 2016; Loyd *et al.* 2018; Bernicchia & Gorjón 2020; GBIF.org 2026).

Ganoderma applanatum was recorded on broadleaved hosts including *Populus*, *Malus*, *Quercus*, *Betula*, *Morus*, and related woody substrates. Kazakhstan historical sources add dated host-locality reports from the Almaty region, while Uzbekistan, Kyrgyzstan, and Tajikistan contribute voucher, sequence, or herbarium support of differing spatial precision. (Shvartsman 1964; Kalymbetov 1969; Gafforov 2014; Cho *et al.* 2019; Gafforov *et al.* 2020, 2023a, 2023b; Rakhimova *et al.* 2023; TAAM herbarium data; GBIF.org 2026).

Ganoderma adspersum records from Uzbekistan were associated with *Acer* and mature broadleaved woody substrates in published and sequence-linked material. Historical names within the *G. australe*/*G. adspersum* complex were not merged without voucher reassessment. (Donk 1969; Ryvarden & Gilbertson 1993; Gafforov 2014; Bernicchia & Gorjón 2020; Gafforov *et al.* 2020, 2023a, 2023b).

Ganoderma resinaceum was associated with *Salix* in sequence-linked material from Uzbekistan and with *Quercus robur* in historical reports from Kazakhstan. These represent documented host records; broader habitat descriptions were not treated as evidence that people observed, named, collected, or used the fungi. (Shvartsman 1964; Ryvarden & Gilbertson 1993; Torres-Torres & Guzmán-Dávalos 2012; Cabarroi-Hernández *et al.* 2019; Gafforov *et al.* 2020, 2023b; Luangharn *et al.* 2021).

Records under *G. lucidum* s.l. remain unsuitable for species-specific host synthesis unless voucher and molecular support are linked. Commercial or cultivated material was excluded from the wild host dataset. (Cao *et al.* 2012; Zhou *et al.* 2015; Hennicke *et al.* 2016; Loyd *et al.* 2018).

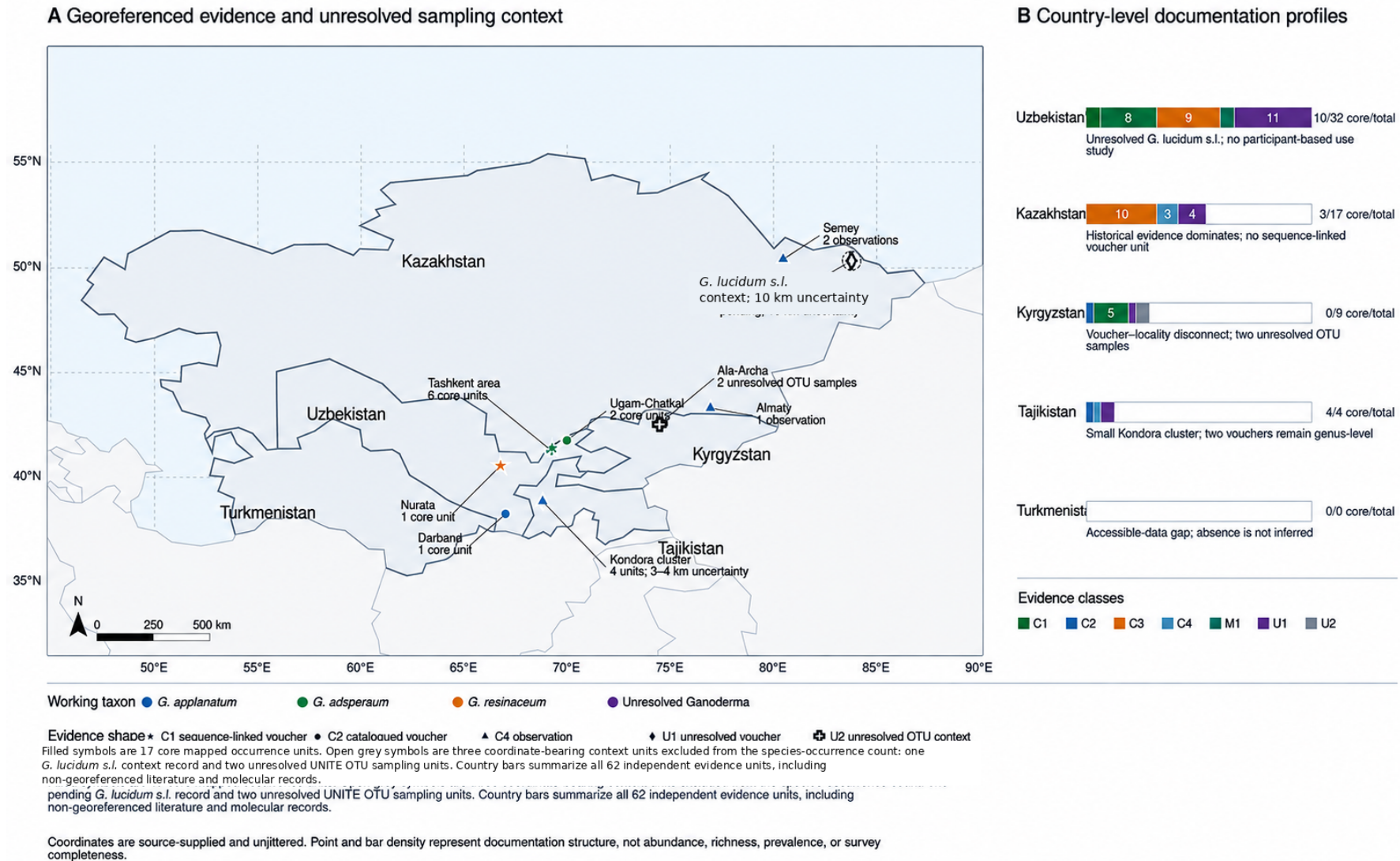


Figure 2. Georeferenced *Ganoderma* evidence and country-level documentation structure in Central Asia. Panel A plots 17 core source-georeferenced occurrence units as filled symbols and three coordinate-bearing context units as open grey symbols: one Kazakhstan *G. lucidum* s.l. record and two unresolved Kyrgyzstan UNITE OTU sampling units. The context units are not counted as species occurrences. Panel B summarises all 62 independent evidence units by country and evidence class, including non-georeferenced literature and molecular records. Repeated GBIF, GenBank, ENA, UNITE, and publisher representations were collapsed; the exact plotted dataset is provided in Table S7, and representation links are audited in Table S8. Coordinates are source-supplied and unjittered; documentation density is not abundance, richness, prevalence, or survey completeness. Country boundaries use Natural Earth 1:110m admin-0 data.

Explicit taxon–host associations in the independent evidence register

	<i>Acer</i>	<i>Salix</i>	<i>Quercus</i>	<i>Populus</i>	<i>Malus</i>	<i>Fraxinus</i>	<i>Tilia</i>	<i>Picea</i>	<i>Betula</i>	<i>Abies</i>
<i>G. adspersum</i>	1 UZ C1 1 unit									
<i>G. resinaceum</i>		1 UZ C1 1 unit	2 KZ C3 2 units							
<i>G. applanatum</i>	1 KZ C3 1 unit		1 KZ C3 1 unit	4 KZ C3 4 units	1 KZ C3 1 unit	1 KZ C3 1 unit	1 KZ C3 1 unit	1 KZ C3 1 unit	1 KZ C3 1 unit	1 KZ C3 1 unit
<i>G. applanatum f. australe</i> (historical)				1 KZ U1 1 unit	1 KZ U1 1 unit					

Evidence provenance ● C1 sequence-linked voucher with locality ● C3 historical/cadastral occurrence; voucher unverified ● U1 historical taxon unresolved

Each filled cell counts independent evidence units with an explicit named host. Multiple host species from the same genus within one evidence unit are counted once at genus level. Generic woody substrates and unverified commercial records are excluded.

No host-linked independent unit was available from Kyrgyzstan, Tajikistan, or Turkmenistan; this indicates a documentation gap, not biological absence.

Figure 3. Explicit taxon–host associations in the independent evidence register (Table S6). Each filled cell counts independent units in which a named host genus was attached to the same evidence unit; colour indicates the strongest provenance class represented (C1, C3, or U1). Multiple host species from the same genus within one unit were counted once. Generic woody substrates and unverified commercial records were excluded. An empty cell indicates missing documented linkage, not host absence.

Across verified and literature-supported units, recorded substrates included living trunks, basal stems, roots, stumps, fallen wood, and dead wood in forest, riparian, orchard, park, botanical-garden, and urban-tree settings. These statements describe where records were documented, not human encounter or cultural practice. (Shvartsman 1964; Gafforov *et al.* 2020, 2023a, 2023b; GBIF.org 2026).

Table 4 summarises documented hosts, substrates, and habitat or locality context together with the verification status of each working unit.

Figure 3 is deliberately restricted to record-level host links supported by the evidence register (Table S6): sequence-linked Uzbek *G. adspersum*-*Acer* and *G. resinaceum*-*Salix* units, historical Kazakhstan *G. applanatum* and *G. resinaceum* host units, and two unresolved historical *G. applanatum* f. *australe* units. This avoids converting habitat occurrence into inferred human encounter or use. No host-linked independent unit was available from Kyrgyzstan, Tajikistan, or Turkmenistan; this is a metadata gap rather than biological absence. (Shvartsman 1964; Kalymbetov 1969; Gafforov *et al.* 2020, 2023a, 2023b).

Representative basidiomata are shown in Figure 4 to illustrate laccate and non-laccate morphotypes. The photographs provide morphological context and do not substitute for voucher examination or molecular identification.



Figure 4. Representative *Ganoderma* basidiomata relevant to the Central Asian evidence audit. A. *Ganoderma adspersum* (TASM/bot24). B. *Ganoderma applanatum* (photo 159113739 by Mike Mulqueen). C. *Ganoderma lucidum* s.l. (photo by Michal Tomšovský). D. *Ganoderma resinaceum* (photo by Michal Tomšovský). Panel A is regional material; panels B-D are comparative morphological context.

The host synthesis is intentionally conservative. Incomplete host or habitat statements remain targets for voucher revision, recollection, and metadata improvement rather than evidence of human use or confirmed species expansion.

Table 4. Documented host, substrate, and habitat or locality context of the principal *Ganoderma* working units in Central Asia.

Taxon/working unit	Documented hosts and substrates	Documented habitat or locality context	Verification note	Key references
<i>Ganoderma applanatum</i>	Broadleaved trees, living and dead trunks, basal stems, exposed roots, stumps, fallen logs, and dead wood. Reported hosts include <i>Populus</i> , <i>Juglans</i> , <i>Betula</i> , <i>Malus</i> , <i>Crataegus</i> , <i>Morus</i> , and <i>Quercus</i> .	Forest, riparian, orchard, park, botanical-garden, and urban-tree records; no inference of human recognition or use	Supported by mixed voucher, sequence, historical, and observation evidence; each unit retains its evidence class	Shvartsman 1964; Kalymbetov 1969; Cho <i>et al.</i> 2019; Gafforov <i>et al.</i> 2020, 2023a, 2023b; Rakhimova <i>et al.</i> 2023; GBIF.org 2026
<i>Ganoderma adspersum</i>	<i>Acer</i> spp., including material reported from <i>A. saccharum</i> ; mature broadleaved trees, decaying trunks, old woody substrates, and stumps.	Botanical-garden, park, urban-tree, and broadleaved woody-substrate records	Uzbek evidence includes ITS/LSU links; historical complex names require reassessment	Donk 1969; Ryvarden & Gilbertson 1993; Gafforov 2014; Bernicchia & Gorjón 2020; Gafforov <i>et al.</i> 2020, 2023a, 2023b; GBIF.org 2026
<i>Ganoderma resinaceum</i>	<i>Salix</i> sp. in sequence-linked Uzbek material; <i>Quercus robur</i> in historical Kazakhstan records; living broadleaved trees, basal stems, trunks, stumps, and old woody substrates.	Riparian or alluvial <i>Salix</i> records in Uzbekistan; historical Almaty-region records on <i>Quercus</i>	Uzbek sequence support and Kazakhstan C3 literature evidence are kept distinct	Shvartsman 1964; Kalymbetov 1969; Gafforov <i>et al.</i> 2020, 2023b
<i>Ganoderma lucidum</i> s.l. / unresolved laccate <i>Ganoderma</i>	Broadleaved trees, roots, basal stems, trunks, buried wood, dead wood, and cultivated or commercially processed fungal material reported under reishi/lingzhi terminology.	Wild habitat statements unresolved; cultivated and commercial contexts excluded from the host synthesis	Host or substrate information recorded under <i>G. lucidum</i> does not confirm <i>G. lucidum</i> s. str. Wild regional records require voucher-linked molecular evidence; commercial material is not evidence of local wild occurrence.	Shvartsman 1964; Ryvarden & Gilbertson 1993; Cao <i>et al.</i> 2012; Zhou <i>et al.</i> 2015; Hennicke <i>et al.</i> 2016; Loyd <i>et al.</i> 2018; Gafforov <i>et al.</i> 2020, 2023b
Unresolved <i>Ganoderma</i> records	Broadleaved trees, woody trunks, fallen wood, dead wood, and incompletely documented host or substrate records. This group includes genus-level identifications, historical <i>G. applanatum</i> f. <i>australe</i> , broadly applied <i>G. australe</i> , material samples, and technical identifiers such as SH1217207.09FU.	Country- or locality-level sampling contexts with incomplete identification or georeferencing	These entries indicate sampling activity and potential survey targets but should not be assigned to species level without voucher reassessment, diagnostic morphology, complete sequence metadata, or phylogenetic placement.	Shvartsman 1964; Cho <i>et al.</i> 2019; Bernicchia & Gorjón 2020; TAAM herbarium data; GBIF.org 2026

Note: Ecological occurrence does not demonstrate human recognition, naming, collection, or use. Host names and substrate descriptions are not an exhaustive or taxonomically revised host checklist.

Comparative chemical context

Table 5 is retained because global chemistry explains why taxonomic authentication of regional material matters. However, the underlying studies largely concern non-Central Asian collections, cultivated strains, or commercial products and cannot establish the composition, safety, efficacy, or identity of Central Asian specimens. (Paterson 2006; Boh *et al.* 2007; Baby *et al.* 2015; Bishop *et al.* 2015; Cör *et al.* 2018; Wang *et al.* 2020; Zhao *et al.* 2020; Biswal *et al.* 2022; Lin *et al.* 2022)

Across *Ganoderma*, reported metabolites include polysaccharides, beta-glucans, triterpenoids, ganoderic and related acids, sterols, phenolics, fatty acids, proteins, and nucleosides. Profiles vary with species, strain, host, geography, developmental stage, cultivation, extraction, and analytical method.

For Central Asia, the defensible priorities are molecularly supported Uzbek *G. adspersum* and *G. resinaceum*, well-documented *G. applanatum* from several countries, and carefully verified laccate *Ganoderma*. Chemical claims should be made only for the same voucher-backed material that is directly analysed. (Tel-Çayan *et al.* 2015, 2020; Tokul-Olmez *et al.* 2018; Deveci *et al.* 2019; Shomali *et al.* 2019; Mayaka *et al.* 2020; Sułkowska-Ziaja *et al.* 2022; Gafforov *et al.* 2020, 2023a, 2023b)

Table 5 therefore functions as a comparative rationale for future analysis, not as ethnopharmacological evidence from Central Asia.

Taxonomic reliability, evidence independence, and country comparison

The audit distinguishes five questions that are often conflated: whether a representation is independent, whether the name is current, whether a voucher exists, whether the locality is precise, and whether a cultural claim has primary participant provenance. A record can be strong on one axis and weak on another.

Historical combinations remain essential search pathways but were not counted as additional taxa. Records under *Fomes applanatus*, *Polyporus applanatus*, *Elfvigia applanata*, *Phaeoporus applanatus*, *Ganoderma lipsiense*, *G. australe* sensu auct., or *G. lucidum* s.l. require interpretation against voucher, locality, host, morphology, and sequence evidence. (Donk 1969; Ryvarden & Gilbertson 1993; Bernicchia & Gorjón 2020)

The *G. lucidum* label is especially sensitive because medicinal and commercial material may represent several laccate lineages or cultivated strains. Reishi and lingzhi identify cultural or market categories, not a single verified wild Central Asian species. (Cao *et al.* 2012; Zhou *et al.* 2015; Hennicke *et al.* 2016; Loyd *et al.* 2018)

Repeated GBIF, GenBank, ENA, UNITE, and publisher records were linked to the same specimen or event whenever identifiers and metadata agreed. Technical labels such as SH1217207.09FU were retained as traceable U2 units and were not converted into species records.

Historical records without accessible vouchers were classified C3 rather than confirmed. Molecular records without adequate locality or voucher linkage were classified M1. Genus-level vouchers were U1, observations were C4, and duplicates or non-target Ganodermataceae were X. These distinctions are applied consistently in Tables S5-S8.

Country profiles therefore describe different evidence structures rather than different fungal richness. Uzbekistan combines several evidence types; Kazakhstan has strong historical locality-host documentation and a secondary medicinal classification; Kyrgyzstan has important voucher and sequence support but poor point-level georeferencing; Tajikistan has a small, concrete TAAM cluster requiring revision; and Turkmenistan lacks a verified record in the assessed evidence.

Ethnomycological coverage is weaker than occurrence evidence in all five countries. Uzbekistan-focused sources provide secondary Uzbek terminology and medicinal labels, but their detailed indications and preparations are mainly non-regional comparisons; Kazakhstan provides a secondary medicinal classification without application details. The remaining country searches mainly returned scientific or commercial terminology. No country yielded participant-based primary *Ganoderma* data in the assessed sources.

Table 6 summarises these evidence structures and verification priorities without ranking countries by record density, abundance, or species richness; the underlying country counts, gaps, actions, and validation endpoints are provided in Table S9.

Table 5. Condensed comparative chemical context for four *Ganoderma* working units. Compounds and experimental activities derive mainly from non-Central Asian, cultivated, or commercial material and are not evidence of regional composition or clinical efficacy.

Taxon/working unit	Main chemical context	Reported experimental activity context	Central Asian relevance	Interpretive limitation	Key references
<i>Ganoderma adspersum</i>	Polysaccharides, phenolics, fatty acids, steroids, and lanostane-type triterpenoids reported outside Central Asia	Experimental antioxidant, antimicrobial, and enzyme-inhibition contexts	Uzbek ITS/LSU-linked material is a priority for direct analysis	No chemical profile or efficacy may be transferred to Uzbek material	Tel-Çayan <i>et al.</i> 2015, 2020; Tokul-Olmez <i>et al.</i> 2018; Deveci <i>et al.</i> 2019; Shomali <i>et al.</i> 2019; Mayaka <i>et al.</i> 2020; Sułkowska-Ziaja <i>et al.</i> 2022; Gafforov <i>et al.</i> 2020, 2023a, 2023b
<i>Ganoderma applanatum</i>	Polysaccharides, triterpenoids, phenolics, lipids, and minerals reported globally	Experimental antioxidant, antimicrobial, immunomodulatory, and enzyme-inhibition contexts	Broad regional occurrence support permits future voucher-matched comparison	Host or geographical differences require standardised direct analysis	Jeong <i>et al.</i> 2008; Kozarski <i>et al.</i> 2012; Osińska-Jaroszuk <i>et al.</i> 2014; Baby <i>et al.</i> 2015; Sun <i>et al.</i> 2015; Zengin <i>et al.</i> 2015; Rašeta <i>et al.</i> 2016; Balamurugan <i>et al.</i> 2021; Karaman <i>et al.</i> 2022; Gafforov <i>et al.</i> 2023b
<i>Ganoderma lucidum</i> s.l. / unresolved laccate <i>Ganoderma</i>	Polysaccharides, triterpenoids, ganoderic/lucidenic acids, sterols, and related metabolites	Extensive reishi/lingzhi experimental and product literature	Explains contemporary medicinal-mushroom discourse	Taxonomically heterogeneous; product chemistry is not wild Central Asian chemistry	Paterson 2006; Boh <i>et al.</i> 2007; Cao <i>et al.</i> 2012; Baby <i>et al.</i> 2015; Bishop <i>et al.</i> 2015; Zhou <i>et al.</i> 2015; Hennicke <i>et al.</i> 2016; Ahmad 2018; Cör <i>et al.</i> 2018; Loyd <i>et al.</i> 2018; Liang <i>et al.</i> 2019; Wang <i>et al.</i> 2020; Ahmad <i>et al.</i> 2021; Lin <i>et al.</i> 2022
<i>Ganoderma resinaceum</i>	Lanostane triterpenoids, polysaccharides, phenolics, and sterols reported outside Central Asia	Experimental antioxidant, anti-inflammatory, metabolic, and antimicrobial contexts	Uzbek sequence-linked and Kazakhstan historical evidence identifies a verification target	Direct voucher-matched regional analysis is absent	Niu <i>et al.</i> 2007; Peng <i>et al.</i> 2013; Silva <i>et al.</i> 2013; Zengin <i>et al.</i> 2015; Chen <i>et al.</i> 2018a, 2018b; Sedky <i>et al.</i> 2018; Yang <i>et al.</i> 2019a, 2019b; Shi <i>et al.</i> 2019, 2020; Huang <i>et al.</i> 2020a, 2020b; Kozarski <i>et al.</i> 2020; Rašeta <i>et al.</i> 2020, 2021; Karaman <i>et al.</i> 2022; Gafforov <i>et al.</i> 2020, 2023b

Note: Regional inference requires a voucher, linked sequence, locality and host metadata, and direct standardised chemical analysis of that same material.

Table 6. Country-level evidence structure and verification priorities for Central Asian *Ganoderma*. Profiles describe documentation and provenance, not biological abundance or national species richness.

Country	Principal evidence base	Ethnomycological and use-related evidence	Overall evidence profile	Principal gap and priority action	Key references
Uzbekistan	Published taxonomic and ecological literature, GBIF occurrences, host and substrate records, voucher-associated studies, and ITS/LSU-linked material	Secondary Uzbek terminology and medicinal labels in Uzbekistan-focused literature; detailed indications and preparations mainly derive from non-regional comparisons; no participant-based primary study identified.	Multiple evidence types, with duplicates and coordinate limitations explicitly separated	Verify older vouchers and <i>G. lucidum</i> s.l.; add participant-provenance research and voucher-matched chemistry	Gafforov 2014; Gafforov & Ordynets 2022; Gafforov <i>et al.</i> 2020, 2023a, 2023b; GBIF.org 2026
Kazakhstan	Historical monographs and cadastre plus three georeferenced independent units	Secondary medicinal classification of <i>G. applanatum</i> in the Almaty-region cadastre; no indication, preparation, or participant-based local-use study identified.	Strong C3 host-locality history plus a provenance-limited secondary medicinal-use statement; physical vouchers remain to be located or revised	Trace Kalymbetov/Shvartsman vouchers, georeference labels, recollect dated host-locality combinations	Shvartsman 1964; Kalymbetov 1969; Rakhimova <i>et al.</i> 2023; GBIF.org 2026
Kyrgyzstan	Five ITS-linked KNA/KA vouchers, two H vouchers, and unresolved SH representations	Modern Kyrgyz commercial 'reishi mushroom' wording; no primary Kyrgyz vernacular/use source identified	Strong taxonomic support for <i>G. applanatum</i> but voucher-specific coordinates are unavailable	Recover KA/H coordinates and metadata; keep SH identifier units unresolved; survey with vouchers	Cho <i>et al.</i> 2019; H/GBIF records; GBIF.org 2026
Tajikistan	Three TAAM vouchers and one observation with exact coordinates	Modern Tajik commercial wording only; no participant-based record identified	Small georeferenced cluster with two genus-level vouchers requiring revision	Re-examine TAAM vouchers, resolve conflicting label metadata, and barcode recollections	TAAM herbarium data; GBIF.org 2026
Turkmenistan	No verified <i>Ganoderma</i> unit in the assessed evidence; non-target Ganodermataceae excluded	Modern Turkmen commercial reishi wording only; no participant-based record identified	Documentation gap; not evidence of biological absence	Targeted voucher surveys and curator-assisted herbarium work	TAAM herbarium data; GBIF.org 2026

Note: Failure to retrieve a specimen from a public portal or a name from the literature is a documentation outcome. It is not evidence of absence from a physical herbarium, a country, or local knowledge.

Research priorities arising from the evidence audit

The revised synthesis yields testable priorities rather than a generic statement that more research is needed. Each unresolved unit has a defined next action: locate or image a historical voucher, recover missing voucher coordinates, verify sequence-voucher linkage, recollect a dated locality-host combination, or document terminology with participant provenance.

Primary ethnomycological work should use prior informed consent and comparable Uzbek, Kazakh, Kyrgyz, Tajik, Turkmen, and Russian instruments. It should distinguish participant-defined names from scientific or commercial vocabulary and link statements, where appropriate, to photographs, hosts, localities, and deposited vouchers.

Market and product surveys form a related priority. Pharmacies, retail outlets, online trade, traditional-medicine sellers, and functional-food markets may contain products labelled as reishi, lingzhi, *Ganoderma*, or *G. lucidum*. Such surveys should record the declared species, product form, geographical origin, cultivated or wild status, manufacturer or supplier, processing method, and available quality-control information. Product photographs, label data, batch information, and representative material should be documented where ethically and legally appropriate. Molecular or chemical authentication would help distinguish imported and cultivated products from locally collected wild material. Commercial terminology alone should not be interpreted as evidence of regional occurrence or species identity.

Voucher and herbarium work should prioritise historical Kazakhstan localities and hosts, coordinate-poor Kyrgyz H and KNA/KA material, the Tajikistan TAAM cluster, and targeted Turkmenistan surveys. AA and FRU holdings require curator-assisted or physical catalogue work because comprehensive public fungal portals were unavailable. New collections should link coordinates, uncertainty, event date, host, photographs, herbarium accession, and DNA barcodes.

Sequence evidence should remain linked to physical vouchers and specimen-level locality metadata. Difficult laccate complexes may require additional loci and phylogenetic analysis beyond ITS/LSU.

Database corrections should preserve relationships among occurrence identifiers, voucher numbers, sequence accessions, original and accepted names, hosts, localities, and literature. The independent-unit model used here provides a reproducible basis for returning duplicate and metadata corrections to data publishers.

Chemical profiling should be limited to taxonomically verified regional vouchers and use standardised extraction and analytical protocols. Table 5 identifies priority taxa but does not predict their regional chemistry or efficacy. Cultivation, biotechnology, and wastewater-remediation studies are retained only as non-regional methodological context and do not support Central Asian composition, use, or occurrence (Asad *et al.* 2025; Hanafiah *et al.* 2025a, 2025b; Zahuri *et al.* 2024; Zheng *et al.* 2024; Pandey *et al.* 2026).

A shared Central Asian evidence register could coordinate voucher revision, georeferencing, sequencing, database curation, and ethically collected ethnomycological data while preserving the provenance of every claim. Adjacent work on integrative taxonomy and imaging-based botanical documentation illustrates transferable documentation approaches, but it does not add *Ganoderma* occurrence or ethnobiological evidence to this review (Cheek *et al.* 2020; Majeed *et al.* 2022, 2023).

Figure 1 and Figure 5 have complementary roles. Figure 1 is retrospective: it shows how heterogeneous representations were linked and audited. Figure 5 is prospective: it converts each country's present evidence structure into a defined critical gap, a priority action, and a validation endpoint. Together, they link evidence auditing to testable country-level evidence upgrades rather than a generic list of future research needs.

Country-specific evidence-to-validation roadmap

Current documentation is converted into explicit, testable evidence upgrades rather than a generic list of future research needs.

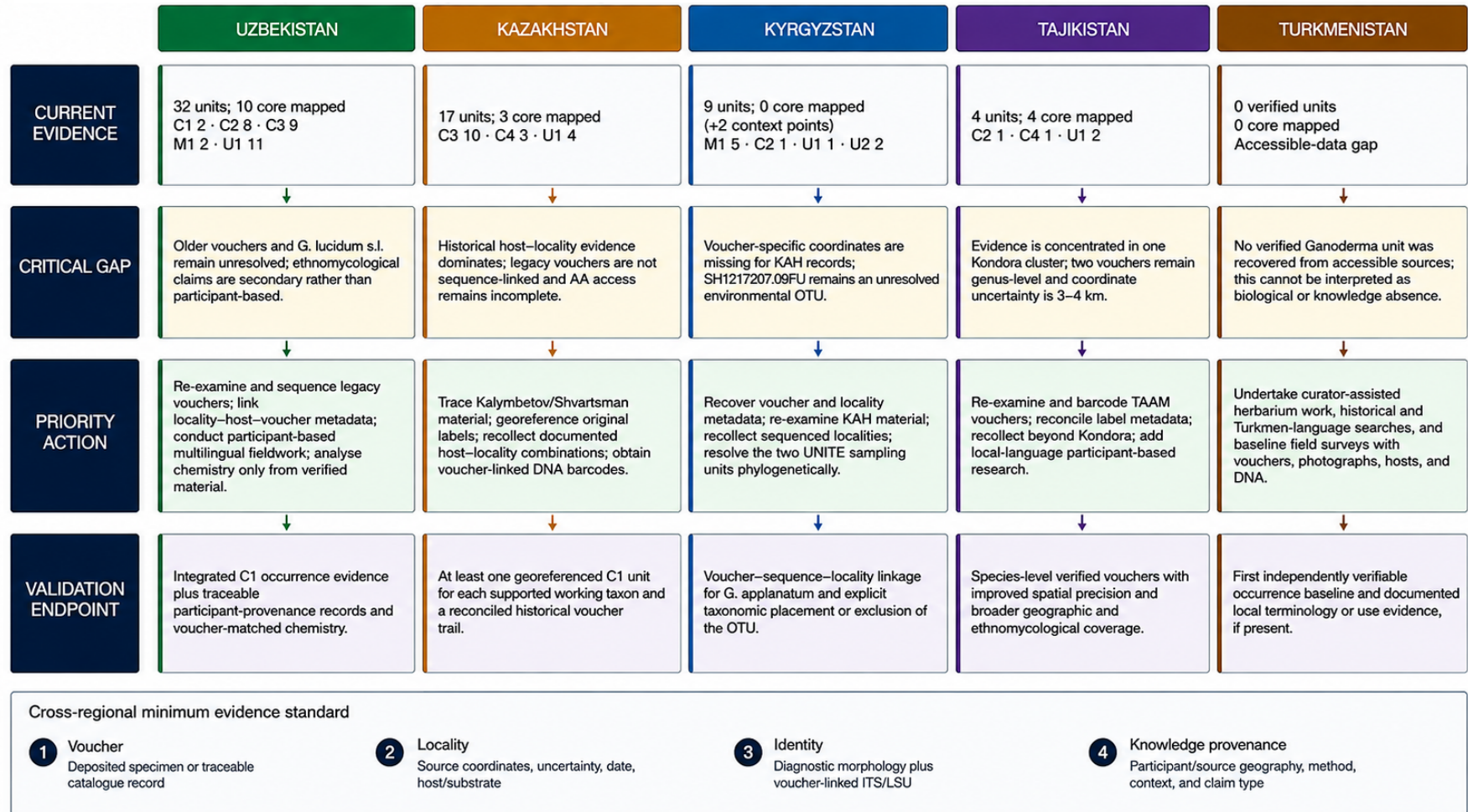


Figure 5. Country-specific evidence-to-validation roadmap for Central Asian *Ganoderma*. For each country, current evidence is linked to a critical gap, a priority action, and an explicit validation endpoint; the underlying audit is provided in Table S9. The cross-regional minimum standard requires a traceable voucher, source-level locality and uncertainty, authenticated identity, and explicit knowledge provenance. The roadmap is not a ranking of countries and does not infer biological or cultural absence from missing documentation.

Conclusions

Central Asia remains an appropriate geographical scope when the study is framed as a comparative evidence audit rather than a distribution census or regional ethnography. The evidence differs among countries in source type, independence, spatial precision, taxonomic support, and ethnobiological provenance; those differences are the analytical result, not a proxy for fungal diversity.

Ganoderma applanatum has the broadest support, while *G. adspersum* and *G. resinaceum* from Uzbekistan include molecularly linked evidence. Historical sources from Kazakhstan add dated host and locality records not captured by GBIF counts, and the 2023 cadastre classifies *G. applanatum* as medicinal. Kyrgyzstan has important vouchers and ITS sequences but lacks voucher-specific coordinates for mapping. Tajikistan contributes a small TAAM cluster, whereas no verified *Ganoderma* record from Turkmenistan was recovered. *Ganoderma lucidum* remains an unresolved laccate label unless voucher-linked molecular evidence is available.

No participant-based ethnobiological study of *Ganoderma* was identified. Sources focused on Uzbekistan provide local terminology and classify *G. adspersum* and *G. applanatum* as medicinal, but they do not document participants from Uzbekistan or locally specific preparation traditions; the detailed therapeutic indications they discuss are derived mainly from broader global comparisons. Kazakhstan provides a separate medicinal classification for *G. applanatum* without a stated indication or preparation, whereas searches from Kyrgyzstan, Tajikistan, and Turkmenistan mainly recovered scientific terminology or modern commercial reishi usage. The available evidence therefore supports medicinal relevance, but not a claim of living Central Asian ethnomedical practice, until participant-based research is conducted.

The novel contribution is a reproducible separation of database representation, independent evidence unit, taxonomic confidence, georeferencing status, host linkage, and ethnobiological provenance, followed by country-specific validation endpoints. Applying this framework to voucher revision, field collection, multilingual participant research, and chemical analysis will produce evidence that is comparable across Central Asia without overinterpreting current gaps.

Declarations

List of abbreviations: AA (Herbarium of the Institute of Botany and Phytointroduction, Almaty); DNA (deoxyribonucleic acid); ENA (European Nucleotide Archive); FRU (Herbarium of the Institute of Biology, Bishkek); GBIF (Global Biodiversity Information Facility); H (Finnish Museum of Natural History herbarium); ITS (internal transcribed spacer); KNA/KA (Korea National Arboretum voucher collection/code used by Cho *et al.* 2019); LSU (large subunit ribosomal DNA); TAAM (Mycological Herbarium, Estonian University of Life Sciences); TASM (Mycological Herbarium, Institute of Botany, Academy of Sciences of Uzbekistan); UDB (UNITE database sequence identifier); UNITE (Unified system for DNA-based fungal species). Generative AI tools assisted with language refinement and the visual layout of conceptual figures; all evidence decisions, data, maps, citations, and interpretations were verified by the authors.

Ethics approval and consent to participate: Not applicable.

Consent for publication: Not applicable.

Availability of data and materials: All evidence evaluated in this review derives from published literature, biodiversity and sequence databases, and documented herbarium or voucher sources. The accompanying workbook, *Ganoderma_Central_Asia_Supplementary_Tables_S1-S9.xlsx*, contains Table S1 (raw GBIF representations), Table S2 (sequence-linked units), Table S3 (voucher and repository-access evidence), Table S4 (historical names and multilingual searches), Table S5 (excluded or downgraded evidence), Table S6 (the 62-unit independent evidence register), Table S7 (the exact 20-row Figure 2 dataset: 17 core mapped occurrence units plus three context units), Table S8 (representation-to-evidence-unit links and duplicate decisions), and Table S9 (the country evidence-gap audit underlying Figure 5). The regional GBIF download identifier is 0065445-260519110011954.

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Supplementary materials: The accompanying workbook “Ganoderma_Central_Asia_Supplementary_Tables_S1-S9.xlsx” contains Table S1 (raw GBIF representations), Table S2 (sequence-linked units), Table S3 (voucher and repository-access evidence), Table S4 (historical names and multilingual searches), Table S5 (excluded or downgraded evidence), Table S6 (independent evidence register), Table S7 (exact Figure 2 map dataset), Table S8 (source links and duplicate resolution), and Table S9 (country evidence gaps and validation endpoints). Figure S1 is provided below.

Synonymy and taxonomic uncertainty pathways affecting *Ganoderma* records in Central Asia

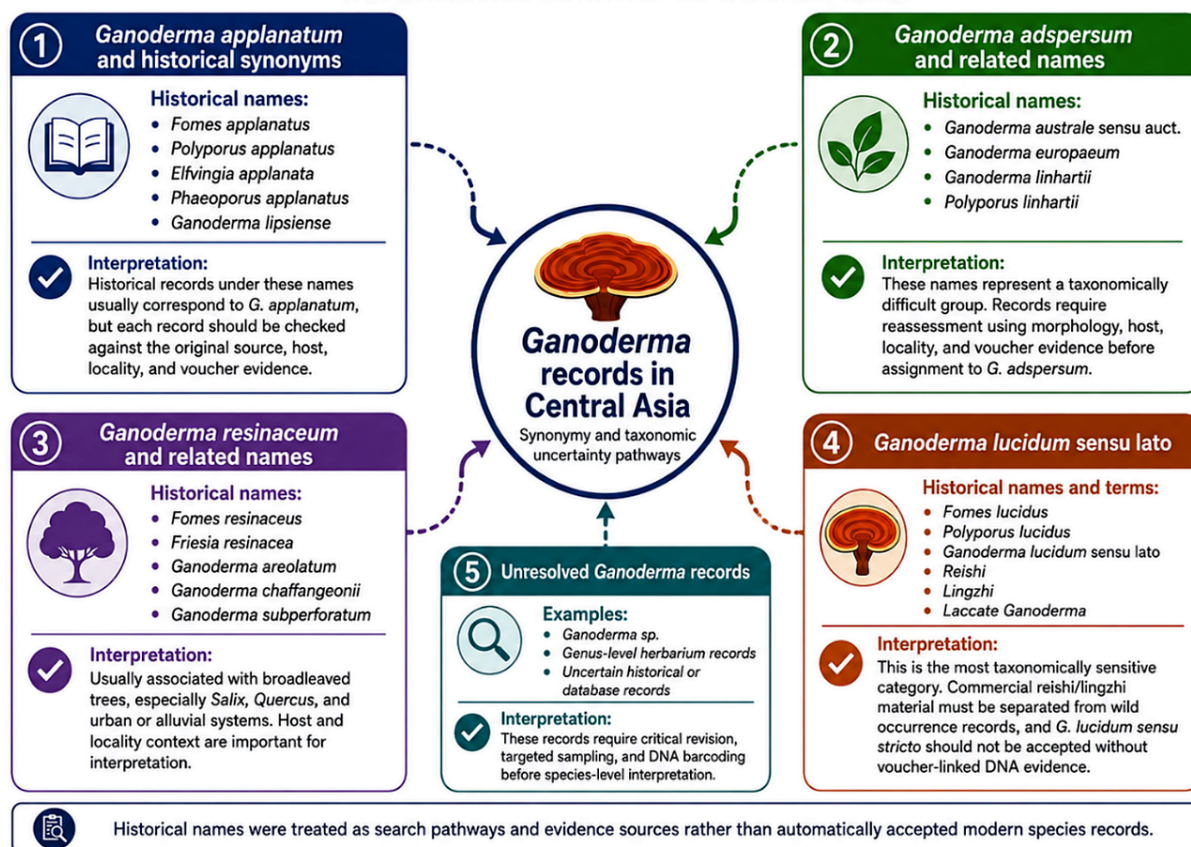


Figure S1: Synonymy and taxonomic-uncertainty pathways affecting the interpretation of Central Asian *Ganoderma* records. The diagram traces historical combinations, broadly applied species names, reishi/lingzhi-related commercial terminology, and unresolved technical or sample identifiers to their corresponding modern interpretive categories. Historical names and commercial labels were retained as traceable evidence but were not accepted as separate verified taxa without supporting locality, host or substrate, voucher documentation, diagnostic morphology, and, where available, voucher-linked molecular evidence.