

Study on Rust Disease of Siberian Larch (*Larix sibirica* Ledeb.)

Исследование ржавчинного заболевания лиственницы сибирской (*Larix sibirica* Ledeb.)

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Summary. In this study, we present the results of research on rust disease spread in Siberian larch, based on disease samples collected through field surveys in Ovorkhangai, Arkhangai, Zavkhan, Khuvsgul, and Bulgan provinces. The aim was to determine the prevalence and damage of dominant diseases affecting coniferous trees in Mongolia's forest fund, using general phytopathological methodologies. Through route surveys, Siberian larch rust disease was detected in 7 soums of 4 provinces, specifically in 1 point in the Baikal-Forest-Vegetation region, Darkhad provinces Khoshuu; 4 locations in the Central Khangai Khoshuu belonging to the Khangai Forest-Vegetation region; 1 point in the Northeast Khangai Khoshuu; and 3 points in the Southeast Khangai Khoshuu, all within larch-pine and larch-birch forests. The development of rust disease in Siberian larch (*Larix sibirica* Ledeb.) ranged from 0.02–0.14 %, with the highest severity score of 3 in Khuvsgul, Zankhai. Statistical analysis to determine climatic differences between the sampled areas showed relative air humidity differed by 10 days (ANOVA; $P < 0.002$), with Khuvsgul Khatgal having higher relative air humidity than others.

Key words. Conifer rust, *Larix sibirica* Ledeb., woody plant disease.

Реферат. В данной работе мы представляем результаты исследования распространения ржавчины лиственницы сибирской на основе образцов болезней, собранных в ходе полевых исследований в аймаках Увурхангай, Архангай, Завхан, Хубсугул и Булган. Целью было определить распространенность и вредоносность доминирующих болезней, поражающих хвойные деревья в лесном фонде Монголии, с использованием общих фитопатологических методологий. В ходе маршрутных исследований ржавчина лиственницы сибирской была обнаружена в 7 сомонах 4 аймаков, в частности в 1 точке в Дархадской провинции Забайкальской лесорастительной области; в 4 точках в Центрально-Хангайской провинции, относящейся к Хангайской лесорастительной области; в 1 точке в Северо-Восточной Хангайской провинции; и в 3 точках в Юго-Восточной Хангайской провинции; все в лиственнично-сосновых и лиственнично-березовых лесах. Развитие ржавчины лиственницы сибирской (*Larix sibirica* Ledeb.) варьировалось от 0,02 до 0,14 %, с наивысшим баллом 3 в Хубсугуле, Жанхай. Статистический анализ для определения климатических различий между отобранными районами показал, что относительная влажность воздуха различалась на 10 дней (ANOVA; $P < 0,002$), при этом Хубсугул Хатгал имел более высокую относительную влажность воздуха, чем другие.

Ключевые слова. Болезнь древесных растений, хвойная ржавчина, *Larix sibirica* Ledeb.

Introduction. The mycoflora, a crucial part of Mongolia's flora, remained largely unstudied until 1961 when systematic research began, identifying approximately 300 microfungi causing diseases in cultivated, hayfield, and pasture plants. By 2012, among the 135 species of 32 genera of higher vascular plants, 28 species of disease-causing agents belonging to 4 genera of 5 families were identified in 21 species of woody plants (Puntsag, 1976). Disease is defined as a change in plant metabolism, manifesting in various forms, caused by infection from pathogenic microorganisms and unfavorable environmental influences (Byambasuren, Itgel et al., 2025).

Siberian larch (*Larix sibirica* Ledeb.) is a dominant woody plant in Mongolia's coniferous forests, and its health significantly impacts ecosystem balance. In recent years, fungal infections such as rust disease, witches' broom, and stem and branch cankers have caused damage to forests. Providing information for forest

management and preventing the spread of infectious diseases is crucial. To determine the dominant diseases, prevalence, and damage of larch in the forest fund of Mongolia, the following objectives were set and worked on:

- Conduct inspections and analyses in forest areas along the routes.
- Collect samples of rust disease from Siberian larch (*Larix sibirica*).
- Determine the distribution of rust disease.

The Pinaceae family includes various conifers such as cedar, fir, spruce, larch, and pine. Larch is a coniferous tree originating from the temperate regions of the Northern Hemisphere. Larch sheds its needles in autumn. Larch cones are ovoid, 2–3 cm long. Larch is an evergreen conifer that grows up to 40–50 m tall.

Materials and Methods. In 2024, field surveys were conducted in 8 soums of 5 provinces, and samples of Siberian larch needle rust disease were collected from 7 soums of 4 provinces (Table 1).

Table 1

Larix sibirica Ledeb. needle rust disease samples (2024)

No.	Collection Site	Forest Type	Sampling Point
1	Ovorkhangai, Bat-Ulzii	Larch-Pine Forest	N46°59'53.28" E102°13'04.64"
2	Ovorkhangai, Bat-Ulzii	Larch-Pine Forest	N46°99'55.26" E102°22'51.52"
3	Ovorkhangai, Bat-Ulzii	Larch-Pine Forest	N46°99'51.8" E102°99'16.12"
4	Arkhangai, Tariat	Larch Forest	N48°07'09.1" E99°47'28.36"
5	Khuvsgul, Tsetserleg	Larch Forest	N49°25'36.68" E97°24'23.75"
6	Khuvsgul, Tesiin Gol	Larch Forest	N49°28'45.32" E97°15'40.71"
7	Khuvsgul, Zankhai	Larch Forest	N50°31'45.61" E100°06'48.9"
8	Khuvsgul, Khatgal	Larch Forest	N50°39'79.88" E100°20'42.27"
9	Bulgan, Bugat	Larch-Birch	N49°03'35.82" E103°60'08.95"

Sample Collection and Inspection: During sample collection, each tree was thoroughly inspected from the crown to the roots, considering external factors, and carefully checking for disease symptoms and mechanical damage on every tree and shrub.

Main Stem and Branch Inspection: This includes checking for the formation of fruiting bodies, resin exudation, cracks in the main stem, and changes in bark color.

Needle and Leaf Sample Collection: This includes checking for discoloration, fruiting bodies, spots, swellings, and the presence of fungal growth on the underside of leaves.

Sample Collection: After inspection, samples of main stems, roots, branches, shoots, and fruits showing disease symptoms were collected and placed in paper bags or herbarium folders.

Sample Labeling: Labels included the province and soum name, location name, coordinates, date, tree name, forest type, and observed symptoms.

Disease Prevalence: The prevalence of the disease is expressed as a percentage of diseased plants or specific affected organs (needles) in all surveyed areas (Geshele, 1971; Dementyeva, 1985). The severity of the disease is determined by the extent of the affected part of the plant (leaf, fruit) or the total surface area. To determine this, the percentage of the total surface area occupied by the affected part (spots, fungal growth, etc.) is calculated. The severity of damage is expressed as a percentage or in scores. If the disease severity is 1–2, it is considered low; if it is 3, it indicates a tendency for the disease to increase; and if it approaches 4, it signals a potential epiphytotic.

Severity of Damage in Coniferous Trees is determined by the following 4 scores:

0 score: No disease symptoms observed.

1 score: Up to 5 % of the needle surface is affected.

2 scores: 5–33 % of the needle surface is affected.

3 scores: 33–66 % of the needle surface is affected.

4 scores: 66–100 % of the leaf surface is affected.

Method for Calculating Disease Development: Disease development was determined using the method of M. I. Dementyeva (1985), calculating the average percentage of damage during the disease period. $P_x = \frac{\sum(a \cdot b)}{n \cdot k} \cdot 100$ Where:

P_x – Disease development, %

a – Number of diseased plants, pieces

b – Disease severity, in scores

n – Number of plants included in the calculation, pieces

k – Highest disease severity score

Research Results. Classifying the distribution of forest woody plant diseases by forest zoning in Mongolia allows for the possibility of preventing forest diseases. The main forest type refers to a forest community that has maintained its pristine state for generations under the most suitable ecological conditions for that tree species. Due to human activities such as fires, (disease pests), and clear-cutting, the environmental factors of the main forest type change, and are replaced by temporary communities. Forest-vegetation zoning reflects the regional soil, climate, forest-vegetation conditions, and characteristics of the forest. Based on the natural conditions of the sampled areas in Mongolia, the forests belong to the Trans Baikal-Forest-Vegetation region and the Khangai Forest-Vegetation region, specifically larch-pine and larch-birch forests (Fig. 1, 2).

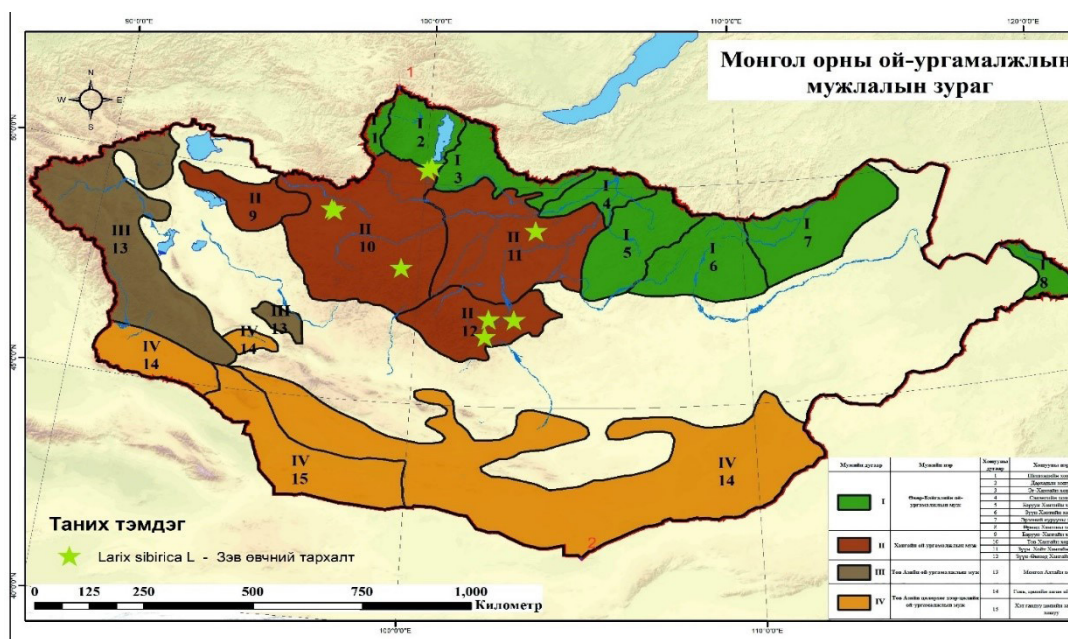


Fig. 1. Distribution of rust disease in *Larix sibirica* Ledeb. – Siberian larch – in the forest fund.

Looking at the map, rust disease of Siberian larch needles was detected in 1 point in the TransBaikal-Forest-Vegetation region, Darkhad province Khoshuu (I); 4 points in the Central Khangai Khoshuu (II), 1 point in the Northeast Khangai Khoshuu (II), and 3 points in the Southeast Khangai Khoshuu (II), all belonging to the Khangai Forest-Vegetation region, within larch-pine and larch-birch forests (Dorjsuren et al., 2020).

The Baikal-Forest-Vegetation region is divided into 4 khoshuus based on its continental temperate humid vegetation zones. The Darkhad Khoshuu includes forests distributed at altitudes of 1700–2600 m above sea level in the Darkhad Depression and the surrounding mountains to its south. Larch and birch are the most widespread, with Siberian pine forests on mountain peaks, and Siberian spruce occurring at the headwaters of the Delger River in the Darkhad Depression.

The Central Khangai Khoshuu, belonging to the Khangai Forest-Vegetation region, has larch as its main forest-forming tree, with pine growing on the peaks of mountain ranges. This khoshuu includes the main Khangai mountain range, the Tarvagatai Bulnai mountain range, and the mountains west of Lake Khuvsgul.

In the Northeast Khangai Khoshuu, the main forest-forming trees are larch and birch, with occasional pine and cedar. Excluding the Burenkhantai, Erchim, and Buteel mountain ranges, there are fragmented forests growing on isolated mountain slopes. This area has been affected by harmful insects for many years after fires, with active foci of infestation. In the Southeast Khangai Khoshuu, the main forest-forming tree is larch, with pine growing on the peaks of mountain ranges. This area belongs to the Khangai mountain range's natural complex, where many tributaries of the Tamir and Orkhon rivers originate.

Disease prevalence was analyzed by inspecting samples using the methods of M. N. Dementyeva (1985) and E. E. Geshele (1971). The percentage of diseased plants or specific affected organs (needles) in all surveyed areas was determined, and the disease severity was identified by the extent of the affected part of the plant (needles) or its total surface area. Disease development was calculated as the average percentage of damage during the disease period (Table 2). The prevalence of rust disease in Siberian larch needles in the surveyed forest areas ranged from 3–9.5 %. The Khangai Forest-Vegetation region, specifically the larch-pine forests of the Southeast Khangai Khoshuu, showed the highest prevalence at 9.5 %.

Table 2

State of Siberian larch (*Larix sibirica* Ledeb.) rust disease in the forest fund

No.	Collection Site	Forest Type	Disease Type	Disease Prevalence %
	Khangai Forest-Vegetation Region			
1	Ovorkhangai, Bat-Ulzii	Southeast Khangai Khoshuu Larch-Pine Forest	Rust	0.046
2	Bulgan, Bugat	Northeast Khangai Khoshuu Larch, Birch	Rust	0.028
3	Arkhangai, Tariat	Central Khangai Khoshuu Larch Forest	Rust	0.03
4	Khuvsgul, Tsetserleg		Rust	0.028
5	Khuvsgul, Tesiin Gol		Rust	0.02
	Baikal-Forest-Vegetation Region			
6	Khuvsgul, Khatgal Zankhai	Darkhad Khoshuu Larch, Birch Forest	Rust	0.14

The development of rust disease in Siberian larch (*Larix sibirica*) ranged from 0.02–0.14 %. In Khuvsgul province, Khatgal soum (Zankhai), the severity of the disease was the highest, meaning that when needle damage was evaluated by score, the disease showed a tendency to increase from low to high, while in other areas, the percentage of disease was low (Table 2).

Statistical analysis was performed to determine climatic differences between the sampled areas. Relative air humidity differed by 10 days (ANOVA; $P < 0.002$). The relative air humidity in Khuvsgul, Khatgalsoum, was higher than in other areas, which positively influenced disease development (Fig. 2).

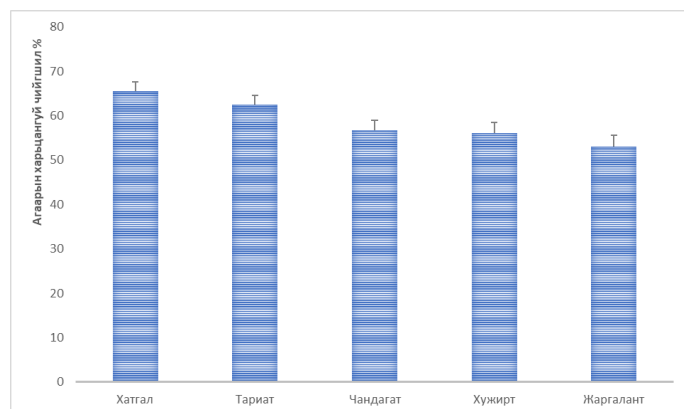


Fig. 2. Disease prevalence and progression.

All rust fungi are highly specialized obligate parasites that cause diseases known as rusts in many plant species. The main symptom of rust disease is the accumulation of rust-brown, orange-yellow, or dark-brown spores, which in most cases erupt through the plant's epidermal tissues. These fungi develop through 3 stages (spring, summer, winter) and form 5 types of spore-bearing structures (spermagonia with spermatia, aecia with aeciospores, uredinia with urediniospores, telia with teliospores, and basidia with basidiospores). The development of rust-causing fungi often occurs on two different host plants. In such cases, the fungus is

called heteroecious, and if its development occurs on a single type of plant, it is called autoecious. *Larix* is the primary host plant for rust fungi, and subsequent development occurs on deciduous trees such as Salicaceae, Betulaceae, and *Populus*. Further monitoring and control work regarding the spread of rust fungi (*Melampsora*) are necessary.

Conclusion. Field survey research noted larch disease in 7 soums of 4 provinces. In the surveyed forest areas, the prevalence of rust disease in Siberian larch needles ranged from 3–9.5 %. The Khangai Forest-Vegetation region, specifically the larch-pine forests of the Southeast Khangai Khoshuu, showed the highest prevalence at 9.5 %. The development of rust disease ranged from 0.02–0.14%. In Khuvsgul province, Khatgal soum (Zankhai), in larch and birch forests, the disease severity was the highest. The tendency for disease to increase from low to high in larch and birch forests in Khuvsgul province, Khatgal soum, was positively influenced by favorable environmental conditions for disease development. Infection by rust fungi can reduce the photosynthetic activity of trees, slow down growth, and pose a threat to the overall degradation of the forest ecosystem.

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