Investigation and Diversity Analysis of White Rot Fungus Resources in Xian-weng Mountain National Forest Park in Yichun

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Abstract. The diversity of white rot fungi in Xian-weng Mountain National Forest Park was investigated by randomized method and key area sampling survey method. According to apparent characteristics, living habits and structural analysis, comparative literature and expert consultation were used. The collected white rot fungi specimens were classified and identified. The white rot fungi are abundant in the Xian-weng Mountain National Forest Park, mostly distributed in broad-leaved forests, followed by mixed forests and coniferous forests. The white rot fungi in Xian-weng Mountain National Forest Park has good development and application prospects.

1. Introduction
Xian-weng Mountain National Forest Park was located in Yichun City, Heilongjiang Province, with a total area of 1.2×10⁵ m² and an altitude of in 270~780 m. It is a typical low hilly landform. The annual average precipitation is 600 mm, and the annual average temperature is -0.2°C. Xian-weng Mountain National Forest Park was rich in forest plant resources, diverse forest types, and intertwined with trees and rot. It is a representative temperate primitive Korean pine mixed forest belt in northeastern China and Asia, especially natural Korean pine species[1]. The soil in the reserve is fertile, with less human disturbance, and the litter layer is deep and fertile. It provides superior growth and development conditions for white rot fungi populations with different ecological habits such as saprophytic and facultative parasites, and is rich in white rot fungi resources[2]. In this study, field investigation and literature review were used to investigate the white rot fungi resources in Xian-weng Mountain National Forest Park of Heilongjiang Province, with provided evidence for the protection, development and utilization of local white rot fungi resources, and obtain industrialized degradation pollutant production bacteria. It is applied to environmental protection, pollution control and new energy development, and theoretical basis for the large-scale production and application of high-yield laccase fungi[3]. White rot fungi growing in nature are an important source of laccase. Therefore, through field investigation and collection of white rot fungi, high-yield laccase strains are screened, and the medium composition and culture conditions of laccase-producing strains are optimized for...
bio-bleaching. Industrial wastewater treatment and degradation of wood are of great significance[4]. Heilongjiang Province is rich in forest plant resources, fertile soil, less human disturbance, and abundant white rot fungi in the forest.

2. Materials and methods

2.1. Classification and identification of specimens
Based on the apparent characteristics of fruiting bodies, the white rot fungi were identified according to habitats, ecology and other living habits. The collected specimens were identified by reviewing the color maps and classification monographs of large fungi. The main basis for the identification of this study in: "Ainsworth and Bisby's Dictionary of the Fungi"[5], "The Diversity of Large Fungi in China"[6], "Chinese Large Fungi"[7] and "Color Map of Large Fungi in China"[8].

2.2. Method
Survey method adopts dotted random survey and key area sampling survey. Since the growth of white rot fungi is closely related to temperature and rainfall, the survey time at between June and October of 2016-2019. The collection was carried out according to the low to high level, such as grass layer, leaf layer, fallen wood, standing wood and so on. After the strains were detected, with numbered, photographed, collected, and the specimens kept intact.

3. Results

3.1. White rot fungi species in Xian-weng Mountain National Forest Park
In this study, a total of 305 specimens of white rot fungi were collected and identified by laboratory identification. They belong to 64 species of 4 orders, 14 families and 4 orders of Basidiomycota. According to the identification results, the investigated white rot fungi were counted according to their tax status and characteristics (in Table 1).

| Fungal of Latin name(1)       | Fungal of Latin name (2)             |
|-------------------------------|--------------------------------------|
| Aphyllophorales               | Trametes suaveolens (L.) Fr.         |
| Thelephoraceae                | Trametes pubescens (Schum. ex Fr.) Pilát |
| Stereum frutulosum (Pers.) Fr.| Trametes cinnabarina (Jacq. ex Fr.) Fr. |
| Stereum gausapatum Fr.        | Trametes cervina (Schw.) Bres         |
| Stereum hirsutum (Willd. ex Fr.) S. F. Gray | Daedalea albida Fr.                  |
| Hymenochaetaceae              | Daedalea borealis. (Fr.) Quél.        |
| Hymenochaete mougeotii (Fr.) Cooke. | Daedaleopsis rubescens (Alb. ex Schw. : Fr.) Imaz. |
| Ganodermataceae               | Daedalea quercina (L. ex Fr.) Br.     |
| Ganoderma tsugae Murr.        | Polyporellus brumalis (Pers.) Karst.  |
| Ganoderma applanatum (Pers.) Pat. | Phellinus hartigii (Allesch. ex Schnabl) Imaz. |
| Hericiaceae                   | Phellinus squamosus (Huds. ex Fr.) Ames. |
| Hericium caput-medusae (Bull. ex Fr.) Pers. | Polyporellus pseudosquamosus (Pers.) Pat. |
| Hericium ramosum (Bull. ex Merat) Letellier | Agaricales | Polyporellus porphyrosporus (Fr.) Karst. |
| Hericium abietis (Weir ex Hubert) | Phellinus rubustus (Karst.) Bond. et Sing. |
| Polyporaceae                  | Inonotus radiatus (Sow. ex Fr.) Karst. |
| Phellinus hartigii (Allesch. ex Schnabl) Imaz. | Inonotus rheades (Pers.) Pilat |
| Polyporellus porphyrosporus (Fr.) Karst. | Inonotus cuticularis (Bull. ex Fr.) Karst. |
| Phellinus robustus (Karst.) Bond. et Sing. | Polyporellus porphyrosporus (Fr.) Karst. |
| Polyporellus porphyrosporus (Fr.) Karst. | Spongipellis squamosus (Sow. ex Fr.) Pat. |
| Spongipellis squamosus (Sow. ex Fr.) Pat. | Agaricales | Spongipellis spumeus (Sow. ex Fr.) Pat. |
| Cryptoporus volvatus (Peck) Hubb. | Phellinus ochraceus (Batsch. ex Fr.) Murr. |

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Table 1. The directory of white rot fungi in LiangShui reserve

| Fungal of Latin name(1)       | Fungal of Latin name (2)             |
|-------------------------------|--------------------------------------|
| Aphyllophorales               | Trametes suaveolens (L.) Fr.         |
| Thelephoraceae                | Trametes pubescens (Schum. ex Fr.) Pilát |
| Stereum frutulosum (Pers.) Fr.| Trametes cinnabarina (Jacq. ex Fr.) Fr. |
| Stereum gausapatum Fr.        | Trametes cervina (Schw.) Bres         |
| Stereum hirsutum (Willd. ex Fr.) S. F. Gray | Daedalea albida Fr.                  |
| Hymenochaetaceae              | Daedalea borealis. (Fr.) Quél.        |
| Hymenochaete mougeotii (Fr.) Cooke. | Daedaleopsis rubescens (Alb. ex Schw. : Fr.) Imaz. |
| Ganodermataceae               | Daedalea quercina (L. ex Fr.) Br.     |
| Ganoderma tsugae Murr.        | Polyporellus pseudosquamosus (Pers.) Pat. |
| Ganoderma applanatum (Pers.) Pat. | Phellinus hartigii (Allesch. ex Schnabl) Imaz. |
| Hericiaceae                   | Phellinus squamosus (Huds. ex Fr.) Ames. |
| Hericium caput-medusae (Bull. ex Fr.) Pers. | Polyporellus porphyrosporus (Fr.) Karst. |
| Hericium ramosum (Bull. ex Merat) Letellier | Spongipellis squamosus (Sow. ex Fr.) Pat. |
| Hericium abietis (Weir ex Hubert) | Agaricales | Spongipellis squamosus (Sow. ex Fr.) Pat. |
| Polyporaceae                  | Cryptoporus volvatus (Peck) Hubb.    |
| Phellinus hartigii (Allesch. ex Schnabl) Imaz. | Phellinus ochraceus (Batsch. ex Fr.) Murr. |
| Polyporellus porphyrosporus (Fr.) Karst. | Spongipellis spumeus (Sow. ex Fr.) Pat. |
| Spongipellis spumeus (Sow. ex Fr.) Pat. | Agaricales | Spongipellis spumeus (Sow. ex Fr.) Pat. |
| Cryptoporus volvatus (Peck) Hubb. | Phellinus ochraceus (Batsch. ex Fr.) Murr. |
| Hydnaceae                     | Phellinus ochraceus (Batsch. ex Fr.) Murr. |
| Hirschioporus lacteus (Fr.) Teng. | Spongipellis squamosus (Sow. ex Fr.) Pat. |
| Steccherinum ochraceum (Pers. ex Fr.) Gray | Agaricales | Spongipellis spumeus (Sow. ex Fr.) Pat. |
| Pyroporaceae                  | Cryptoporus volvatus (Peck) Hubb.    |
| Pleurotaceae                  | Phellinus ochraceus (Batsch. ex Fr.) Murr. |
| Agaricales                    | Phellinus ochraceus (Batsch. ex Fr.) Murr. |
| Pyroporaceae                  | Phellinus ochraceus (Batsch. ex Fr.) Murr. |
| Pleurotaceae                  | Phellinus ochraceus (Batsch. ex Fr.) Murr. |
| Agaricales                    | Phellinus ochraceus (Batsch. ex Fr.) Murr. |
Inonotus nodulosus (Fr.) Pilat.
Fomes populinus (Schum. ex Fr.) Cooke
Hirschioporus pargamenus (Fr.) Bond. et Singer
Hirschioporus abietinus (Dicks. ex Fr.) Donk.
Hirschioporus laricinus (Karst.) Teram
Coriolus unicolor (L. ex Fr.) Pat.
Lenzites betalina (L. ex Fr.) Fr.
Lenzites tricolor (Bull.) Fr. var. rubescens
Pholiota sphaeroides (Peck) Sacc.
Pholiota adioxide (Fr.) Quel
Hymenochaetaceae
Corticium seminulatus (Pers.) J.E. Lange
Psathyrellaceae
Psathyrella candolleana (Fr.) A. H. Smith
Tremellales
Tremella fuciformis Berk
Tremella foliacea (Pers.) Fr.

3.2. Xian-weng Mountain National Forest Park White Rot Fungi Advantage Division

The investigation found that there are 64 species of white rot fungi in Xian-weng Mountain National Forest Park, belonging to 14 families. Among them, there are 3 families with more species (≥4 species), followed by Polyporaceae, Glomus and Pleurotus. Although the above three subjects accounted for only 21.43% of the total number of surveyed subjects, the number of white rot fungi included was 44, accounting for 67.69% of the investigated species. The most common species were Polyporaceae, which contains 36 species of white rot fungi, accounting for 55.39% of the total number of surveys. In addition, according to the order of the species, the order of the species were Hericiaceae, Phytophthora, Grey Hammer, G. edulis, Tremella, Ganoderma lucidum, Helminthaceae, Aspergillus, Coprinus and Mushroom branch. (in Table 2).

Table 2. List of dominant family of white rot fungi

| Family Name          | Number of species | proportion | Family Name          | Number of species | proportion |
|----------------------|-------------------|------------|----------------------|-------------------|------------|
| Steraceae            | 3                 | 4.62%      | Pluteaceae           | 2                 | 3.08%      |
| Hymenochaetaceae     | 1                 | 1.54%      | Strophariaceae       | 4                 | 6.16%      |
| Ganodermataceae      | 2                 | 3.08%      | Psathyrellaceae      | 1                 | 1.54%      |
| Hericiaceae          | 3                 | 4.62%      | Tremella fuciformis Berk | 2                 | 3.08%      |
| Polyporaceae         | 36                | 55.93%     | Exidia               | 1                 | 1.54%      |
| Hydnaceae            | 2                 | 3.08%      | Psathyrellaceae      | 1                 | 1.54%      |
| Pleurotaceae         | 4                 | 6.16%      | Tulostomataceae      | 3                 | 4.62%      |
| total                | 64                | 100%       |                      |                   | ---        |

3.3. Distribution of white rot fungi in different forests in Xian-weng Mountain National Forest Park

From the aspects of vegetation types (broad-leaved forests, mixed forests, coniferous forests, grasslands, and shrubs) grown by white rot fungi, the white rot fungi in Xian-weng Mountain National Forest Park mostly grow in broad-leaved forests and coniferous forests. In mixed forests, there were fewer white rot fungi that grow in grass and shrubs. Among them, there were 27 species of white rot fungi in broad-leaved forests, accounting for 41.54% of the number of white rot fungi investigated; 15 species were found in coniferous forests, accounting for 23.08% of the total; 12 species were grown in mixed forests, accounting for 18.46% of the total (in Figure 1).
4. Conclusions

Xian-weng Mountain National Forest Park belongs to the primary and secondary mixed forests. The trees and rot are interlaced, and the litter layer is deep and fertile, which provides a good environment for the growth of white rot fungi. This study was collected in Xian-weng Mountain National Forest Park. There were 305 specimens of white rot fungi, belonging to 64 species of 4 orders, 14 orders and 4 orders of Basidiomycota. The investigation found 64 species of white rot fungi in the Xian-weng Mountain National Forest Park area, belonging to 14 families. Some scholars have found that the large fungi resources in the Daliangzi River National Forest Park are abundant. There were 71 species of wood rot fungi have been found. The Xian-weng Mountain National Forest Park is adjacent to the Daliangzi River National Forest Park and the ecological environment is similar. The results of this survey were consistent with this. It showed that the white rot fungi resources in Xian-weng Mountain National Forest Park are rich, and further supplement the research data of fungi resources in Xian-weng Mountain National Forest Park, which provides a basis for the development and utilization of white rot fungi resources in this area.

The investigation found that white rot fungi are widely distributed. Among them, the number of white rot fungi growing in forest land was as high as 44, accounting for 67.69% of the investigated species. White rot fungi mostly distributed in broad-leaved forests, followed by mixed forests and coniferous forests. The three forests were the preferred host of white rot fungi, white rot fungi grown in 3 families of Polyporaceae, Pleurotus ostreatus and Glomus. It is the dominant species, while the white rot fungi that grow in shrubs and forest margins are relatively few. The survey found that 50% of the large fungi in the Hailuogou reserve in Sichuan Province distribute in broad-leaved forests, 30% in coniferous forests, 20% in mixed forests, and very few fungi in grassland and shrubs. The forest type is consistent. The reason for the analysis may be that the soil moisture, pH, light intensity and other conditions in the forest environment are more conducive to the survival of white rot fungi than shrubs and forest edge grassland[9].

5. Discussion

Xian-weng Mountain National Forest Park is rich in white rot resources. Through investigation, collection and identification, 64 species of white rot fungi were found, belonging to 14 families. Among the 14 families of white rot fungi, there were more than 3 species of Polyporaceae, Pleurotus ostreatus and Pleurotus ostreatus, including 44 species, accounting for the number of species 67.69%; the largest family is Polyporaceae, including 36 species, accounting for 55.39%. The white rot fungi in Xian-weng Mountain National Forest Park distribute in broad-leaved forest, followed by mixed forest and coniferous forest. There were 54 species of forest land, accounting for 83.01% of the
species, but less white rot fungi with grassland and shrub. The white rot fungus resources in the woodland of Xian-weng Mountain National Forest Park are abundant, and the white rot fungi growing in forest land have good development and application prospects.

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