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RESEARCH ARTICLE

# Potential pharmaceutical resources of the Qinling Mountain in central China: medicinal fungi

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**Abstract** The present investigation on fungal diversity shows that there were rich fungal resources of up to 196 species, belonging to 41 families and 90 genera, in the Qinling Mountainous Range of central China. The dominant families were *Polyporaceae*, *Russulaceae*, *Tricholomatacea* and *Lycoperdaceae*, which comprised 107 species, 54.59% of the total species. The dominant genera were *Russula, Lactarius, Trametes, Phellinus, Coprinus, Lycoperdon, Suillu,* and *Calvatia*, which consisted of 59 species, 30.09% of the total species. According to the geographical characteristics, the genera were grouped into: cosmopolitan element (74.98%), pantropical element (3.57%), tropical element (1.02%) and north temperate element (21.43%), with the cosmopolitan element constituting the majority. Among these, the cosmopolitan and North Temperate Zone were characteristic of this region. Based on relevant literature review, the primary pharmaceutical action of the medicinal fungi in Qinling Mountain can be classified as follows: anti-cancer, anti-bacteria, anti-inflammation, relief of muscle rigidity and activation of collaterals, hemostasis, immunological regulation, as well as nourishing the stomach and tonification which means enhancing the body system.

**Keywords** medicinal fungi, floristic, pharmacological function, diversity, Qinling Mountains

## 1 Introduction

The Qinling Mountain Range, outlying the Kunlun Mountains, between the Wei and Han rivers, is located in the center of China (104°30′–115°52′E, 32°50′–34°45′N) and stretches from east Gansu Province in the west to west Henan Province in the east, with an average elevation of 2000 to 3000 meters. Its main peak, Mount Taibai, is 3767 meters above sea level. The range is wooded and coal is mined in the central region. The Qinling Mountain Range, with the Huai River to the east, marks the geographical boundary between north and central China. Rice and citrus fruits are generally not found south of this line. The area is an integrated region of the Palaearctic realm and the Oriental realm and a transitional district of the North Subtropics Zone and the Warm Temperate Zone.

Due to the obvious differences in property and structure between the north and south slopes, the climate in the cliffy North Slope, with little rainfall, is similar to the climate of Warm Temperate Zone and Frigid Zone. The climate in the gentle South Slope, with sufficient rainfall is similar to that in the Subtropics Zone. This region holds diverse vegetation distributions up and down the mountains and has an average temperature of 13.3°C. The extremely highest temperature is 45.2°C and the lowest is −20.6°C. The annual rainfall is up to 604.2 mm. Meanwhile, the freezing season lasts 158 days.

The unique ecological environment, a long history of geological formation and various biological resources in the Qinling Mountainous Ranges provide favorable conditions for fungal growth and reproduction as they can absorb sufficient nutrition and other essential elements. However, data on fungus resources are relatively few as there are only a few small scale investigations (Wang et al., 1999; Tian et al., 2000; Zhang et al., 2005; Zhang and Cao, 2007). With regard to detailed data on fungal resources in the whole Qinling Mountainous Ranges, especially of medicinal fungus resources, reports are even rare. Therefore, the current study was carried out to investigate the resources of pharmaceutical fungi in the Qinling Mountainous Ranges, focusing on the distributions and medical therapeutic functions of the fungi.

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**Table 1** Fungi resources in the Qinling area

| species | distribution | primary function | species | distribution | primary function |
|---|---|---|---|---|---|
| *Agaricus arvensis* | ① | AT | *Merulius tremellusus* | ① | AT |
| *Agaricus bisporus* | ① | AT | *Morchella conica* | ② | AT |
| *Agaricus campestris* | ① | AB | *Morchella crassipes* | ② | AT |
| *Agrocybe erebia* | ① | AT | *Morchella deliciosa* | ② | AT |
| *Agrocybe praecox* | ① | AT | *Morchella esculenta* | ② | AT |
| *Amanita agglutinata* | ① | OT | *Mycena alcalina* | ① | AT |
| *Armillariella mellea* | ① | AB | *Mycena galericulate* | ① | AT |
| *Armillariella tabescens* | ① | AB | *Mycena haematopus* | ① | AT |
| *Auricularia auricula* | ① | OT | *Mycena prua* | ① | AT |
| *Auricularia polytricha* | ① | OT | *Naematoloma fasciculare* | ① | AT |
| *Beauveria bassiana* | ② | AB | *Naematoloma squamosum* | ① | AT |
| *Bjerkandera fumosa* | ④ | AT | *Naematoloma sublateritium* | ① | AT |
| *Boletus edulis* | ① | OT | *Oudemansiella radiata* | ① | AT |
| *Bovista plumbea* | ② | AB | *Oudenlansiella mucida* | ① | AV |
| *Bovistella sinensis* | ② | AT | *Panellus stypticus* | ① | AT |
| *Calvatia caelata* | ① | AB | *Panus torulosus* | ① | AT |
| *Calvatia candida* | ① | OT | *Peziza sylvestris* | ② | AT |
| *Calvatia craniiformis* | ① | AB | *Phallus rubicundus* | ① | AV |
| *Calvatia gigantea* | ① | OT | *Phallus rubicundus* | ① | AV |
| *Calvatia lilacina* | ① | AB | *Phellinus conchatus* | ① | AV |
| *Cantharellus cibarius* | ① | OT | *Phellinus hanigii* | ① | AT |
| *Cantharellus minor* | ① | OT | *Phellinus igniarius* | ① | AT |
| *Cantharellus tubaeformis* | ① | AB | *Phellinus linnteus* | ① | AT |
| *Claviceps purpurea* | ① | OT | *Phellinus pini* | ① | AT |
| *Clavicorona pyxidata* | ② | OT | *Phellinus pomaceus* | ① | AT |
| *Clitocybe infundibuliformis* | ① | AB | *Phillinus gilvus* | ① | AT |
| *Coprinus atramentarius* | ① | AT | *Phlogiotis helvelloides* | ③ | AT |
| *Coprinus comatus* | ① | AB | *Phonliota adiposa* | ② | AT |
| *Coprinus lagopus* | ① | AT | *Piptoporus betulinus* | ① | AT |
| *Coprinus micaceus* | ① | AT | *Pleurotus ostreatus* | ① | AT |
| *Coprinus plicatilis* | ① | AT | *Podostroma yunnansis* | ① | OT |
| *Coprinus sterquilinus* | ① | OT | *Polyporellus melanopus* | ① | AT |
| *Cordyceps cicadicola* | ① | AT | *Polyporus elegans* | ① | OT |
| *Cordyceps militaris* | ① | AT | *Polyporus mylittae* | ① | OT |
| *Cordyceps sinensis* | ① | AT | *Polyporus umbellatus* | ① | AT |
| *Coriolus consors* | ① | AT | *Polyporus varius* | ① | AT |
| *Coriolus hirsutus* | ① | AT | *Poria cocos* | ① | AT |
| *Coriolus unicolor* | ① | AT | *Poria eupora* | ① | AT |
| *Coriolus versicolor* | ① | AT | *Poxillus involotes* | ③ | OT |
| *Cortinarius cinnamomeus* | ② | AT | *Pseudoclitocybe cyathiformis* | ② | AT |
| *Cortinarius elatior* | ② | AT | *Pulveroboletus ravenelii* | ① | OT |
| *Cortinarius mucifluus* | ② | AT | *Pyropolyporus fomentarius* | ② | AT |
| *Cyathus stercoreus* | ① | OT | *Pyropolyporus mc. gregori* | ① | AT |
| *Cyathus striatus* | ② | OT | *Rhodophyllus abortivus* | ① | AT |
| *Daedalea albida* | ① | AT | *Russula alutacea* | ① | OT |
| *Daedalea biennis* | ① | AT | *Russula crustosa* | ① | AT |
| *Daedalea dickinsii* | ① | AB | *Russula cyanoxantha* | ① | AT |
| *Daedaleopsis confragosa* | ① | AT | *Russula densifolia* | ① | OT |
| *Daedaleopsis tricolor* | ① | AT | *Russula emetica* | ① | OT |
| *Favolus alveolaris* | ① | AT | *Russula fotens* | ① | AT |
| *Favolus arcularius* | ① | AT | *Russula integra* | ① | OT |
| *Flammulina velutipes* | ② | AT | *Russula lepida* | ① | AT |
| *Fomes fomentarius* | ② | AT | *Russula lilacea* | ① | AT |
| *Fomes officinalis* | ② | AT | *Russula nigricans* | ① | AT |
| *Fomitopsis pinicola* | ① | AT | *Russula rubra* | ① | OT |
| *Fuscoporia punctata* | ① | OT | *Russula virescens* | ① | AB |
| *Ganoderma applanatum* | ③ | AT | *Schizophyllum commune* | ① | AT |
| *Ganoderma lucidum* | ③ | AV | *Scleroderma bovista* | ① | AB |
| *Ganoderma sinense* | ③ | AV | *Sclerospora graminicola* | ② | OT |
| *Geastrum hygrometricum* | ① | OT | *Shiraia bambusicola* | ② | OT |
| *Geastrum triplex* | ① | AV | *Sparassia crispa* | ① | AB |
| *Gloeophyllum saepiarium* | ① | AT | *Sphacelotheca sorghi* | ② | OT |
| *Helvella elastica* | ① | OT | *Stereum gausapatum* | ① | AT |

(*Continued*)

| species | distribution | primary function | species | distribution | primary function |
|---|---|---|---|---|---|
| *Helvella sulcata* | ① | OT | *Stereum hirsutum* | ① | AT |
| *Hericium coralloides* | ② | OT | *Stereum ostrea* | ① | OT |
| *Hericium erinaceus* | ② | AT | *Stereum purpureum* | ① | OT |
| *Hirschioporus abietinus* | ① | AT | *Stereum sanquinolentum* | ① | OT |
| *Hirschioporus fusco-violaceus* | ① | AT | *Stropharia rugosoannulata* | ① | AT |
| *Hirschioporus pargamenus* | ① | AT | *Suillus bovinus* | ② | AT |
| *Hohenbuehelia serotina* | ① | OT | *Suillus granulatus* | ② | AT |
| *Irpex lacteus* | ② | AB | *Suillus grevillei* | ② | AT |
| *Ischnoderma resinosum* | ① | AT | *Suillus laricinus* | ② | AT |
| *Laccaria amethystea* | ① | AT | *Suillus luteus* | ② | AT |
| *Lactarius camphoratum* | ② | AT | *Termitomyces albuminosus* | ④ | OT |
| *Lactarius hatsudake* | ② | AT | *Thelephora vialis* | ① | OT |
| *Lactarius hygroporoides* | ② | AT | *Trametes albida* | ① | AT |
| *Lactarius insulsus* | ② | AT | *Trametes cinnabarina* | ① | AV |
| *Lactarius pallidus* | ② | AT | *Trametes gallica* | ① | AT |
| *Lactarius picinus* | ② | AT | *Trametes gibbosa* | ① | AT |
| *Lactarius piperatus* | ② | AT | *Trametes hispida* | ① | AT |
| *Lactariusvellereus* | ② | AT | *Trametes robiniophila* | ① | OT |
| *Lactarius volemus* | ② | AT | *Trametes sanquinea* | ① | AT |
| *Laetiporus sulphureus* | ① | AT | *Trametes suaveolens* | ① | AT |
| *Lasiosphaera fenzlii* | ① | OT | *Trametus dickinsii* | ① | AT |
| *Lentinus edodes* | ③ | AV | *Tremella aurantialba* | ① | OT |
| *Lentinus lepideus* | ③ | AT | *Tremella fimbriata* | ① | OT |
| *Lenzites betulina* | ① | AB | *Tremella foliacea* | ① | OT |
| *Lepista irina* | ② | AT | *Tremella fuciformis* | ① | AB |
| *Leucopaxillus giganteus* | ① | AB | *Tricholoma album* | ① | AT |
| *Lycoperdon perlatum* | ① | AB | *Tricholoma robustum* | ① | AT |
| *Lycoperdon pusillum* | ① | AB | *Tricholoma vaccinum* | ① | AT |
| *Lycoperdon pyriforme* | ① | AB | *Tyromyces caesius* | ① | OT |
| *Lycoperdon pyriforme* | ① | AB | *Tyromyces chioneus* | ① | OT |
| *Lycoperdon umbrinum* | ① | AB | *Tyromyces pubescens* | ① | AT |
| *Lycoperdon wrightii* | ① | AB | *Ustilaginoides virens* | ② | AB |
| *Marasmiellus ramealis* | ① | AT | *Ustilago crameri* | ① | OT |
| *Marasmius androsaceus* | ① | AT | *Ustilago nuda* | ② | OT |
| *Marasmius oreades* | ① | AT | *Xanthochrous hispidus* | ① | AT |

Distribution: ①Cosmopolitan; ②North temperate; ③Pantropic; ④Tropics. Main function: AT, antitumor (anti-carcinogenic); AB, antibiotic; AV, antivirus; OT, others

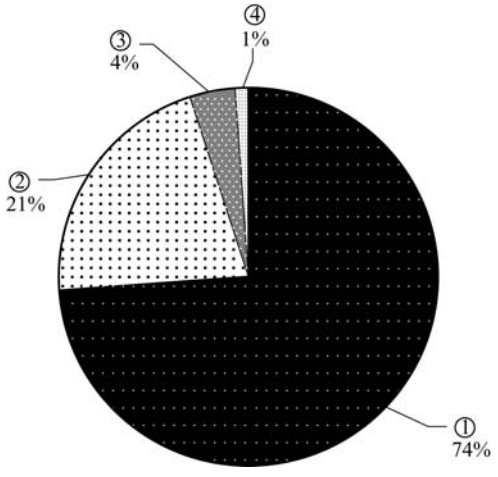


**Fig. 1** Percentage of fungi resources in different geographical distributions

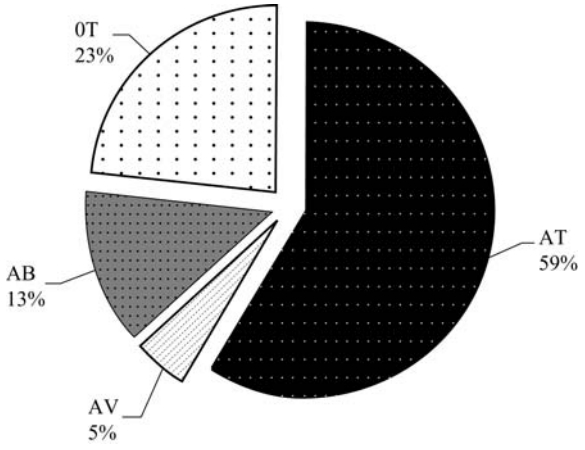


**Fig. 2** Percentage of fungi resources with different functions

## 2 Research methods

Through a lot of field investigations in different sample lines around the Qinling Mountain, we collected many valuable medicinal mushroom samples. We classified their distributions into cosmopolitan, north temperate, pantropic and tropics according to Xu (1997). Their main functions were divided into AT (anti-tumor or anti-carcinogenic), AB (antibiotic), AV (antivirus) and OT (others, including relief of muscle rigidity and activation of collaterals, hemostasis, immunological regulation, nourishment of the stomach and tonification which means enhancement of the body system), based on previous studies by Ellis (2007), Li et al. (2007), Song and Sun (2007), Xu (1997) and Zhuang (2005).

## 3 Medicinal fungus resources

The survey results demonstrated that fungi resources were up to 196 species, belonging to 41 families and 90 genera (Table 1). The dominant families were *Polyporaceae*, *Russulaceae*, *Tricholomatacea* and *Lycoperdaceae*, which contained 107 species and accounted for 54.59% of the total species. The dominant genera were *Russula*, *Lactarius*, *Trametes, Phellinus*, *Coprinus*, *Lycoperdon, Suillus* and *Calvatia*, which comprise 59 species and 30.09% of the total species.

### 3.1 Geographical distributions of fungi resources

The main distributions of fungal resources in this area were classified into 4 general groups based on their habitat selection (Fig. 1). From the geographical perspective, the genera were grouped into: (1) Cosmopolitan element (74.98%), (2) North temperate element (21.43%), (3) Pantropical element (3.57%) and (4) Tropical element (1.02%). The cosmopolitan element was the major component, and cosmopolitan and North Temperate Zones were characteristic of this region.

### 3.2 Pharmaceutical functions of the fungi

The Qinling Mountainous Ranges are rich in biological resources, most of which possess medical therapeutic functions such as fungi. According to Chu et al. (1995), Wang (2005) and Zhao et al. (2003), the primary pharmaceutical action of the medicinal fungi in the Qinling Mountain includes antitumor, antibiotic, antivirus and others, such as relief of muscle rigidity and activation of collaterals, hemostasis, immunologic regulation, nourishment of the stomach and tonification, which means the enhancement of the body system(s). As displayed in Figure 2, the anti-tumor (AT) fungi constituted more than half (59%) of the total, followed next by others (OT), 23.47%; antibiotic type, 13.27%; and antivirus type, 4.59%, respectively.

## 4 Discussion

The Qinling Mountainous Ranges have been recognized as the region with most abundant biodiversity in China. Due to their geographical location, which is remote from urban areas, and with little human interference, fungal growth and development have cycled favorably. However, the deterioration of environmental quality has slightly affected this region as well. Over the past years, a large number of Chinese scholars paid countless visits to this important area. From the perspective of geographical distributions of fungi resources, the cosmopolitan element and north temperate element took up more than 95% of fungal distribution types in the Qinling region, which is accorded to the general temperate climate and habitat status.

In China, fungi have long been recognized as one of the most dramatic resources in disease treatment. In the Qinling region, antitumor or anticancer fungi take up more than a half of the total fungi. In order to protect the rich pharmaceutical resources, it is suggested that the following measures be taken. First, we should re-enforce environmental management and quality control. Second, the concept of biodiversity conservation should be promoted not only in local neighborhoods, but also in nearby cities of the Qinling region. Third, further research on the biology, ecology and medical functions of fungi should be carried out. Finally, we should increase the extent of manual planting and effective taming for fungal application. Moreover, downstream engineering of fungi is a trend in order to yield new products.

## References

Chu M, Truumees I, Patel M, Blood C, Das P R, Puar M S (1995). Sch 50673 and Sch 50676, Two Novel Antitumor Fungal Metabolites. The Journal of Antibiotics, 48(4): 329–331

Ellis D, Davis S, Alexiou H, Handke R, Bartley R (2007). Descriptions of medical fungi. Adelaide, South Australia, Australia: Nexus Print Solutions

Li L Y, Jin H, Zhang J Y, Li R C (2007). A Brief Account of Chinese Medical Fungi. Journal of Microbiology, 27(2): 57–61 (in Chinese)

Song G, Sun L H (2007). The Study on the Resources of Edible and Medical Fungi in Honghuaerji Nature Reserve. Journal of Inner Mongolia Agricultural University (Natural Science Edition), 28(3): 345–347 (in Chinese)

Tian C M, Wang J R, Yang J X, Dai S F, He S L, Zhang W J (2000). The Distributional Features of Macro fungi in the Taibaishan Mts. Journal of Northwest Forestry University, 15(3): 62–67 (in Chinese)

Wang H J (2005). Varieties and development of medical fungi. Journal of Zhengzhou College of Animal Husbandry & Engineering, 25(1): 7–10 (in Chinese)

Wang M L, Ren Y, Dang G D (1999). The mushrooms in Foping nature preserve (II). Journal of Northwest University (Natural Science Edition), 29(6): 595–597 (in Chinese)

Xu J T (1997). Chinese Medicinal Mycology. Beijing: United Press of Beijing Medical University and Peking Union Medical College (in Chinese)

Zhang C X, Cao Z M (2007). Primary Analysis of Macro fungi Flora of Huoditang Mtrs. Journal of Yunnan Agricultural University, 22(3): 345–348 (in Chinese)

Zhang C X, Cao Z M, Gao Z H (2005). Distributional Features of Macrofungi in Huoditang Forest Farm. Journal of Northwest Forestry University, 20(1): 127–131 (in Chinese)

Zhao H P, Zhang X T, Ma Z S, Fan M Z, Li Z Z (2003). Research Progress on Antineoplastic Fungal Drug. Journal of Anhui Agricultural University, 30(4): 462–465 (in Chinese)

Zhuang Y (2005). The Present Condition and Looking Forward to Chinese Medicinal Fungus. Edible Fungi of China, 24(5): 1–4 (in Chinese)