Chapter 6
Edible Mushrooms and Their Cultural Importance in Yunnan, China

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6.1 Introduction

Yunnan is a province in southwest China, which is famous for its rich biological and cultural diversity (Fig. 6.1). Northwest Yunnan is adjacent to the Eastern Himalayas and has many high snowy mountains over 5000 m in altitude and deep valleys. In the south of the province are tropical rainforests and dry hot valleys. Between these extremes there is a plateau. Elevation varies from 6740 m in the northwest to only 80 m in the south. Three rivers run north to south, and lakes are widespread. Such diverse topography created a variety of climates and nourished a rich biodiversity. Yunnan is recognized as a global biodiversity hotspot (Myers et al. 2000) The province is considered a center of distribution and divergence of many plants in the Fagaceae and the Pinaceae and of edible mushrooms such as *Tricholoma matsutake* (Zhou 1992; Li 1995; Murata et al. 2008). Visitors travelling to Yunnan during the mushroom season from June to October are impressed by the variety and the delicacy of mushrooms available in countless markets and restaurants. However, scientific knowledge of the diversity of the wild edible and medicinal mushroom in the region is still limited (Ying and Zang 1994; Wang and Liu 2002; Wang et al. 2004). More detailed and systematic surveys are needed.

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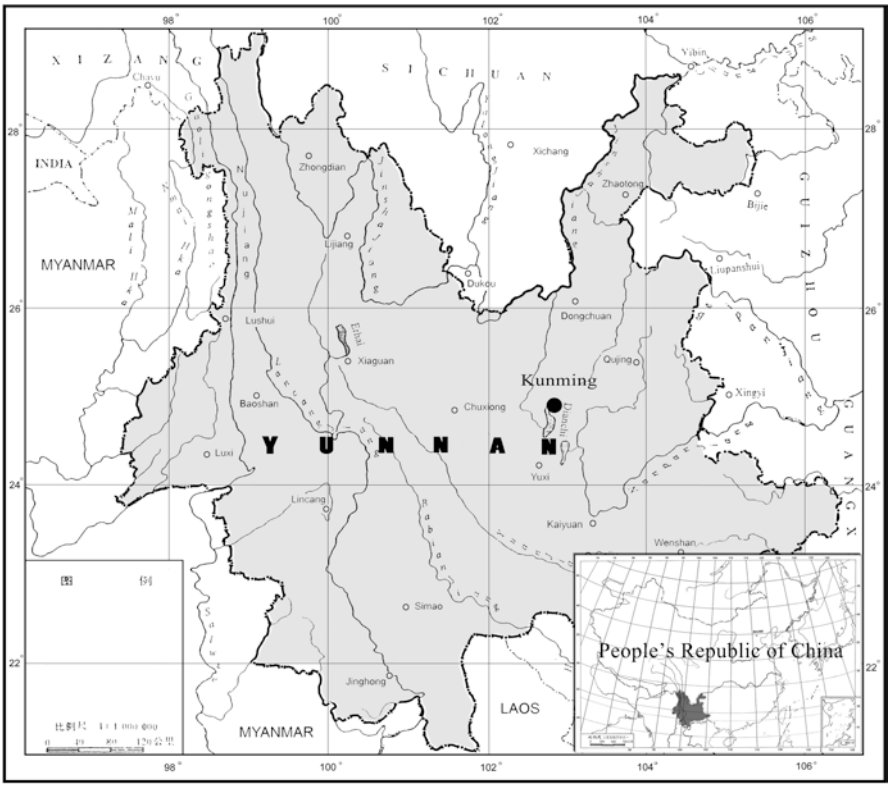

Fig. 6.1 Map of Yunnan

6.2 Diversity of Edible Mushroom in Yunnan

6.2.1 Wild Edible Mushrooms

The great variation in climate and topography has created very diverse habitats and species in Yunnan. This diversity has been sustained over geological time because of the light impact of the Quaternary glaciation on Yunnan, in comparison with its effects in Europe and North America, where the land was largely covered by glacial ice. Yunnan has the world's richest diversity of wild edible mushrooms, with over 600 edible species recorded (mycorrhizal and saprobes), which represents around 75% of the nation's total (Wang and Yang 2006). In 2011, production of edible mushrooms was over 135,000 tons, 51.85% of which were wild edible mushrooms (Tan 2012). Over 90% of these were ectomycorrhizal mushrooms. At local markets, it is possible to find 321 species of wild edible mushrooms, of which 164 are commonly traded. From 2006 to 2013, over 50,000 tons of edible mushrooms were exported annually (Sheng 2013). China is the world's largest exporter of matsutake (*T. matsutake*), and over 90% is produced in Yunnan (Wang et al. 1997). China is

Fig. 6.2 Yi people in Chuxiong, Yunnan

also emerging as a truffle-producing nation, and more than 60% of its truffles are harvested in Yunnan (Wang et al. 2008). Yunnan has 24 ethnic minorities such as Yi, Bai, Tibetan, Thai, Hani, Naxi, Miao, and Lisu (Fig. 6.2). Most of these people live in mountainous regions (Pei 2004), and wild edible mushrooms are an important livelihood in these areas (Wang and Hall 2004; Wang et al. 2008; Yang et al. 2009). Production of wild edible mushrooms has declined since large-scale commercial harvesting began in the 1990s. Protection and restoration of wild edible mushroom resources are urgent.

6.2.2 Commercial Wild Mushrooms

Every county in Yunnan has at least one wild mushroom market trading wild edible mushrooms harvested from surrounding forests (Fig. 6.3). At the main markets such as in Kunming and Nanhua, hundreds of tons of wild edible mushrooms change hands daily during mushroom season from June to October. A total of 321 species, belonging to 101 genera, and 47 families were identified as wild mushrooms traded in the local markets (Appendix) (Petersen and Zang 1986, 1989, 1990; Ying and Zang 1994; Wang and Liu 2002; Wang et al. 2004, 2009; Wang and Yao 2005; Yu and Liu 2005; Tang et al. 2006; Wang and Yang 2006; Wei et al. 2006, 2009; Yu et al. 2006; Zang 2006, 2013; Kirk et al. 2008; Zheng and Liu 2008; Li 2009; Li et al. 2009, 2011a, b, 2014a, b; Tian et al. 2009, 2012; Dai et al. 2010; Zhang 2010;

Fig. 6.3 Mushuihua wild edible mushroom market at Kunming

Shao 2011; Shao et al. 2011, 2012, 2014, 2016; Wang and Liu 2011; Zeng 2011, Zeng et al. 2013, 2014a, b; Cao et al. 2012; Fan and Cao 2012; Fan et al. 2012a, b, 2013, 2014; Tang 2013; Yu and Liu 2013; Tang and Yang 2014; Deng et al. 2013; Shi 2013; Zhao et al. 2013, 2015; Zhao et al. 2014a, b; Cui et al. 2015; Tang et al. 2015; Wang et al. 2015a, b; Wu et al. 2015; Yang 2015; Wang 2016). Of these commercial mushrooms, Boletaceae was the best represented family, with 27 genera and 23.05% (74 spp.) of the total species. Russulaceae, with 9.97%, includes *Russula* (15 spp.), *Lactarius* (13 spp.), and *Lactifluus* (4 spp.). Those traded in Gomphaceae, include 4 genera with 26 species, and *Ramaria* is the most species-rich genus in this family,with 22 species and 6.83% of the total. Nineteen species were in Cantharellaceae (5.92%), 16 in Tricholomataceae (4.98%), 13 in Tuberaceae (4.05%), and 11 in Lyophyllaceae (3.43%), Amanitaceae (3.12%), and Helvellaceae (3.12%). More than 164 species in the genera *Albatrellus*, *Amanita*, *Boletus*, *Cantharellus*, *Helvella*, *Lactarius*, *Morchella*, *Phylloporus*, *Ramaria*, *Russula*, *Suillus*, *Termitomyces*, *Tricholoma*, and *Tuber* were found to represent 51.09% of the total wild mushroom species in the Yunnan's local markets (Table 6.1).

We have listed 60 dominant commercial species in Yunnan belonging to the genera *Boletus*, *Cantharellus*, *Lactarius*, *Russula*, *Termitomyces*, *Tricholoma*, *Ramaria*, etc. (Table 6.2). The main commercial mushroom species sold in Yunnan and China (Boa 2004; Yu and Liu 2005), ordered by quantity and frequency of their appearance in markets, are listed in the Appendix.

Table 6.1 Species, genera, and families of commercial wild mushrooms in Yunnan

Family	No. of genera (%)	No. of species (%)
Basidiomycota		
Boletaceae	27 (27)	74 (23.05)
Russulaceae	3 (3)	32 (9.97)
Gomphaceae	4 (4)	26 (8.10)
Cantharellaceae	2 (2)	19 (5.92)
Tricholomataceae	7 (7)	16 (4.98)
Lyophyllaceae	2 (2)	11 (3.43)
Amanitaceae	1 (1)	10 (3.12)
Albatrellaceae	2 (2)	8 (2.49)
Bankeraceae	3 (3)	7 (2.18)
Ganodermataceae	2 (2)	7 (2.18)
Suillaceae	1 (1)	7 (2.18)
Polyporaceae	4 (4)	6 (1.87)
Thelephoraceae	2 (2)	6 (1.87)
Agaricaceae	3 (3)	5 (1.56)
Gomphidiaceae	2 (2)	4 (1.25)
Physalacriaceae	2 (2)	3 (0.93)
Hydnangiaceae	1 (1)	4 (1.25)
Hygrophoraceae	1 (1)	4 (1.25)
Sclerodermataceae	2 (2)	3 (0.93)
Auriculariaceae	1 (1)	3 (0.93)
Cortinariaceae	1 (1)	3 (0.93)
Hericiaceae	1 (1)	3 (0.93)
Pleurotaceae	1 (1)	3 (0.93)
Scutigeraceae	2 (2)	2 (0.62)
Gyroporaceae	1 (1)	2 (0.62)
Sparassidaceae	1 (1)	2 (0.62)
Boletinellaceae	1 (1)	1 (0.31)
Clavariaceae	1 (1)	1 (0.31)
Clavulinaceae	1 (1)	1 (0.31)
Entolomataceae	1 (1)	1 (0.31)
Hydnaceae	1 (1)	1 (0.31)
Inocybaceae	1 (1)	1 (0.31)
Meripilaceae	1 (1)	1 (0.31)
Meruliaceae	1 (1)	1 (0.31)
Omphalotaceae	1 (1)	1 (0.31)
Rhizopogonaceae	1 (1)	1 (0.31)
Schizophyllaceae	1 (1)	1 (0.31)
Tremellaceae	1 (1)	1 (0.31)
Ascomycota		
Tuberaceae	1 (1)	13 (4.05)
Helvellaceae	1 (1)	10 (3.12)

(continued)

Table 6.1 (continued)

Morchellaceae	1 (1)	7 (2.18)
Ophiocordycipitaceae	1 (1)	3 (0.93)
Cordycipitaceae	2 (2)	2 (0.62)
Leotiaceae	1 (1)	1 (0.31)
Nectriaceae	1 (1)	1 (0.31)
Shiraiaceae	1 (1)	1 (0.31)
Xylariaceae	1 (1)	1 (0.31)

6.2.3 Important Wild Edible Mushrooms

6.2.3.1 Matsutake

Tricholoma matsutake is a traditional, special delicacy in Japan, also popular in Korea and China. China is the biggest matsutake producer and exporter worldwide (Fig. 6.4). Ninety percent of Chinese matsutake are produced in Yunnan, especially in the northwest region, and exported yearly to Japan as fresh mushrooms (1000 tons, worth USD 50 million), frozen mushrooms (700 tons, USD ten million), and brined mushrooms (300 tons, USD 3.4 million), according to Wang et al. (1997).

T. matsutake is the most important species in the matsutake group. Three other related species have been found in Yunnan, including *T. bakamatsutake* Hongo, *T. fulvocastaneum* Hongo, and *T. lavendulophyllum* F. Q. Yu (Yu et al. 2006). *Tricholoma matsutake* associates with pine species in Korea, Japan, and northeast China. However, in Yunnan, in addition to growing with pines such as *Pinus yunnanensis*, it associates with many species in the Fagaceae including *Castanopsis delavayi*, *Cyclobalanopsis delavayi*, *Lithocarpus sphaerocarpus*, and *Quercus pannosa* (Fig. 6.5). Matsutake is thus called "qing-gang-jun" (evergreen oak mushroom) in southwestern China where it is harvested from oak-dominated forests (Yu 2007).

Tricholoma bakamatsutake is called "hua" (flower-like cracking pattern on cap) matsutake or fake matsutake and is only harvested by local people for domestic consumption in Yunnan (Fig. 6.6). It is quite similar to *T. matsutake* but can be distinguished by its shorter and thinner stem, dark brown zoned scales on cap, and stronger matsutake smell with a slight aroma of honey. It associates with species in the Fagaceae, such as *Quercus serrata* in Japan and northeast China, but in Yunnan, it can also be found with *Castanopsis* and *Lithocarpus* (Yu 2007).

6.2.3.2 Truffles

Yunnan has one of the richest truffle diversities in China and worldwide (Jeandroz et al. 2008; García-Montero et al. 2010; Wang and Liu 2011; Bonito et al. 2013). However, this truffle richness was unknown until the discovery, in 1989, of *Tuber sinense* (a taxon of the *Tuber indicum* complex) in Huidong County, Sichuan

Table 6.2 Dominant species of commercial wild mushrooms in Yunnan

Species name
Albatrellus ellisii
Amanita hemibapha var. *ochracea*
Auricularia delicata
Butyriboletus roseoflavus
Boletopsis grisea
Boletus bainiugan
Boletus reticuloceps
Boletus shiyong
Boletus sinoedulis
Boletus viscidiceps
Cantharellus cibarius
Cantharellus cinnabarinus
Cantharellus formosus
Catathelasma ventricosum
Craterellus tubaeformis
Cortinarius emodensis
Ganoderma cochlear
Ganoderma lingzhi
Hygrophorus russula
Laccaria laccata
Lactarius deliciosus
Lactarius hatsudake
Lactarius hygrophoroides
Lactarius vividus
Lactifluus volemus
Lanmaoa asiatica
Leccinum aurantiacum
Lentinula edodes
Lyophyllum shimeji
Morchella eximia
Morchella importuna
Morchella sextelata
Neoboletus brunneissimus
Ophiocordyceps sinensis
Phlebopus portentosus
Polypus dispansus
Ramaria eryuanensis
Ramaria hemirubella
Ramaria indoyunnaniana
Ramaria mairei
Rugiboletus extremiorientalis
Retiboletus fuscus
Russula compacta
Russula cyanoxantha

(continued)

Table 6.2 (continued)

Species name
Russula griseocarnosa
Russula virescens
Sarcodon imbricatus
Scleroderma yunnanense
Suillus pinetorum
Suterius magnificus
Termitomyces clypeatus
Termitomyces eurhizus
Termitomyces heimii
Termitomyces microcarpus
Thelephora ganbajun
Tricholoma matsutake
Tricholoma myomyces
Tuber indicum
Tuber liyuanum
Tuber pseudohimalayense

Fig. 6.4 *Tricholoma matsutake* on Shangri-La wild edible mushroom market

Province. Since then, more than 20 truffle species have been reported in Yunnan, including the commercial species *T. indicum*, *T. sinoaestivum*, and *T. pseudohimalayense* (Chen and Liu 2012; Fan and Cao 2012; Fan et al. 2012a, 2012b, 2013, 2014; Deng et al. 2013; Li et al. 2014a, b; Wan et al. 2017; Xu et al. 2017). Concurrently with increasing quantities of truffles exported to Europe, species from the *T. indicum* complex have been found in more than 20 counties in Yunnan. In

Fig. 6.5 Evergreen oak matsutake forests in northwest Yunnan

Fig. 6.6 *Tricholoma bakamatsutake* on Mushuihua wild edible mushroom market, Kunming

2006, 835 tons of fresh truffles (worth USD 26.19 million) were exported; most were from Yunnan. Recently, more than ten new white truffle species have been reported from Yunnan. Among these, *T. panzhihuanense* has been commercialized (Deng et al. 2013), and *T. liyuanum*, another newly described white truffle species,

Fig. 6.7 Truffle at Mushuihua wild edible mushroom market, Kunming

has commercial potential (Fan and Cao 2012). Harvesting and trading of truffles are quickly becoming a multimillion-dollar industry in Yunnan (Fig. 6.7).

Recent research on the *T. indicum* complex revealed that it is composed of two subspecies or species: Lineage A and Lineage B (Bonito et al. 2013; Qiao 2013; see also Chap. 2 by Wang et al. for more details). The ascocarps of *T. indicum* complex produced in dry-hot valleys have better taste than those from the plateau. The Gongshan truffles produced in the dry-hot valley of the Nu River are considered the best quality truffles of the *T. indicum* complex in Yunnan (Fig. 6.8), according to truffle dealers (Qiao et al. 2018).

6.2.3.3 Boletes

Porcini mushrooms (*Boletus* sect. *Boletus*) and closely related species are the most important wild edible mushrooms in Yunnan (Wang and Liu 2002). Around 1000 tons of dried porcini are annually exported to Europe and the USA, with a value of USD 19 million (Fig. 6.9). The majority of exported boletes are from Yunnan (Wu and Lu 2006).

Cui et al. (2015) indicated that Chinese porcini can be divided into 15 species, including nine new species, namely, *Boletus bainiugan*, *B. fagacicola*, *B. griseiceps*, *B. monilifer*, *B. sinoedulis*, *B. subviolaceofuscus*, *B. tylopilopsis*, *B. umbrinipileus*, and *B. viscidiceps*. In addition to porcini mushrooms, there are other popular edible boletoid mushrooms such as *Neoboletus brunneissimus*, *Retiboletus fuscus*, and *Rugiboletus extremiorientalis* (Wang and Yao 2005; Wu et al. 2014; Zhao et al. 2014a, b).

Fig. 6.8 The truffle habitat at Nu River valley, Gongshan, Yunnan (Photo by Shu-Hong Li)

Fig. 6.9 Dried sliced porcini at Mushuihua wild edible mushroom market, Kunming

Some boletes known as "jian-shou-qing" (turning blue when bruised or cut) are considered hallucinogenic, causing visions that Yunnan's people call "xiao-ren-ren" (little men or little people, similar to the "Lilliputian hallucinations" found in the Kuma people from New Guinea) (Arora 2008). Among these boletes are *Butyriboletus roseoflavus*, *Lanmaoa asiatica*, and *Sutorius magnificus*, all

Fig. 6.10 Jianshouqing boletes at Mushuihua wild edible mushroom market, Kunming

commonly collected in Yunnan and even more popular than porcini (Fig. 6.10) (Wang et al. 2004). Though some of these species can cause gastrointestinal distress, the local people continue to consume them (Arora 2008).

Eleven boletes, some causing confusion/uncertainty in persons and some producing toxic effects to animals in lab test, were found commonly mixed with commercial edible species in Yunnan's mushroom markets (Fig. 6.11). These are *Boletellus ananas*, *Buchwaldoboletus hemichrysus*, *Heimioporus retisporus*, *Pulveroboletus ravenelii*, *Suillellus queletii*, *Sutorius eximius*, *Tylopilus neofelleus*, *T. otsuensis*, *T. plumbeoviolaceus*, *T. virens*, and *Gyroporus castaneus* (Wang et al. 2004; Li 2009; Li et al. 2011a, b; Wu et al. 2014).

Suillus pinetorum and other six closely related species (*S. cavipes*, *S. granulatus*, *S. grevillei*, *S. luteus*, *S. pictus*, and *S. sibiricus*) are common ectomycorrhizal edible mushrooms in Yunnan (Fig. 6.12). Thirty-two species of this genus have been found including 17 new species and two new records from China (Shi 2013).

6.2.3.4 Russulaceae

In central and southern China (e.g., Hunan, Guizhou, and Yunnan Provinces), six species of *Lactarius* sect. *Deliciosi* (*L. akahatsu*, *L. deliciosus*, *L. hatsudake*, *L. hengduanensis*, *L. pseudohatsudake*, and *L. vividus*) are commonly collected, consumed, and commercialized, with various local names including "gu-shou-jun"

Fig. 6.11 Poisonous boletes mixed with other edible ones sold at the markets

Fig. 6.12 *Suillus pinetorum* at Nanhua wild edible mushroom market

Fig. 6.13 *Lactarius* mushrooms at Ciba wild edible mushroom market, Kunming

(mushroom that fruits when the corn is ripe), "tong-lv-jun" (coppery green mushroom), and "song-jun" (pine mushroom). Because of their similar appearance and overlapping geographic distribution, *L. vividus* was misidentified as *L. akahatsu* or *L. deliciosus* in China (Wang et al. 2015a, b). *Lactarius vividus*, *L. hatsudake*, *L. deliciosus*, *Lactifluus hygrophoroides*, *L. volemus*, and other 14 milk cap mushrooms are commonly found in Yunnan markets (Fig. 6.13) (Wang et al. 2004, Wang 2016). Research on the production of mycorrhizal seedlings with *L. vividus*, *L. deliciosus*, *L. hatsudake*, and related species is now being undertaken (Wang et al. 2019). Yields of *L. volemus* were increased by field inoculation using spore inoculum in the natural habitats of this mushroom in Lancang County, Yunnan (Liu et al. 2009).

Mushrooms in the genus *Russula* are very popular in southern China. Fifteen species of *Russula* were encountered in the local markets in Yunnan, and several of these were extensively collected and sold. *Russula griseocarnosa* is the most renowned Chinese edible and medicinal mushroom. It is mainly distributed in tropical and subtropical areas and is collected, sold, and consumed under a well-known local name "da-hong-jun" (bright red mushroom) in Yunnan, Fujian, and Guangdong Provinces (Fig. 6.14) (Wang et al. 2009). *Russula virescens*, known as "qing-tou-jun" (green head mushroom), is common in central Yunnan.

6.2.3.5 *Termitomyces*

Termitomyces is known as "ji-zong" (chicken mushroom) and is very popular in Yunnan (Fig. 6.15). These grow in tropical and subtropical regions of China and are associated with termites (Fig. 6.16). Twenty-six species of *Termitomyces* were reported from China, but only 11 have been confirmed recently (Tang et al. 2006;

Fig. 6.14 *Russula griseocarnosa* at Chuxiong wild edible mushroom market, Kunming

Fig. 6.15 *Termitomyces* at Mushuihua wild edible mushroom market, Kunming

Fig. 6.16 A mushroom produced in a nest formed by *Termitomyces* and termites (Photo by Rong-Chun Li)

Wei et al. 2006, 2009). Ten *Termitomyces* species are found in Yunnan, and nine can be found in local markets, with *T. clypeatus*, *T. eurhizus*, and *T. heimii* as the dominant species (Wang et al. 2004).

6.2.3.6 *Cantharellus* and *Craterellus*

Cantharellus and *Craterellus* are commercially important genera of wild edible mushrooms, collected in Europe, Africa, Asia, and North and Central America. They are very common in the wild mushroom markets in Yunnan (Fig. 6.17). Twenty-three species of *Cantharellus* have been found in China, including four new species and four new records (Shao 2011; Shao et al. 2011, 2012, 2014, 2016; Tian et al. 2009, 2012). Twenty species have been confirmed in Yunnan, and 15 species can be encountered on the local markets, with *Cantharellus cibarius*, *C. cinnabarinus*, and *C. formosus* as the dominant species (Wang et al. 2004). *Craterellus aureus*, *C. cornucopioides*, *C. lutescens*, and *C. tubaeformis* are also common species on the markets. Due to the high species diversity and economical importance, more work on Cantharellaceae should be carried out in China.

Fig. 6.17 *Cantharellus* mushrooms at Nanhua wild edible mushroom market

6.2.3.7 Morels

Morels are usually known as "yang-du-jun" (sheep stomach mushroom) and are high-priced, popular edible mushrooms in Yunnan (Fig. 6.18). They are widely distributed throughout China. Du (2012) reported 11 new phylogenetically distinct species in China, thus establishing China as the most taxon-rich country with a total of 30 morel species. Seven species can be found at local markets, with *Morchella eximia*, *M. importuna*, and *M. sextelata* as the dominant species in Yunnan. Although cultivation of *M. rufobrunnea* and *M. importuna* has been achieved independently in the USA and China, morels collected from the wild still dominate the markets. Besides *Morchella*, ten species of *Helvella* were found on the markets in Yunnan, including four species new to science (Zhao et al. 2015).

6.2.3.8 *Amanita*

Amanita sect. *Caesareae* is a group of edible mushrooms distributed worldwide. Forty-seven species were reported from this section, including many popular species, such as *Amanita caesarea* (Caesar's mushroom), *A. caesareoides*, *A. hemibapha* var. *ochracea*, and *A. zambiana* (Tang 2013; Yang 2015). The *A. hemibapha* complex is known as "ji-dan-jun" (egg mushroom) by local people and is very popular in Yunnan (Fig. 6.19). Another good edible species is *A. yuaniana* (Yang

Fig. 6.18 Morels at Mushuihua wild edible mushroom market, Kunming

Fig. 6.19 *Amanita hemibapha* at Mushuihua wild edible mushroom market, Kunming

Fig. 6.20 *Lyophyllum shimeji* at Shangri-La wild edible mushroom market

2015). Every year, poisoning incidents with *Amanita* species are common worldwide (see for example Chap. 2 by Wang et al.) and Yunnan is no exception.

6.2.3.9 *Lyophyllum*

Lyophyllum shimeji ("honshimeji" = true shimeji in Japanese) is known as "yi-wo-ji" (a den of hens) or "yi-wo-yang" (a den of sheep) by local people and is a popular edible mushroom in Yunnan (Fig. 6.20). Based on research by Japanese mycologists, different genotypes of *L. shimeji* can adopt different trophic lifestyles. See also Chap. 2 by Wang et al. for more information about this group.

6.2.3.10 *Albatrellus*

Albatrellus species are common wild edible mushrooms sold at local markets in Yunnan. The common names are "huang-hu-zhang-jun" (yellow tiger-paw mushroom) and "di-hua-jun" (flower on earth). Zheng and Liu (2008) reported 19 species of *Albatrellus* from China, including three species new to science. *Albatrellus ellisii* is one of the 13 species of *Albatrellus* recorded in Yunnan and is the most important one found in the majority of markets (Fig. 6.21). Grilling or boiling them with water prior to cooking is known to enhance their flavor.

Fig. 6.21 *Albatrellus ellisii* at Mushuihua wild edible mushroom market, Kunming

6.2.3.11 Shoro and Other Hypogeous Fungi

The "shoro" (*Rhizopogon roseolus*) is a delicacy in Japan. In China, it is known as "ji-yao-zi" (chicken kidney) and is commonly collected and traded in Yunnan (Wang et al. 2012). The taxonomy and phylogeny of Chinese shoros has recently been revised and contains three new species (see Chap. 2 by Wang et al.) including *Rhizopogon jiyaozi* (Fig. 6.22). Two other species described from Yunnan are *R. flavidus* and *R. sinoalbidus* (Li 2014). In addition, a few species in *Gautieria*, *Gymnomyces*, *Hydnotrya*, *Hymenogaster*, *Hysterangium*, *Melanogaster*, *Rossbeevera*, and *Zelleromyces* have been found in Yunnan (Orihara et al. 2012; Li et al. 2013; unpublished data). Further research on hypogeous fungi is needed.

6.2.4 Other Edible Wild Mushrooms

6.2.4.1 *Ophiocordyceps sinensis*

This mushroom is called "chong-cao" (insect-fungus) or "dong-chong-xia-cao" (insect in winter and fungus in summer). This is the most expensive (on a par with gold) edible or medicinal fungus in the world (Fig. 6.23). It is considered as a tonic for both men and women, although this needs scientific confirmation, and is traditionally cooked with meat, especially with duck (it is inserted into the chest of the duck and then stewed). Southwestern China is the center of origin and differentiation of *O. sinensis*. The alpine mountains of northwest Yunnan (over 4000 m in altitude) are an important collecting region. Harvesting of *O. sinensis* provides an

Fig. 6.22 *Rhizopogon jiyaozi* at Shangri-La wild edible mushroom market

Fig. 6.23 *Ophiocordyceps sinensis* sold at Shangri-La

Fig. 6.24 *Thelephora ganbajun* at Ciba wild edible mushroom market, Kunming

important income for Tibetan populations. When snow begins to melt in early spring, it is time to search for *O. sinensis*.

6.2.4.2 *Thelephora ganbajun*

This is the world's only known edible *Thelephora* species and the most expensive edible mycorrhizal fungus in Yunnan (Fig. 6.24). In many parts of the world, *Thelephora* species are troublesome contaminants in the production of mycorrhizal seedlings. However, until recently, *T. ganbajun* has defied cultivation, and pure culture isolates have been difficult to obtain (see also Chap. 2 by Wang et al.). Protection and improvement of natural habitats are the only known means to maintain and increase yield of these economically important mushrooms. They are mainly harvested from *Pinus armandii*, *P. yunnanensis*, and *Keteleeria evelyniana* forests (unpublished data).

6.2.4.3 *Scleroderma yunnanense*

There is no mushroom book or scientific paper stating that any *Scleroderma* species is edible at a large scale. Instead, there have been quite a few reports of unpleasant results from eating *Scleroderma* species (Stevenson and Benjamin 1961; Arora 1986). Surprisingly however, a *Scleroderma* species is commonly sold at tropical and subtropical local markets in Yunnan (Fig. 6.25). This was misidentified as *S. citrinum*. It is now considered a new species, *S. yunnanense* (Zhang et al. 2013),

Fig. 6.25 *Scleroderma yunnanense* at Lancang wild edible mushroom market, Pu'er

and is associated with pine (*Pinus kesiya* var. *langbianensis*) and broadleaf (*Betula alnoides*) trees. Although local people also eat mature specimens, *S. yunnanense* is best eaten immature.

6.2.4.4 *Phlebopus portentosus*

It is a favorite edible mushroom in Xishuangbanna, the tropical region of Yunnan (Fig. 6.26). It is not an ectomycorrhizal fungus; it can be saprobic and cultivated by using saprophytic methods (Ji et al. 2011). However, in most circumstances, *Phlebopus portentosus* is associated with mealy bugs, forming fungus-insect galls on plants; more galls indicate greater productivity. Based on the fungus-insect association, *P. portentosus* can be produced by field inoculation of plants with fungal mycelia (Zhang et al. 2015).

6.2.4.5 *Schizophyllum commune*

The split gill mushroom, locally known as "bai-sheng" (white ginseng) is a popular edible mushroom in Yunnan (Fig. 6.27). Although considered a widely distributed basidiomycetous, *Schizophyllum commune* has been consumed for its nutritional value and medical efficacy in mostly Southeast Asia and is now both harvested from the wild and cultivated in Yunnan (Arbaayah and Umi 2013). It is usually cooked with eggs.

Fig. 6.26 *Phlebopus portentosus* at Jinghong wild edible mushroom market, Xishuangbanna (Photo by Chunxia Zhang)

Fig. 6.27 *Schizophyllum commune* at Lancang wild edible mushroom market, Pu'er

Fig. 6.28 Dried *Naematelia aurantialba* at a market

6.2.4.6 *Naematelia aurantialba*

An orange-red *Naematelia* species parasitizing *Stereum hirsutum* and allied species in southwestern China has recently been commercialized and cultivated (Fig. 6.28). It has traditionally been used in medicinal preparations for treatment of "lung fever," flu, coughing, asthma, and hypertension in China (Bandoni and Zang 1990).

6.2.4.7 *Oudemansiella raphanipes*

The local name for *Oudemansiella raphanipes* is "lu-shui-ji-zong" (dew termitomyces) or "cao-ji-zong" (grass termitomyces) in Yunnan. It was successfully cultivated in the 1990s (Yu et al. 2002). Until recently, this new edible mushroom, commercially called "heipijizong" or "black termite mushroom," has been widely cultivated in many parts of China (Fig. 6.29) (Hao et al. 2016).

6.3 Cultural Importance

Most species of wild edible mushrooms are eaten locally, and many are commercially harvested in Yunnan. Total quantities sold in local markets can be considerable. During the rainy season, huge quantities are collected and taken to markets in small towns and from there to larger cities. The financial contributions to rural

Fig. 6.29 Cultivation of *Oudemansiella raphanipes* in plastic greenhouse

livelihoods are not known, though the widespread sale of wild edible mushroom within Yunnan and then substantial export business demonstrate that significant amounts of money are earned. The foreign income produced from wild mushroom exportation is over USD 100 million every year. Marketing of *T. matsutake* and a few additional species, such as *O. sinensis*, *T. indicum*, and *B. bainiugan*, has significantly improved the local economy in the last few years (Wang and Yang 2006).

The majority of land in Yunnan is mountainous and home of 36 million farmers who mostly identify with ethnic minorities such as Yi, Tibetan, Hani, Naxi, Lisu, and Miao (Pei 2004). Harvesting of wild mushrooms is an important livelihood and generates 15–90% of these people's annual income. The most important commercial mushroom is probably matsutake. In the last 10 years, over 1000 tons of fresh fruit bodies of matsutake have been exported from Yunnan and Sichuan annually. More than 40 counties in Yunnan are reported to harvest matsutake. In the Shangri-La region, northwest Yunnan, harvesting matsutake can result in an annual return of over 10,000 Chinese Yuan (about USD 1500) for an average family. New houses have been constructed in Tibet using the money generated from this harvest (Fig. 6.30). Cultivation of edible mushrooms is another important means by which a farming family may transition from poverty to wealth. *Stropharia rugosoannulata* and *Phallus impudicus* are saprobic species commonly cultivated during the less busy farming seasons (Fig. 6.31) and grown in rotation with crops or under crops, fruit trees, or natural forests.

Processing edible mushrooms is a way of adding value to the harvest and increasing a family's income. Truffle wines and *Termitomyces* oils (Fig. 6.32) are special products in Yunnan and are sold nationwide.

Fig. 6.30 New Tibetan houses at Geza, Shangri-La

Fig. 6.31 Cultivation of *Stropharia rugosoannulata* in the field

Fig. 6.32 *Termitomyces* sp. in oil

6.4 Conservation

The natural production of wild edible mushrooms has declined since large-scale commercial harvesting initiated in the 1990s. Decreasing yields of wild mushrooms has been exacerbated by global warming, particularly during consecutive years of drought. A variety of efforts have been deployed to protect wild edible mushrooms. The most important has been the forest ownership reformation which occurred in 2008, giving farmers the right to manage forest products including wild mushrooms. A few regulations have been launched such as prohibiting the harvesting of immature matsutake and truffles. A few reserves for protection and study of matsutake and truffles have been established and more are planned. Experimental plantations have been set up for truffle cultivation, and the production of *T. indicum* has begun (Fig. 6.33). Other attempts to cultivate truffles (*T. borchii*, *T. melanosporum*, and *T. sinoaestivum*) and milk cap mushrooms (*L. akahatsu*, *L. deliciosus*, *L. hatsutake*, and *L. vividus*) and to understand the biology, ecology, and cultivation potential of edible mushrooms are being undertaken (Geng et al. 2009; Deng et al. 2014; Wang and Liu 2014; Wang et al. 2015a, b; Wan et al. 2016; Wang et al. 2019). However, conservation of the precious wild edible mushroom remains a vital and urgent issue.

Fig. 6.33 An experimental plantation for the cultivation of *T. indicum* at Shilin County

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Appendix 1. Commercial Wild Mushrooms in Yunnan, Their Use/Property, and Quantity Traded

Taxa	Use/property[a]	Quantity
Ascomycota		
Hypocreales		
Cordycipitaceae		
Cordyceps militaris	Medicine	I
Metacordyceps liangshanensis	Medicine NC	I
Nectriaceae		

(continued)

Pseudonectria bambusae	Medicine	I
Ophiocordycipitaceae		
Ophiocordyceps crassispora	Medicine	I
O. sinensis	Medicine	I
O. sobolifera	Medicine	III
Leotiales		
Leotiaceae		
Leotia aurantipes	Medicine NC	I
Pezizales		
Helvellaceae		
Helvella elastica	Food	I
H. involuta	Food	I
H. macropus	Food	I
H. maculatoides	Food	I
H. orienticrispa	Food	I
H. orienticrispa	Food	I
H. pseudoreflexa	Food	I
H. rugosa	Food	I
H. sublactea	Food	I
H. zhongtiaoensis	Food	II
Morchellaceae		
Morchella galilaea	Food	I
M. eohespera	Food	I
M. eximia	Food	III
M. exuberans	Food	I
M. importuna	Food	III
M. meiliensis	Food	I
M. sextelata	Food	III
Tuberaceae		
Tuber glabrum	Food	I
T. himalayense	Food	II
T. indicum	Food	IV
T. liyuanum	Food	III
T. microspermum	Food	I
T. microsphaerosporum	Food	I
T. microspiculatum	Food	I
T. microverrucosum	Food	I
T. panzhihuanense	Food	II
T. pseudohimalayense	Food	III
T. sinoaestivum	Food	II
T. sinopuberulum	Food	I
T. vesicoperidium	Food	I
Pleosporales		
Shiraiaceae		
Shiraia bambusicola	Medicine	I

(continued)

Xylariales		
Engleromyces sinensis	Medicine	II
Basidiomycota		
Agaricales		
Agaricaceae		
Agaricus flocculosipes	Food	I
A. guizhouensis	Food	I
A. macrocarpus	Food	I
Calvatia cyathiformis	Food & Medicine	I
Macrolepiota procera	Food	I
Amanitaceae		
Amanita caesareoides	Food	II
A. fritillaria	Poisonous NC	I
A. hemibapha	Food	II
A. hemibapha var. *ochracea*	Food	IV
A. javanica	Food	I
A. manginiana	Food	II
A. pseudoporphyria	Food NC	I
A. sinensis	Food NC	I
A. virgineoides	Poisonous AM	I
A. yuaniana	Food	I
Clavariaceae		
Scytinopogon echinosporus	Food	II
Cortinariaceae		
Cortinarius emodensis	Food	III
C. purpurascens	Food	I
C. tenuipes	Food	I
Entolomataceae		
Entoloma clypeatum	Food	I
Hydnangiaceae		
Laccaria alba	Food	I
L. amethystina	Food	II
Laccaria laccata	Food	III
L. vinaceoavellanea	Food	II
Hygrophoraceae		
Hygrophorus camarophyllus	Food	I
H. eburneus	Food	I
H. robustus	Food	I
H. russula	Food	III
Inocybaceae		
Inocybe flavobrunnea	Poisonous AM	I
Lyophyllaceae		
Lyophyllum fumosum	Food	II
L. shimeji	Food	IV
Termitomyces aurantiacus	Food	II

(continued)

T. bulborhizus	Food	III
T. clypeatus	Food	IV
T. eurhizus	Food	IV
T. globulus	Food	II
T. heimii	Food	III
T. mammiformis	Food	II
T. microcarpus	Food	III
T. striatus	Food	II
Omphalotaceae		
Lentinula edodes	Food	III
Physalacriaceae		
Armillaria mellea	Food	I
A. tabescens	Food	I
Oudemansiella raphanipes	Food	I
Pleurotaceae		
Pleurotus flabellatus	Food NC	I
P. ostreatus	Food	I
P. platypus	Food	I
Schizophyllaceae		
Schizophyllum commune	Food & Medicine	II
Tricholomataceae		
Catathelasma imperiale	Food	II
C. ventricosum	Food	IV
Clitocybe eccentrica	Food	I
Collybia obscura	Food	I
Lepista nuda	Food	I
Leucopaxillus tricolor	Food	I
Macrocybe gigantea	Food	I
Tricholoma bakamatsutake	Food	II
T. flavovirens	Food NC	II
T. fulvocastaneum	Food	I
T. imbricatum	Food	I
T. lavendulophyllum	Food	I
T. matsutake	Food	IV
T. myomyces	Food	III
T. robustum	Food	I
T. saponaceum	Poisonous NC	I
Auriculariales		
Auriculariaceae		
Auricularia delicata	Food	III
A. heimuer	Food	II
A. nigricans	Food	II
Boletales		
Boletaceae		
Baorangia pseudocalopus	Food	I

(continued)

Boletellus ananas	Poisonous NC	I
Boletus bainiugan	Food	IV
B. citrifragrans	Food	I
B. gertrudiae	Food	I
B. instabilis	Food	II
B. miniato-olivaceus	Food WC	I
B. obscureumbrinus	Food WC	II
B. orientialbus	Food	I
B. punctilifer	Food	I
B. reticuloceps	Food	II
B. sensibilis	Food WC	II
B. shiyong	Food	IV
B. sinoedulis	Food	IV
B. taienus	Food	I
B. tomentipes	Food	I
B. violaceofuscus	Food	I
B. viscidiceps	Food	III
B. yunnanensis	Food	I
Buchwaldoboletus hemichrysus	Poisonous NC	I
Butyriboletus roseoflavus	Food WC	IV
Caloboletus panniformis	Food	I
C. yunnanensis	Food	I
Crocinoboletus laetissimus	Food	I
Heimioporus retisporus	Poisonous AM	I
Hortiboletus rubellus	Food	II
H. subpaludosus	Food	I
Hourangia cheoi	Food	I
H. microcarpa	Food	I
H. nigropunctata	Food	I
Lanmaoa asiatica	Food WC	IV
Leccinellum crocipodium	Food	II
Leccinum aurantiacum	Food	III
L. holopus	Food	I
L. rubropunctum	Food	I
L. rugosiceps	Food	I
L. scabrum	Food	I
Neoboletus brunneissimus	Food	IV
N. thibetanus	Food	I
Phylloporus bellus	Food	I
P. brunneiceps	Food	I
P. imbricatus	Food	I
P. luxiensis	Food	I
P. maculatus	Food	I
P. pachycystidiatus	Food	I
P. rubrosquamosus	Food	I

(continued)

P. yunnanensis	Food	II
Pulveroboletus ravenelii	Poisonous NC	I
Retiboletus fuscus	Food	IV
R. griseus	Food	I
R. kauffmanii	Food	I
R. nigerrimus	Food	I
R. ornatipes	Food NC	I
Rubinoboletus balloui	Food	I
Rubroboletus sinicus	Food WC	II
Rugiboletus brunneiporus	Food	I
R. extremiorientalis	Food	IV
Strobilomyces confusus	Food NC	I
S. mirandus	Food NC	I
S. strobilaceus	Food NC	I
Suillellus luridus	Food	I
S. queletii	Poisonous NC	I
Sutorius eximius	Poisonous NC	I
S. magnificus	Food WC	IV
Tylopilus brunneirubens	Food NC	I
T. nanus	Food NC	I
T. neofelleus	Poisonous NC	I
T. otsuensis	Poisonous NC	I
T. plumbeoviolaceus	Poisonous AM	I
T. virens	Poisonous AM	I
Veloporphyrellus velatus	Food NC	I
Xerocomellus chrysenteron	Food	I
Zangia olivaceobrunnea	Food	I
Z. roseola	Food	I
Boletinellaceae		
Phlebopus portentosus	Food	IV
Gomphidiaceae		
Chroogomphus confusus	Food	I
C. filiformis	Food	I
C. orientirutilus	Food	I
Gomphidius roseus	Food	I
Gyroporaceae		
Gyroporus castaneus	Poisonous NC	I
G. longicystidiatus	Food NC	I
Rhizopogonaceae		
Rhizopogon jiyaozi	Food	I
Suillaceae		
Suillus cavipes	Food	I
S. granulatus	Food	II
S. grevillei	Food	II
S. luteus	Food	II

(continued)

S. pictus	Food NC	I
S. pinetorum	Food	III
S. sibiricus	Food	I
Sclerodermataceae		
Pisolithus arhizus	Medicine NC	I
Scleroderma flavidum	Poisonous NC	I
S. yunnanense	Food	III
Cantharellales		
Cantharellaceae		
Cantharellus appalachiensis	Food	I
C. carneoflavus	Food	I
C. cibarius	Food	IV
C. cinereus	Food	I
C. cinnabarinus	Food	III
C. formosus	Food	IV
C. hygrophorus	Food	I
C. infundibuliformis	Food	II
C. minor	Food	II
C. odoratus	Food	II
C. phloginus	Food	I
C. subalbidus	Food	II
C. tuberculosporus	Food	I
C. xanthopus	Food	III
C. yunnanensis	Food	II
Craterellus aureus	Food	II
C. cornucopioides	Food	II
C. lutescens	Food	II
C. tubaeformis	Food	III
Clavulinaceae		
Clavulina coralloides	Food	I
Hydnaceae		
Hydnum repandum	Food	II
Gomphales		
Gomphaceae		
Gomphus orientalis	Poisonous NC	I
Phaeoclavulina cyanocephala	Food	II
Ramaria asiatica	Food	II
R. botrytoides var. *microspora*	Food	II
R. brunneipes	Food	I
R. cyanocephala	Food	I
R. distinctissima	Food	II
R. eryuanensis	Food	III
R. fennica	Food	II
R. formosa	Poisonous NC	I
R. hemirubella	Food	IV

(continued)

R. hilaris	Food	II
R. indoyunnaniana	Food	III
R. laeviformosoides	Food	I
R. linearioides	Food	I
R. linearis	Food NC	I
R. mairei	Food	III
R. nanispora	Food NC	I
R. neoformosa var. *sinensis*	Food	II
R. rubriattenuipes	Food	II
R. rubricarnata var. *laeta*	Food	I
R. sanguinipes	Food	II
R. sinoconjunctipes	Food	I
R. zebrispora	Food	I
Turbinellus floccosus	Poisonous NC	II
T. fujisanensis	Poisonous NC	I
Polyporales		
Ganodermataceae		
Amauroderma rugosum	Medicine	I
Ganoderma applanatum	Medicine	II
G. cochlear	Medicine	III
G. lingzhi	Medicine	IV
G. lucidum	Medicine	II
G. mutabile	Medicine	I
G. sinense	Medicine	I
Meripilaceae		
Meripilus giganteus	Food	I
Meruliaceae		
Irpex lacteus	Food	I
Polyporaceae		
Cryptoporus sinensis	Medicine	I
Grifola frondosa	Food	I
Lentinus sajor-caju	Food	I
L. squarrosulus	Food	I
L. tuber-regium	Food	I
Wolfiporia cocos	Medicine	I
Sparassidaceae		
Sparassis latifolia	Food	I
S. subalpina	Food NC	I
Russulales		
Albatrellaceae		
Albatrellus confluens	Food	II
A. ellisii	Food	IV
A. flettii	Food	I
A. fumosus	Food	I
A. ovinus	Food	I

(continued)

A. skamanius	Food	I
A. yunnanensis	Food	I
Neoalbatrellus yasudae	Food	I
Polypus dispansus	Food NC	III
Scutiger pes-caprae	Food	I
Hericiaceae		
Hericium alpestre	Food	I
H. coralloides	Food	I
H. erinaceus	Food	I
Russulaceae		
Lactarius chichuensis	Food	I
L. cinnamomeus	Food	II
L. deliciosus	Food	IV
L. echinatus	Food	II
L. gerardii	Food	I
L. hatsudake	Food	IV
L. hengduanensis	Food	II
L. piperatus	Food WC	I
L. pseudohatsudake	Food	II
L. vividus	Food	III
L. zonarius	Food	I
Lactifluus hygrophoroides	Food	III
L. volemus	Food	IV
L. subpiperatus	Food	I
L. subpruinosus	Food	I
L. tenuicystidiatus	Food	I
L. tropicosinicus	Food	I
Russula atroaeruginea	Food	II
R. aurata	Food	I
R. brunneoviolacea	Food	I
R. compacta	Food	III
R. cyanoxantha	Food	III
R. densifolia	Food	I
R. griseocarnosa	Food & Medicine	IV
R. laurocerasi	Food	II
R. lepida	Food	I
R. melliolens	Food	I
R. nigricans	Food	I
R. ochroleuca	Food	I
R. sanguinea	Poisonous NC	I
R. virescens	Food	IV
R. viridirubrolimbata	Food	II
Thelephorales		
Bankeraceae		
Boletopsis grisea	Food	III

(continued)

Hydnellum cumulatum	Food	II
Sarcodon amarescens	Food	I
S. excentricus	Food	I
S. imbricatus	Food	IV
S. scabrosus	Food	II
S. squamosus	Food	II
Thelephoraceae		
Polyozellus multiplex	Food	I
Thelephora ganbajun	Food	IV
T. japonica	Food	I
T. palmata	Food	I
T. vialis	Food	II
T. aurantiotincta	Food	I
Tremellales		
Tremellaceae		
Naematelia aurantialba	Food & Medicine	I

[a]Food, with clear evidence that the species is used as food; Food NC, not certain/confirmed that the species is used as food; Food WC, with caution/conditions and recorded as poisonous in some references; Poisonous AM, toxic to animals in lab test, effect on humans not recorded or unknown; Poisonous NC, confusion/uncertainty; Medicine, with clear evidence that the species is used as medicine; Medicine NC, not certain/confirmed or where there is a lack of consensus; Quantity traded: I, small; II, moderate; III, large; IV, enormous quantity

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