Ethnomycological study on wild mushrooms in Pu‘er Prefecture, Southwest Yunnan, China

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Abstract

Background: Yunnan is rich in fungal diversity and cultural diversity, but there are few researches on ethnomycology. In addition, extensive utilization of wild edible fungi (WEF), especially the ectomycorrhizal fungi, threatens the fungal diversity. Hence, this study aims to contribute to the ethnomycological knowledge in Pu‘er Prefecture, Yunnan, China, including information on the fungal taxa presented in markets and natural habitats, with emphasis in ectomycorrhizal fungi (EMF).

Methods: Semi-structured interviews with mushroom vendors in markets and with mushroom collectors in natural habitats were conducted. Information related to local names, habitat, fruiting time, species identification, price, cooking methods and preservation methods of wild edible mushrooms were recorded. Wild edible fungi were collected from forests, and morphological and molecular techniques were used to identify fungal species.

Results: A total of 11 markets were visited during this study. The 101 species collected in the markets belonged to 22 families and 39 genera, and about 76% of them were EMF. A wealth of ethnomycological knowledge was recorded, and we found that participants in the 45–65 age group were able to judge mushroom species more accurately. Additionally, men usually had a deepest mushroom knowledge than women. A total of 283 species, varieties and undescribed species were collected from natural habitats, and about 70% of them were EMF. Mushroom species and recorded amounts showed correspondence between markets and the natural habitats on different months.

Conclusion: The present study shows that Pu‘er Prefecture is rich in local mycological knowledge and fungal diversity. However, it is necessary to continue the research of ethnomycological studies and to design and conduct dissemination of local knowledge in order to preserve it, since it currently remains mainly among the elderly population.

Keywords: Ethnomycology, Fungal diversity, Pu‘er, South of the Tropic of Cancer

Background

Wild edible fungal fruiting bodies, or mushrooms, known as “delicacies from the mountains,” are a natural forest resource widely acknowledged for their nutritional, medicinal, economic and cultural value [1–4]. China is one of the most important mushroom producers in the world in terms of the total volume of trade and commercialized fungal species. The Yunnan Province in southwestern China, in particular, has an important tradition of consumption and mushroom trade [5]. In China, there are about 900 species of wild edible fungi (WEF), 90% of which are present in Yunnan and utilized by local people as both a source of food and income [6]. Most of the main mushroom markets, with a large variety of species, are located in the central regions of the province because of the dense population, convenient transportation and high market demand, while countless small...
mushroom markets with unique fungal species are scattered throughout Yunnan in mountainous areas which are inhabited by a number of ethnic groups [7] where gathering of WEF and mushroom industry has become an important tool for poverty alleviation [8–10].

The rural population of Yunnan has a wealth of traditional knowledge related to WEF and is familiar with many species as well as their uses and ecology. The traditional mycological knowledge, generally gathered by the indigenous communities in their long interaction with nature, is an important part of human cultural heritage [11–15]. Ethnomycology is a relatively new area of research that investigates traditional knowledge, as well as cultural and environmental effects, of the association between human societies and fungi [16]. Yunnan is the province with the largest number of ethnic groups in China, each minority with their own culture, language, history and, of course, different uses for wild forest fungi. Brown [17] investigated Yi ethnomycological knowledge in four communities in Nanhua County, Yunnan Province, which showed that documenting ethnomycological knowledge highlights the importance of fungi in local ecosystems and livelihoods. Ethnomycological knowledge is a key tool for forest conservation to predict anthropic harvesting pressure zones of WEF and support the management and sustainable utilization of wild fungi [18]. For example, documenting the fungal biodiversity which has a local use would allow to design and implement strategies to cultivate the most important WEF in specific areas and at the same time to integrate this cultivation into production systems which contribute to the recycling of local agricultural wastes, providing at the same time nutritious and healthy food. Additionally, the record of the local ethnomycological knowledge would allow to increase the promotion of responsible use and to design preservation techniques for the most valuable WEF, in order to maintain this important natural resource as a livelihood opportunity in rural areas. Additionally, the documentation and preservation of traditional mycological knowledge are fundamental to avoid poisonings [19]. However, compared with local folk knowledge related to plants and animals, ethnomycological knowledge started late and remains scarce [20, 21].

The annual production of WEF in Yunnan amounts to about 80,000 t [6]. The largest market share of commercial fungi, either in terms of monetary value or of quantity, includes truffles (Tuber indicum Cooke & Massee, Tuber sinoaestivum J.P. Zhang & P.G. Liu), matsutake (Tricholoma matsutake (S. Ito & S. Imai) Singer), porcini (Boletus edulis Bull.), chanterelles (Cantharellus cibarius Fr.) and milk agaric (e.g., Lactarius deliciosus (L.) Gray, Lactifluus volens (Fr.) Kuntze). Most of high-priced WEF are ectomycorrhizal fungi (EMF) which form a symbiotic relationship with trees and play an important role in the ecosystem [22, 23]. Wang and Liu [7] studied systematically the trade of fungi in Yunnan markets and showed that about 81.2% of the WEF species are EMF. Limited by cultivation techniques, mushrooms, especially of EMF, have been almost exclusively harvested from the wild [24]. Their high economic value has been driving forest-dependent communities to completely devote their resources to hunting mushrooms for immediate cash thanks to an endless market demand [25, 26]. Disorderly digging and hunting, habitat loss, and vegetation deterioration, has caused overexploitation of many species and is threatening the survival of fungal populations and the forests that support them [27–30]. A survey of mushroom markets and natural habitats in Yunnan, to a large extent, will reveal the problems of development and utilization of WEF [31, 32].

Based on this scenario, in the present research we studied the areas in Pu'er Prefecture in the southern part of Yunnan Province which has the highest diversity of both cultures and fungi. Yu et al. [33] studied the species diversity, use and threatened status of WEF in two counties of Pu'er Prefecture and found that large-scale commercial harvesting had led to the decline of mushroom production. Pu'er Prefecture has an area of 45,385 km², and its population is 2.4 million. It is located in southwest Yunnan and bordered by Myanmar, Laos and Vietnam. The Tropic of Cancer runs through the middle of Pu'er. It generally belongs to subtropical monsoon climate with lower altitude, diverse topography, rich forest resources and unique ethnic groups, like Hani, Lahu, Wa or Dai.

In this study, we aimed (1) to gather ethnomycological knowledge regarding the fungal species used by ethnic groups in Pu’er; (2) to update the knowledge about fungal species sold in Pu’er markets, especially ectomycorrhizal species; (3) to document the fungal diversity inhabiting Pu’er forests through natural habitats sampling; and (4) to identify the fungal species (sold in markets and collected in the natural habitats) using taxonomical and molecular approaches.

Methods

Study area

Pu’er Prefecture, with a total area of 45,385 square kilometers, is the largest prefecture in Yunnan Province. It is located between 22°02’ N–24°50’ N and 99°09’ E–102°19’ E, and the Tropic of Cancer runs across the middle of the prefecture. About 62.8% of Pu’er is forested where the main type of vegetation is broad-leaved forest, mixed forest (Alnus, Castanopsis, Olea, Pinus, Quercus) and Pinus forests [34]. Pu’er is one of the most culturally diverse prefectures, with 2.4 million population and fourteen ethnic groups inhabiting this area. Our investigation
was carried out in five nationality autonomous counties (Lancang Lahu, Menglian Dai Lahu Wa, Mojiang Hani, Ning’er Hani Yi, Ximeng Wa) and one homonymous municipality, Pu’er (Fig. 1, Table 1), all located south of the Tropic of Cancer.

Ethnomycological survey in markets
Semi-structured interviews were carried during the mushroom season (July to October) in three consecutive years (2019 to 2021) in established mushroom markets, mobile markets and street-stalls beside county highways or village roads (Fig. 2, Table 2). The number and the male–female ratio of vendors in markets, the knowledge, attitude and practice of human–mushroom interaction including the local names of mushrooms and their local uses (medicine, food, etc.), habitat, seasonality of species, marketability, form of mushrooms used (fresh/dried), methods of preparation for food and preservation (storage) were also recorded. For illiterate vendors, interviews were carried out mainly in Mandarin Chinese, although local languages were also used with assistance from local guides. Twenty percent of vendors in markets were randomly selected as respondents to answer the semi-structured interviews. Obtained information from these interviews was written down in sheets, which avoided distrust in the interviewed people.

Diversity of culturally relevant wild fungi in forests
In order to record the vegetation types associated with the fungal species sold in the markets and to investigate the presence of additional edible fungal species different than those recorded in the markets or with other uses and relevance categories, WEF were collected from forests nearby the studied markets in Pu’er prefecture. The forest areas were selected according to the information provided by some collectors previously interviewed in the markets. Forests nearby visited markets, reforested areas and a national nature reserve (Table 3) were investigated. Field work was conducted during the same season as the interviews were carried out using the random line transect method [35]. In order to gather more ethnomycological information regarding WEF, participant

Table 1 Sociodemographic characteristics of the six studied localities in Pu’er Prefecture

| Locality          | Population | Main ethnic groups | Economy                                |
|-------------------|------------|--------------------|----------------------------------------|
| Pu’er Municipality| 416,200    | Hani, Yi, Lahu     | Agriculture, tea, robber, animal       |
| Mojiang County    | 281,600    | Hani, Yi, Dai      | Agriculture, tea, walnut, tobacco, animal |
| Ning’er County    | 162,700    | Hani, Yi, Dai      | Agriculture, tea, fruit, animal        |
| Lancang County    | 441,500    | Lahu, Wa, Hani     | Agriculture, tea, animal               |
| Ximeng County     | 87,300     | Wa, Lahu, Dai      | Agriculture, tea, robber, coffee, walnut|
| Menglian County   | 144,700    | Lahu, Wa, Dai      | Agriculture, tea, robber, coffee       |
observation was performed in some forest areas. We joined some collectors in their daily routine of collecting WEF. While walking with them, we recorded some local names of the mushrooms, hours invested in this activity, types of collectors and habitat ecological information.

Table 2 The timetable of selling mushrooms, minority and the average number of vendors with different gender in markets in three years

| Markets' name       | Type of market | Business Hours | Ethnic groups          | July Female | July Male | August Female | August Male | September Female | September Male | October Female | October Male |
|---------------------|----------------|----------------|-------------------------|-------------|-----------|---------------|-------------|-----------------|----------------|---------------|--------------|
| Wuyi, Pu'er market  | EM             | 2 p.m–6 p.m    | Hani, Yi, Lahu          | 47          | 19        | 172          | 56          | 141             | 46             | 14            | 9            |
| Lancang street      | EM             | 7 a.m–12 p.m on Sunday | Lahu, Hani, Yi | 44          | 17        | 93           | 25          | 183             | 56             | 55            | 15           |
| Mojiang market      | EM             | 1 p.m–4 p.m    | Hani, Yi               | 10          | 2         | 67           | 37          | 15              | 8              | 4             | 1            |
| Ning'er market      | MM             | 2 p.m–5 p.m    | Yi, Hani               | 17          | 5         | 49           | 13          | 51              | 27             | 26            | 10           |
| Menglian market     | MM             | 7 a.m–11 a.m every five days | Lahu, Dai, Wa | 3           | 2         | 8            | 2           | 23              | 5              | 10            | 4            |
| Ximeng market       | MM             | 4 p.m–8 p.m    | Wa, Lahu, Dai          | 2           | 1         | 2            | 8           | 41              | 7              | 10            | 3            |
| No name             | SS             | 1 p.m–5 p.m    | ×                       | ×           | ×         | ×             | ×           | ×               | ×              | ×             | ×            |

1 Type of markets. EM is established market, MM is mobile market, SS is street-stall
2 Street-stalls beside county highways or village roads. We only recorded information about business time because of strong mobility.
Table 3  Description of the sampling sites in natural habitats

| Location         | Altitude (m) | Locality                        | Forest type                  | Habitat                     |
|------------------|--------------|---------------------------------|------------------------------|-----------------------------|
| Pu’er Municipality | 1450         | 22°49′13″ N, 101°00′12″  E       | Forests nearby markets      | Pure pine forests (Pinus kesiya) |
|                  | 1608         | 22°60′38″ N, 101°09′65″  E       | The Sun River National Forest Park | Mixed forests (Pinus, Quercus, Castanopsis, Olea) |
| Mojiang County   | 1595         | 23°22′48″.85″ N, 101°41′0.69″ E | Forests nearby markets      | Mixed forests (Pinus, Quercus) |
|                  | 1627         | 23°44′43.00″ N, 101°12′56.1″ E  | Ecological forest (Kuaiia village)   | Pure pine forests (P. kesiya) |
| Ning’er County   | 1437         | 23°01′1.35″ N, 100°59′47.6″ E  | Forests nearby markets      | Mixed forests (Pinus, Quercus) |
|                  | 1537         | 22°59′50.84″ N, 101°0′19.18″ E  | Ecological forest (Hualiang village) | Pure pine forests (P. kesiya) |
| Lancang County   | 1350         | 22°19′51″ N, 100°00′34″ E       | Forests nearby markets      | Mixed forests (Quercus, Alnus, Pinus) |
|                  | 1490         | 22°35′02″ N, 99°58′44″ E        | Forests nearby markets      | Mixed forests (Quercus, Pinus) |
| Ximeng County    | 1128         | 22°37′14.06″ N, 99°35′53.98″ E | Forests nearby markets      | Mixed forests (Quercus, Alnus, Pinus) |
|                  | 1497         | 22°36′10.53″ N, 99°35′0.02″ E  | Forests nearby markets      | Mixed forests (Quercus, Alnus, Pinus) |
| Menglian County  | 1250         | 22°16′21.99″ N, 99°16′30.06″ E | Forests nearby markets      | Mixed forests (Quercus, Alnus, Pinus) |
|                  | 1380         | 22°16′46.11″ N, 99°16′27.97″ E | Forests nearby markets      | Mixed forests (Quercus, Alnus, Pinus) |

Morphological study

Collections purchased from markets and collected from natural habitats were identified through taxonomical and molecular studies. Morpho-anatomical descriptions based on fresh samples were obtained following Largent [36]. A small sample of tissue, mostly hymenophore, was stored in silica gel and/or frozen in Eppendorf’s tubes and stored at −20 °C to be used later for molecular analyses. Then, all the samples were dried in a hot air dehydrator at 45 °C for further analyses. All collections were deposited in the Herbarium of Cryptogams, Kunming Institute of Botany, Chinese Academy of Sciences (HKAS). Microscopic characteristics were described from fresh specimens. Dried samples were sectioned with a razor blade by hand, mounted in 5% KOH solution and then stained with Melzer’s reagent. The sections were examined under a compound light microscope (Leica DM2500).

DNA extraction, PCR amplification and sequencing

DNA of samples was extracted using an Aidlab™ kit (Beijing). The internal transcribed spacer (ITS) region of the ribosomal DNA was amplified from DNA extracts using the ITS1F/ITS4 primer pair [37, 38]. To amplify the ribosomal large subunit (LSU), the primer combination of LROR and LR5 [39] was used. Each 25 μL PCR mixture consisted of 2.5 μL 10 × PCR buffer (Mg2+), 1.5 μL dNTPs (1 mM), 1 μL BSA (0.1%), 1 μL each primer (5 μM), 1 μL 25-fold diluted DNA extracts (obtained following the manufacturer’s instructions), 0.5 μL MgCl2 (25 mM) and 1.5 U Taq DNA polymerase (Takara, Takara Biotechnology, Dalian Co. Ltd, China). The amplifications were performed with the following cycling parameters for ITS: 94 °C for 5 min, followed by 35 cycles of 94 °C for 1 min, 50 °C for 1 min and 72 °C for 1 min, and with a final extension at 72 °C for 10 min. The amplifications were performed with the following cycling parameters for LSU: 94 °C for 3 min, followed by 35 cycles of 94 °C for 1 min, 50 °C for 1.5 min and 72 °C for 2 min, and with a final extension at 72 °C for 10 min. Three microliters of each PCR product were run on 1% (w/v) agarose gels and stained with ethidium bromide. The PCR products were purifed and sequenced forward and reverse sequences at TsingKe Biological Technology, Kunming, China, using ITS1F/ITS4 and LROR/LR5 primer pairs. Sequences were edited manually using Sequencher™ 4.1.4 (Gene Codes, USA) and queried against the NCBI public database GenBank with the BLASTn algorithm for identification. Sequences generated in this study were deposited in GenBank.

Results

Diversity of wild mushrooms in markets and in the natural habitats

Update and supplement of mushroom species

A total of 623 (HKAS 106765–HKAS 122601) samples were obtained and identified. From those, 110 were collected from markets and 513 from the natural habitats. A total of 310 wild mushroom species, varieties and some undescribed species which are currently under taxonomic study along with ethnomycological catalog information such as scientific names, family names, ecology and edibility were recorded (Table 4). No significant changes were recorded in the amount or diversity of commercialized species during the sampling period. Edibility information of most of the mushrooms was gathered directly from sellers and confirmed by taxonomists, professional atlases [40–43] and specialized literature. The 310 recorded species belong to 56 families and 112 genera. Approximately 70% of the species are ectomycorrhizal. Among of them, the 101 species collected in the
| Scientific name                          | Family name                  | Market | Natural habitat                  | ECM | Edible part               | Voucher No  |
|-----------------------------------------|------------------------------|--------|----------------------------------|-----|---------------------------|-------------|
| Abortiporus biennis (Bull.) Singer       | Podoscypheaceae              | √      | Inedible, wood-decay fungus      |     |                           | HKAS-111766 |
| Acreus globulosus Ekanayaka, Q. Zhao & K.D. Hyde | Pyronemataceae              | √      | Inedible, too tiny               |     |                           | HKAS-122632 |
| Agaricus heterostyris Heinem. & Gooss.-Font | Agaricaceae                 | √      | Edible                           |     |                           | HKAS-122370 |
| Agaricus luteofibrillosus M.Q. He, Linda L. Chen & R.L. Zhao | Agaricaceae                 | √      | Edible                           |     |                           | HKAS-122412 |
| Agaricus sp                              | Agaricaceae                 | √      | Unknown                          |     |                           | HKAS-122511 |
| Albatrellus sp.                          | Albatrelliaceae              | √      | Edible                           |     |                           | HKAS-111880 |
| Amanita albidostipes Y.Y. Cui, Q. Cai & Zhu L. Yang | Amanitaceae                 | √      | Toxic                            |     |                           | HKAS-124004 |
| Amanita angustilamella (Hohn.) Boedijn | Amanitaceae                 | √      | Unknown                          |     |                           | HKAS-123967 |
| Amanita caqizong Zhu L. Yang, Y.Y. Cui & Q. Cai | Amanitaceae                 | √      | Edible                           |     |                           | HKAS-124005 |
| Amanita cf. grisefarinosa                | Amanitaceae                 | √      | Unknown                          |     |                           | HKAS-122658 |
| Amanita citroaunnulata Y.Y. Cui, Q. Cai & Zhu L. Yang | Amanitaceae                 | √      | Toxic                            |     |                           | HKAS-122410 |
| Amanita elata (Massee) Corner & Bas Matsuda | Amanitaceae                 | √      | Maybe toxic                      |     |                           | HKAS-123968 |
| Amanita esculenta Hongo & L. Matsuda         | Amanitaceae                 | √      | Toxic                            |     |                           | HKAS-122372 |
| Amanita eijiir Zhu L. Yang                | Amanitaceae                 | √      | Unknown                          |     |                           | HKAS-111744 |
| Amanita fritillaria (Sacc.) Sacc          | Amanitaceae                 | √      | Toxic                            |     |                           | HKAS-111691 |
| Amanita grisefolia Zhu L. Yang            | Amanitaceae                 | √      | Edible                           |     |                           | HKAS-111779 |
| Amanita levistriata D.T. Jenkins          | Amanitaceae                 | √      | Toxic                            |     |                           | HKAS-111778 |
| Amanita princeps D.T. Jenkins             | Amanitaceae                 | √      | Toxic                            |     |                           | HKAS-122502 |
| Amanita pseudoporphyria Hongo             | Amanitaceae                 | √      | Toxic                            |     |                           | HKAS-111708 |
| Amanita pseudovaginata Hongo              | Amanitaceae                 | √      | Unknown                          |     |                           | HKAS-122692 |
| Amanita rubescens Pers                    | Amanitaceae                 | √      | Toxic                            |     |                           | HKAS-122544 |
| Amanita rubromarginata Har. Takah. Zhu L. Yang | Amanitaceae                 | √      | Edible                           |     |                           | HKAS-122664 |
| Amanita rubrovolvata S. Imai              | Amanitaceae                 | √      | Toxic                            |     |                           | HKAS-122702 |
| Amanita rufoferruginea Hongo              | Amanitaceae                 | √      | Toxic                            |     |                           | HKAS-111723 |
| Amanita sinensis Zhu L. Yang              | Amanitaceae                 | √      | Edible                           |     |                           | HKAS-122507 |
| Amanita spissacea S. Imai                 | Amanitaceae                 | √      | Toxic                            |     |                           | HKAS-111877 |
| Amanita subglobosa Zhu L. Yang            | Amanitaceae                 | √      | Maybe toxic                      |     |                           | HKAS-122396 |
| Amanita subhemibapha Zhu L. Yang, Y.Y. Cui & Q. Cai | Amanitaceae                 | √      | Edible                           |     |                           | HKAS-122503 |
| Amanita synchopiramis Corner & Bas        | Amanitaceae                 | √      | Toxic                            |     |                           | HKAS-122650 |
| Amanita virgineoides Bas                  | Amanitaceae                 | √      | Maybe toxic                      |     |                           | HKAS-111833 |
| Amanita yuaniana Zhu L. Yang              | Amanitaceae                 | √      | Edible                           |     |                           | HKAS-122505 |
| Amanita zonata Y.Y. Cui, Qing Cai & Zhu L. Yang | Amanitaceae                 | √      | Maybe toxic                      |     |                           | HKAS-122624 |
| Amauroderma rugosum (Blume & T. Nees) Torrend  | Ganodermataceae             | √      | Medicinal                        |     |                           | HKAS-111701 |
| Anamika angustilamellata Zhu L. Yang & Z.W. Ge | Hymenogastraceae            | √      | Maybe toxic                      |     |                           | HKAS-111783 |
| Asterophora lycopeoides (Bull.) Ditmar     | Lyophylliaceae              | √      | Unknown                          |     |                           | HKAS-122678 |
| Aureoboletus mirabilis (Murrill) Halling  | Boletaceae                  | √      | Edible                           |     |                           | HKAS-123972 |
| Auricularia delicata (Mont. ex Fr.) Henn   | Auriculariaceae             | √      | Edible                           |     |                           | HKAS-111857 |
| Scientific name | Family name | Market | Natural habitat | ECM | Edible part | Voucher No |
|-----------------|-------------|--------|----------------|-----|-------------|------------|
| *Auricularia fuscosuccinea* (Mont.) Henn | Auriculariaceae | √ | Edible | HKAS-122598 |
| *Blastosporella zonata* T.J. Baroni & Franco-Mol | Lyophyllaceae | √ | Unknown | HKAS-111854 |
| *Boletus indistinctus* G. Wu, Fang Li & Zhu L. Yang | Boletaceae | √ | Unknown | HKAS-111749 |
| *Boletus sp1* | Boletaceae | √ | Unknown | HKAS-111715 |
| *Boletus sp2* | Boletaceae | √ | Unknown | HKAS-111794 |
| *Boletus sp3* | Boletaceae | √ | Unknown | HKAS-122405 |
| *Boletus aereus* Bull | Boletaceae | √ | Edible | HKAS-124009 |
| *Boletus auripes* Peck | Boletaceae | √ | Edible | HKAS-111826 |
| *Boletus bainiugan* Dentinger | Boletaceae | √ | Edible | HKAS-111821 |
| *Boletus reticulatus* Schaef | Boletaceae | √ | Edible | HKAS-122381 |
| *Boletus subvelutipes* Peck | Boletaceae | √ | Edible | HKAS-111756 |
| *Boletus violaceofuscus* W.F. Chiu | Boletaceae | √ | Edible | HKAS-123966 |
| *Bondarzewia berkeleyi* (Fr.) Bondartsev | Bondarzewiaceae | √ | Unknown | HKAS-122722 |
| *Butyriboletus peckii* (Frost) Kuan Zhao & Zhu L. Yang | Boletaceae | √ | Edible, but sour or bitter | HKAS-111872 |
| *Butyriboletus huangnianlai* N.K. Zeng, H. Chai & Zhi Q. Liang | Boletaceae | √ | Edible | HKAS-111755 |
| *Caloboletus yunnanensis* Kuan Zhao & Zhu L. Yang | Boletaceae | √ | Edible | HKAS-122727 |
| *Ceriporiopsis semisupina* C.L. Zhao, B.K. Cui & Y.C. Dai | Meruliaceae | √ | Unknown | HKAS-111855 |
| *Cerrena zonata* (Berk.) H.S.Yuan | Cerrenaceae | √ | Unknown | HKAS-122586 |
| *Clarkeinda trachodes* (Berk.) Singer | Agaricaceae | √ | Toxic | HKAS-122723 |
| *Clavaria zollingeri* Lév | Clavariaceae | √ | Inedible, contains lectin | HKAS-111865 |
| *Clavulina alpina* Franchi & M. Marchetti | Hydnaceae | √ | Edible | HKAS-122671 |
| *Clavulina cristata* (Holmsk.) J. Schröt | Hydnaceae | √ | Edible | HKAS-111850 |
| *Clavulina flavida* (Holmsk.) J. Schröt | Hydnaceae | √ | Maybe edible | HKAS-122481 |
| *Clavulina rugosa* (Bull.) J. Schröt | Hydnaceae | √ | Edible | HKAS-111717 |
| *Clavulina sp.* | Hydnaceae | √ | Maybe edible | HKAS-122494 |
| *Clavulinopsis fusiformis* (Sowerby) Corner | Clavariaceae | √ | Edible | HKAS-122627 |
| Scientific name                        | Family name       | Market | Natural habitat | ECM | Edible part | Voucher No |
|---------------------------------------|-------------------|--------|-----------------|-----|-------------|------------|
| Clitopilus chalybescens T.J. Baroni & | Entolomataceae    | √      | Unknown         |     |             | HKAS-111784|
| Desjardin                             |                   |        |                 |     |             |            |
| Clitopilus sinoapalus S.P. Jian & Zhu | Entolomataceae    | √      | Unknown         |     |             | HKAS-122631|
| L. Yang                               |                   |        |                 |     |             |            |
| Clitopilus sp.                         | Entolomataceae    | √      | Unknown         |     |             | HKAS-122655|
| Collybiopsis fibrosipes (Berk. & M.A.| Marasmiaceae      | √      | Unknown         |     |             | HKAS-122635|
| Curtis R.H. Petersen                   |                   |        |                 |     |             |            |
| Coltricia crassa Y.C. Dai             | Marasmiaceae      | √      | Inedible, dry   |     |             | HKAS-122441|
|                                       |                   |        | and tough       |     |             |            |
| Coltricia veii Y.C. Dai               | Hymenochaetaceae  | √      | Inedible, dry   |     |             | HKAS-122593|
|                                       |                   |        | and tough       |     |             |            |
| Cortinarius aff. torvus               | Cortinariaceae    | √      | Unknown         |     |             | HKAS-122452|
| Cortinarius Albicyaneus Fr            | Cortinariaceae    | √      | Unknown         |     |             | HKAS-111851|
| Cortinarius alpinus Boud              | Cortinariaceae    | √      | Unknown         |     |             | HKAS-122660|
| Cortinarius boulderensis A.H. Sm      | Cortinariaceae    | √      | Unknown         |     |             | HKAS-122445|
| Cortinarius caesistilus A.H. Sm       | Cortinariaceae    | √      | Unknown         |     |             | HKAS-122446|
| Cortinarius cotonus Fr                | Cortinariaceae    | √      | Edible          |     |             | HKAS-122455|
| Cortinarius croceus (Schaef) Gray     | Cortinariaceae    | √      | Unknown         |     |             | HKAS-122559|
| Cortinarius fulvo-ochraceus Rob.      | Cortinariaceae    | √      | Unknown         |     |             | HKAS-122657|
| Cortinarius frigidus                  | Cortinariaceae    | √      | Unknown         |     |             | HKAS-111713|
| Cortinarius purpurascens Fr           | Cortinariaceae    | √      | Edible          |     |             | HKAS-122529|
| Cortinarius sp.                       | Cortinariaceae    | √      | Unknown         |     |             | HKAS-111771|
| Cortinarius tenuipes (Hongo) Hongo    | Cortinariaceae    | √      | Unknown         |     |             | HKAS-122467|
| Cortinarius trivialis J.E. Lange      | Cortinariaceae    | √      | Unknown         |     |             | HKAS-111789|
| Cortinarius valgus Fr                 | Cortinariaceae    | √      | Unknown         |     |             | HKAS-111836|
| Cortinarius vinaceobrunneus Ammerrati | Cortinariaceae    | √      | Unknown         |     |             | HKAS-122626|
| Beug, Liimat., Niskanen & O. Ceska    |                   |        |                 |     |             |            |
| Craterellus aureus Berk. & M.A. Curtis| Hydnaceae        | √      | Edible          |     |             | HKAS-123973|
| Craterellus cornucopioides (L.) Pers  | Hydnaceae        | √      | Edible          |     |             | HKAS-111827|
| Craterellus luteus T.H. Li & X.R. Zhong| Hydnaceae        | √      | Edible          |     |             | HKAS-111759|
| Craterellus parvogriseus U. Singh, K.| Hydnaceae        | √      | Edible          |     |             | HKAS-122486|
| Das & Buyck                           |                   |        |                 |     |             |            |
| Craterellus sp.                       | Hydnaceae        | √      | Edible          |     |             | HKAS-122643|
| Craterellus tubaeformis (Fr.) Quél    | Hydnaceae        | √      | Edible          |     |             | HKAS-111843|
| Crocinobolus laetissimus (Hongo)      | Boletaceae       | √      | Edible          |     |             | HKAS-122417|
| N.K. Zeng, Zhu L. Yang & G. Wu        |                   |        |                 |     |             |            |
| Crocinobolus sp.                      | Boletaceae       | √      | Edible          |     |             | HKAS-111764|
| Cystotrama asprata (Berk.) Redhead &  | Physalacriaceae  | √      | Unknown         |     |             | HKAS-122721|
| Ginnis                                |                   |        |                 |     |             |            |
| Entocybe trachyspora (Largent) Largent, T.J. Baroni & V. Hofst | Entolomataceae | √ | Maybe toxic | | | HKAS-122647|
| Entoloma amniense (Hongo) E. Horak    | Entolomataceae    | √      | Toxic           |     |             | HKAS-111709|
| Entoloma petchii E. Horak             | Entolomataceae    | √      | Maybe toxic     |     |             | HKAS-122493|
| Entoloma praegracile Xiao L. He & T.H.| Entolomataceae    | √      | Maybe toxic     |     |             | HKAS-111787|
| Li                                   |                   |        |                 |     |             |            |
| Entoloma subsinuatum Murrill          | Entolomataceae    | √      | Maybe toxic     |     |             | HKAS-122542|
| Entoloma sp.                          | Entolomataceae    | √      | Unknown         |     |             | HKAS-111834|
| Fistulina hepatica (Schaeff) With     | Fistulinae       | √      | Edible, but     |     |             | HKAS-111775|
| Fistulina sp.                         | Fistulinae       | √      | slightly bitter |     |             | HKAS-111893|
| Scientific name | Family name | Market | Natural habitat | ECM | Edible part | Voucher No |
|-----------------|-------------|--------|----------------|-----|-------------|------------|
| Fistulina subhepatica | Fistulinaceae | √ | Unknown | HKAS-122466 |
| Fomitopsis pinicola (Sw.) P. Karst | Fomitopsidaceae | √ | Medicinal | HKAS-111896 |
| Ganoderma lingzhi Sheng H. Wu, Y. Cao & Y.C. Dai | Polyporaceae | √ | Medicinal | HKAS-111736 |
| Geastrum velutinum Morgan | Geastraceae | √ | Unknown | HKAS-111879 |
| Gomphus xanthophyllum (Bres.) | Marasmiaceae | √ | Unknown | HKAS-112652 |
| Gloeophyllum sepiarium (Wulfen) P. Karst | Gloeophyllaceae | √ | Medicinal | HKAS-122703 |
| Gymnopilus penetrans (Fr.) Murrill | Hymenogastraceae | √ | Toxical | HKAS-122710 |
| Gymnopilus dryophilus (Bull.) Murrill | Omphalotaceae | √ | Edible, but not worthwhile because of thin flesh and tough stem | HKAS-122640 |
| Gymnopus subnudus (Ellis ex Peck) | Omphalotaceae | √ | Unknown | HKAS-122729 |
| Hymenochaete subferruginea Bres. & Syd | Hymenochaetaceae | √ | Unknown | HKAS-122472 |
| Hymenopellis orientalis (R.H. Petersen & Nagas.) R.H. Petersen | Physalacriaceae | √ | Unknown | HKAS-122599 |
| Hypomyces chlorinigenus | Hypocreaceae | √ | Inedible, parasitic fungus | HKAS-122567 |

*Table 4 (continued)
| Scientific name                        | Family name          | Market | Natural habitat       | ECM | Edible part                          | Voucher No  |
|---------------------------------------|----------------------|--------|-----------------------|-----|--------------------------------------|-------------|
| Hypomyces perniciosus Magnus Magnus   | Hypocreaceae         | √      | Inedible, parasitic fungus |    | HKAS-111690                          |             |
| Hypomyces pseudolactifluorum F.M. Yu, Q. Zhao & K.D. Hyde | Hypocreaceae         | √      | Inedible, parasiticfungus |    | HKAS-122679                          |             |
| Inocybe sp.                           | Inocybaceae          | √      | √                     | Unknown | HKAS-123963                          |             |
| Laccaria amethystina Cooke            | Hydnangiaceae        | √      | Edible | HKAS-122734                        |             |
| Laccaria aurantia Popa, Rexer, Donges, Zhu L. Yang & G. Kost | Hydnangiaceae        | √      | Edible | HKAS-122365                          |             |
| Laccaria fascata (Scop.) Cooke        | Hydnangiaceae        | √      | √                     | Edible | HKAS-111743                          |             |
| Laccaria moshujun Popa & Zhu Liang Yang | Hydnangiaceae        | √      | √                     | Edible | HKAS-122719                          |             |
| Laccaria vinaceaevallanea Hongo       | Hydnangiaceae        | √      | √                     | Edible | HKAS-111721                          |             |
| Laccaria yunnanensis Popa, Rexer, Donges, Zhu L. Yang & G. Kost | Hydnangiaceae        | √      | √                     | Edible | HKAS-123996                          |             |
| Lactarius acerinus Britzelm          | Russulaceae          | √      | Edible, but not tasty | HKAS-111712                        |             |
| Lactarius aff. subplinthogalus       | Russulaceae          | √      | Edible | HKAS-111825                          |             |
| Lactarius akahatsu Nobuj. Tanaka      | Russulaceae          | √      | Unknown | HKAS-111772                          |             |
| Lactarius austrotomentosus H.T. Le & Verbeken | Russulaceae          | √      | √                     | Edible | HKAS-122639                          |             |
| Lactarius cinnamomeus WF. Chiu        | Russulaceae          | √      | √                     | Edible | HKAS-122463                          |             |
| Lactarius conglutinatus X.H. Wang     | Russulaceae          | √      | Toxic | HKAS-111697                          |             |
| Lactarius formosus H.T. Le & Verbeken | Russulaceae          | √      | Unknown | HKAS-111772                          |             |
| Lactarius gracilis Wisitr. & Nuynintrk | Russulaceae          | √      | √                     | Unknown | HKAS-111699                          |             |
| Lactarius hatsudake Nobuj. Tanaka     | Russulaceae          | √      | √                     | Edible | HKAS-111725                          |             |
| Lactarius hirtipes J.Z. Ying          | Russulaceae          | √      | Toxic | HKAS-122708                          |             |
| Lactarius purpureus R. Heim           | Russulaceae          | √      | √                     | Edible, but not tasty | HKAS-111745                        |             |
| Lactarius rubrobrunneus H.T. Le & Nuynintrk | Russulaceae          | √      | √                     | Edible | HKAS-111805                          |             |
| Lactarius sp.                         | Russulaceae          | √      | √                     | Edible | HKAS-122654                          |             |
| Lactifluus aff. tropicosinicus        | Russulaceae          | √      | √                     | Edible | HKAS-122728                          |             |
| Lactifluus ambicystidiatus X.H. Wang  | Russulaceae          | √      | √                     | Maybe inedible, bitter and spicy | HKAS-122435                        |             |
| Lactifluus dvaliensis (K. Das, J.R. Sharma & Verbeken) K. Das | Russulaceae          | √      | √                     | Edible | HKAS-111781                          |             |
| Lactifluus gerardi (Peck) Kuntze      | Russulaceae          | √      | √                     | Edible | HKAS-122402                          |             |
| Lactifluus hygrophoroides (Berk. & M.A. Curtis) Kuntze | Russulaceae          | √      | √                     | Edible | HKAS-123965                          |             |
| Lactifluus leae (D. Stubbe & Verbeken) Verbeken | Russulaceae          | √      | √                     | Edible | HKAS-111695                          |             |
| Lactifluus pilosus (Verbeken, H.T. Le & Lumyong) Verbeken | Russulaceae          | √      | √                     | Edible | HKAS-111859                          |             |
| Lactifluus pinguis (Van de Putte & Verbeken) Van de Putte | Russulaceae          | √      | √                     | Edible | HKAS-122422                          |             |
| Lactarius piperatus (L.) Pers         | Russulaceae          | √      | √                     | Edible | HKAS-111795                          |             |
| Lactifluus pseudoluteopus (X.H. Wang & Verbeken) X.H. Wang | Russulaceae          | √      | √                     | Maybe toxic | HKAS-122349                        |             |
| Lactifluus rugatus (Kühner & Romagn.) Verbeken | Russulaceae          | √      | √                     | Edible | HKAS-111848                          |             |
| Lactifluus subpruninosus X.H. Wang    | Russulaceae          | √      | √                     | Edible | HKAS-122371                          |             |
| Lactifluus valemus (Fr.) Kuntze       | Russulaceae          | √      | √                     | Edible | HKAS-122387                          |             |
| Lannanoma pallidorosea (Both) Raspé & Vadthanarat | Boletaceae          | √      | √                     | Edible | HKAS-123971                          |             |
| Scientific name | Family name | Market | Natural habitat | ECM | Edible part | Voucher No |
|----------------|-------------|--------|----------------|-----|-------------|------------|
| *Lauriomycetes heliocephalus* (V. Rao & de Hoog) R.F. Castañeda & W.B. Kendrick | Lauriomycetaceae | √ | Inedible, pathogenic fungus | HKAS-111894 |
| *Leccinellum quercophilum* M. Kuo | Boletaceae | √ | Edible | HKAS-122418 |
| *Leccinum rugosiceps* (Peck) Singer | Boletaceae | √ | Edible | HKAS-122386 |
| *Lentinula edodes* (Berk.) Pegler | Omphalotaceae | √ | Edible | HKAS-111768 |
| *Lentinus squarrosulus* Mont | Omphalotaceae | √ | Edible | HKAS-111758 |
| *Leotia atroveners* Pers | Leotiaceae | √ | Unknown | HKAS-111847 |
| *Leotia lubrica* (Scop.) Pers | Leotiaceae | √ | Edible, but tasteless | HKAS-111791 |
| *Lyophyllum fumosum* (Pers.) P.D. Orton | Lyophyllaceae | √ | Edible | HKAS-111813 |
| *Lyophyllum rhopalopodium* Clémençon | Lyophyllaceae | √ | Edible | HKAS-111793 |
| *Marasmius chlorinosmus* A.H. Sm. & Trappe | Russulaceae | √ | Unknown | HKAS-122489 |
| *Macrocybe gigantea* (Massee) Pegler & Lodge | Callistosporiaceae | √ | Edible | HKAS-122496 |
| *Macrolepiota velosa* Vellinga & Zhu L. Yang | Agaricaceae | √ | Unknown | HKAS-122634 |
| *Marasmius sp.* | Marasmieae | √ | Unknown | HKAS-111705 |
| *Marasmius pseudopurpureostriatus* Wannathes, Desjardin & Lumyong | Marasmieae | √ | Edible, but not worthwhile because of small size and thin flesh | HKAS-123994 |
| *Microporus xanthopus* (Fr.) Kuntze | Polyporaceae | √ | Inedible, leathery flesh | HKAS-111716 |
| *Ophiocordyceps nutans* (Pat.) G.H. Sung, J.M. Sung, Hywel-Jones & Spatafora | Ophiocordycipitaceae | √ | Medicinal | HKAS-122621 |
| *Ophiocordyceps oxycephala* (Penz. & Sacc.) G.H. Sung, J.M. Sung, Hywel-Jones & Spatafora | Ophiocordycipitaceae | √ | Medicinal | HKAS-123960 |
| *Panellus pusillus* (Pers. ex Lév.) Burds. & O.K. Mill | Boletaceae | √ | Edible | HKAS-122667 |
| *Panus tigrinus* (Bull.) Singer | Polyporaceae | √ | Edible | HKAS-123994 |
| *Paxillus involutus* (Batsch) Fr | Paxillaceae | √ | Toxic | HKAS-122442 |
| *Phaeolus schweinitzii* (Fr.) Pat | Fomitopsidaceae | √ | Inedible, too tough | HKAS-122400 |
| *Pholiota multicingulata* E. Horak | Strophariaceae | √ | Maybe toxic | HKAS-122568 |
| *Phylloporus luxiensis* M. Zang | Boletaceae | √ | Edible | HKAS-111883 |
| *Phylloporus rubiginosus* M.A. Neves & Halling | Boletaceae | √ | Unknown | HKAS-122582 |
| *Polyporus cuticulatus* Y.C. Dai, Jing Si & Schigel | Polyporaceae | √ | Edible | HKAS-111809 |
| Scientific name | Family name | Market | Natural habitat | ECM | Edible part | Voucher No |
|-----------------|-------------|--------|-----------------|-----|-------------|------------|
| Pulveroboletus iteninus (Pat. & C.F. Baker) Watling | Boletaceae | ✓ | ✓ | Toxic, maybe medicinal | HKAS-111741 |
| Pulveroboletus subrufus N.K. Zeng & Zhu L. Yang | Boletaceae | ✓ | ✓ | Toxic | HKAS-122514 |
| Ramaria asiatica (R.H. Petersen & M. Zang) R.H. Petersen | Gomphaceae | ✓ | ✓ | Edible | HKAS-123983 |
| Ramaria cartilaginea Marr & D.E. Stuntz | Gomphaceae | ✓ | ✓ | Edible | HKAS-123998 |
| Ramaria cyanophagea (Berk. & M.A. Curtis) Corner | Gomphaceae | ✓ | ✓ | Maybe toxic | HKAS-122630 |
| Ramaria fennica (P. Karst.) Ricken | Gomphaceae | ✓ | ✓ | Edible, but bitter | HKAS-111790 |
| Ramaria livida (Schaeff.) Quél | Gomphaceae | ✓ | ✓ | Edible, but little bitter | HKAS-111706 |
| Ramaria sanguinipes R.H. Petersen & M. Zang | Gomphaceae | ✓ | ✓ | Edible | HKAS-111746 |
| Ramaria sp. | Gomphaceae | ✓ | ✓ | Edible | HKAS-111774 |
| Ramaria thindii K. Das, Hembrom, A. Parihar & A. Ghosh | Gomphaceae | ✓ | ✓ | Edible | HKAS-122425 |
| Ramaria vinosimaculans Marr & D.E. Stuntz | Gomphaceae | ✓ | ✓ | Edible | HKAS-111785 |
| Retiboletus fuscus (Hongo) N.K. Zeng & Zhu L.Yang | Boletaceae | ✓ | ✓ | Edible | HKAS-122545 |
| Retiboletus sinensis N.K. Zeng & Zhu L.Yang | Boletaceae | ✓ | ✓ | Edible | HKAS-122610 |
| Retiboletus sp. | Boletaceae | ✓ | ✓ | Edible | HKAS-122552 |
| Rhizocybe alba Y.X. Ding & E.J. Tian | Agaricales | ✓ | | Unknown | HKAS-122720 |
| Rhizopogon songmaodan R. Wang & Fu Q. Yu | Gomphaceae | ✓ | ✓ | Edible | HKAS-123980 |
| Rubroboletus esculentus Kuan Zhao, H.M. Shao & Zhu L. Yang | Boletaceae | ✓ | ✓ | Edible | HKAS-124003 |
| Rugiboletus extremiorientalis (Lj.N. Vassiljeva) G. Wu & Zhu L. Yang | Boletaceae | ✓ | ✓ | Edible | HKAS-123978 |
| Russula adusta (Pers.) Fr | Russulaceae | ✓ | ✓ | Edible | HKAS-122583 |
| Russula amarissima Romagn. & E.-J. Gilbert | Russulaceae | ✓ | ✓ | Edible | HKAS-111737 |
| Russula ceracea (Soehner) J.M. Vida | Russulaceae | ✓ | ✓ | Unknown | HKAS-122509 |
| Russula compacta Frost | Russulaceae | ✓ | ✓ | Edible | HKAS-111734 |
| Russula crustosa Peck | Russulaceae | ✓ | ✓ | Edible | HKAS-122506 |
| Russula cyanoxantha (Schaeff.) Fr | Russulaceae | ✓ | ✓ | Edible | HKAS-122577 |
| Russula delica Fr | Russulaceae | ✓ | ✓ | Edible | HKAS-123987 |
| Russula densifolia Sect. ex Gillet | Russulaceae | ✓ | ✓ | Edible | HKAS-122430 |
| Russula dissimulans Shaffer | Russulaceae | ✓ | ✓ | Edible | HKAS-122628 |
| Russula flavida Frost ex Peck | Russulaceae | ✓ | ✓ | Edible | HKAS-122512 |
| Russula foetens Pers | Russulaceae | ✓ | ✓ | Toxic | HKAS-111702 |
| Russula griseocarna X.H. Wang, Zhu L. Yang & Knudsen | Russulaceae | ✓ | ✓ | Edible | HKAS-122424 |
| Russula lachanpalii A. Ghosh, K. Das & R.P. Bhatt | Russulaceae | ✓ | ✓ | Unknown | HKAS-122622 |
| Russula lilacea Quêl | Russulaceae | ✓ | ✓ | Edible | HKAS-111853 |
| Russula nigricans Fr | Russulaceae | ✓ | ✓ | Edible | HKAS-123961 |
| Russula purpureocracilis F. Hampe, Looney & Manz | Russulaceae | ✓ | ✓ | Unknown | HKAS-111722 |
| Russula rosea Pers | Russulaceae | ✓ | ✓ | Edible, but some consider it inedible | HKAS-122342 |
Table 4 (continued)

| Scientific name | Family name | Market | Natural habitat | ECM | Edible part | Voucher No |
|-----------------|-------------|--------|-----------------|-----|-------------|------------|
| Russula senecis S. Imai | Russulaceae | ✓ | ✓ | ✓ | Edible | HKAS-122352 |
| Russula sp. | Russulaceae | ✓ | ✓ | Unknown | HKAS-122376 |
| Russula sororia (Fr.) Romell | Russulaceae | ✓ | ✓ | Edible | HKAS-122487 |
| Russula substriata J. Wang, X.H. Wang, Buyck & T. Bau | Russulaceae | ✓ | ✓ | Unknown | HKAS-122625 |
| Russula virensens (Schaeff.) Fr | Russulaceae | ✓ | ✓ | ✓ | Edible | HKAS-122384 |
| Russula viridicinnamomea F. Yuan & Y. Song | Russulaceae | ✓ | ✓ | Edible | HKAS-122524 |
| Russula vinosa Lindblad | Russulaceae | ✓ | ✓ | ✓ | Edible | HKAS-122380 |
| Sarcoporia polyspora P. Karst | Sarcoporiaceae | √ | Unknown | HKAS-122725 |
| Schizophyllum commune Fr | Schizophyllaceae | √ | Unknown | HKAS-123962 |
| Scleroderma flavidum Ellis & Everh | Sclerodermataceae | ✓ | ✓ | Toxic | HKAS-122469 |
| Scleroderma sinnamariense Mont | Sclerodermataceae | ✓ | ✓ | Toxic | HKAS-111718 |
| Scleroderma yunnanense Y. Wang | Sclerodermataceae | ✓ | ✓ | Unknown | HKAS-111786 |
| Sparassis sp. | Sparassidaceae | ✓ | Unknown | HKAS-122536 |
| Stereopsis radicans (Berk.) D.A. Reid | Stereopsidaceae | ✓ | Unknown | HKAS-111876 |
| Strobilomyces confusus Singer | Boletaceae | ✓ | ✓ | Edible | HKAS-122534 |
| Strobilomyces latirostris J.Z. Ying | Boletaceae | ✓ | ✓ | Edible | HKAS-122520 |
| Strobilomyces seminudus Hongo | Boletaceae | ✓ | ✓ | Edible | HKAS-111720 |
| Stropharia rugosoannulata Farl. ex Murill | Strophariaceae | ✓ | Unknown | HKAS-122474 |
| Sulzbacheromyces yunnanensis D. Liu, Li S. Wang & Goffinet | Lepidostromataceae | ✓ | Unknown | HKAS-122355 |
| Suillellus sp. | Boletaceae | ✓ | ✓ | Unknown | HKAS-111890 |
| Suillellus subvelutipes (Peck) Murrill | Boletaceae | ✓ | ✓ | Maybe toxic | HKAS-111754 |
| Suillus bovinus (L.) Roussel | Suillaceae | ✓ | ✓ | Edible | HKAS-111891 |
| Suillus luteus (L.) Roussel | Suillaceae | ✓ | ✓ | Toxic | HKAS-111788 |
| Suillus placidus (Bonord.) Singer | Suillaceae | ✓ | ✓ | Toxic | HKAS-122590 |
| Tapinella panuoides (Fr) E.-J. Gilbert | Tapinellaceae | ✓ | Toxic | HKAS-122726 |
| Termiticolia sp. | Agaricaceae | ✓ | Unknown | HKAS-111738 |
| Termitomyces albiceps S.C. He | Lyophyllaceae | ✓ | ✓ | Edible | HKAS-111703 |
| Termitomyces aurantiacus (R.Heim) R. Heim | Lyophyllaceae | ✓ | ✓ | Edible | HKAS-122633 |
| Termitomyces clypeatus R. Heim | Lyophyllaceae | ✓ | ✓ | Edible | HKAS-123988 |
| Termitomyces eumrhizus (Berk.) R. Heim | Lyophyllaceae | ✓ | ✓ | Edible | HKAS-124007 |
| Termitomyces heimii Natarajan | Lyophyllaceae | ✓ | Edible | HKAS-123975 |
| Termitomyces fuliginosus R. Heim | Lyophyllaceae | ✓ | Edible | HKAS-111732 |
| Termitomyces microcarpus (Berk. & Broome) R. Heim | Lyophyllaceae | ✓ | Edible | HKAS-111735 |
| Termitomyces sp.1 | Lyophyllaceae | ✓ | Edible | HKAS-122510 |
| Termitomyces sp.2 | Lyophyllaceae | ✓ | Edible | HKAS-122623 |
| Thelephora ganbajun M. Zang | Thelephoraceae | ✓ | ✓ | Edible | HKAS-111698 |
| Thelephora regularis Schwein | Thelephoraceae | ✓ | ✓ | Edible | HKAS-111874 |
| Thelephora sikkimensis K. Das, Hembrum & Kuhar | Thelephoraceae | ✓ | ✓ | Unknown | HKAS-122715 |
| Thelephora sp | Thelephoraceae | ✓ | ✓ | Edible | HKAS-111830 |
| Thelephora virosa Schwein | Thelephoraceae | ✓ | ✓ | Edible | HKAS-122373 |
| Triapaptum abietinum (Pers. ex.J.F. Gmel) Ryvarden | Hymenochaetales | ✓ | Inedible, leathery flesh | HKAS-122706 |
markets belong to 22 families and 39 genera, and about 76% of them are EMF. The 283 species collected in the natural habitats belong to 52 families and 100 genera, and about 70% are EMF.

In the markets, 91 species are edible and about 80% are EMF. A few new species which have only been published in recent years [44–47] were found in markets. And some previously described species were revised or classified in other section or genus by molecular phylogenetic study [48–50]. Furthermore, four species from markets are medicinal, two of which, *Ophiocordyceps nutans* (Pat.) G.H. Sung, J.M. Sung, Hywel-Jones & Spatafora and *O. oxycephala*, are mainly distributed in tropical and subtropical broad-leaved forests. It is interesting that four species which have been reported to cause gastroenteritis type poisoning, including *Heimioporus japonicus* (Hongo) E. Horak and *Tylopilus neofelleus* Hongo (in July) were sold in large quantities in Pu’er market, and *Tricholoma equestre* (L.) P. Kumm. (August to October) was mixed with a few *Tricholoma saponaceum* (Fr.) P. Kumm. in some small stalls. Some specimens, of one inedible species, *Abortiporus biennis* (Bull.) Singer, were recorded to be sold in a few markets as *Thelephora ganbajan* M. Zang. Similarly, *Hygrocybe cuspidata* (Peck) Murrill with unknown toxicity was sold occasionally in some stalls maybe because for some people it is *Cantharellus*-looking. Therefore, the accurate taxonomic status of these apparently toxic species has to be carefully checked, in order to determine if they correspond to new taxa or if the ecotypes in the area are non-toxic species. Most commercial mushrooms are common species in all markets (Fig. 3a–i). Six sampled markets shared 49 mushroom species, while 12 unique species were only sold in Pu’er market and 9 unique species were only sold in Lncang market (Fig. 3j).

The forest areas selected for the natural habitats work (according to information gathered from some collectors) were within 15 km of the markets. Due to its protected status, the Ecological Conservation Forests and the Sun River National Forest Park are less visited by gatherers or recreational visitors. A total of 283 species were recorded and collected from natural habitats, which include 129 edible species, accounting for about 84% EMF, 15 inedible species, 11 medicinal species, 53 poisonous species and 75 species with unknown edibility. Moreover, 23 species are undescribed and are currently under taxonomic study (Fig. 4).

**Local preference and acceptability of WEF species**

A total of 74 species were recorded in both markets and natural habitats, including 65 edible species, 4 medicinal species, 4 toxic species and one species with unknown use. *Amanita caojizong* Zhu L. Yang, Y.Y. Cui & Q. Cai, *Cantharellus cinnabarinus* (Schwein.) Schwein., *Crate -rellus cornucopioides* (L.) Pers., *Lactifluus piperatus* (L.) Pers., *Lactifluus volemus* (Fr.) Kuntze and *Ramaria* spp. were popular in markets and easy to find in natural habitats in mushroom season (Fig. 5). The most frequently bought wild mushrooms belonged mainly to Boletaceae (16 species), Hydnaceae (14 species), Lyophyllaceae (11 species) and Russulaceae (23 species). The families Amanitaceae (26 species), Boletaceae (32 species), Cortinariaceae (16 species), Hydnaceae (24 species), Hydnangiaceae (6 species), Lyophyllaceae (11 species) and Russulaceae (50 species) were common
in natural habitats and forests. Mushroom species and amount showed a high correspondence between markets and the natural habitats on different months (Fig. 5). Preference of WEF for locals was mostly related to their availability in the forests.

**Ethnomycological data**

**Type of markets and constitution of vendors**

A total of 11 markets were visited during this study. As illustrated in Table 2, three markets were established markets, 3 markets were mobile markets and 5 street-stalls were without names. Different markets have different sale time to sell mushrooms according to the local people’s different lifestyles. The highest number of vendors in all markets was recorded in August and September. The vendors in the mobile markets and in the street-stalls were usually low-income people, who travel usually by foot from the natural collection areas to the selling points.

Almost all vendors were able to speak Mandarin in Wuyi market of Pu’er City although most of vendors belong to ethnic groups, like Hani, Yi and Lahu people. This is the largest market in Pu’er, and up to 200 vendors, including gatherers, two-way merchants (those who buy mushrooms from gatherers directly in natural habitats) and brokers (those who buy mushrooms from gatherers or to two-way merchants), sold mushrooms in August and September (Fig. 2a–c). Most of the valuable mushrooms are usually sold at higher prices to large markets or restaurants of Kunming (the capital of Yunnan province) by brokers. Vendor’s main age group was between 35 and 55, and most of them were able to receive contactless payments through their mobile phones.

In the markets of Mojiang and Ning’er Counties, the number of vendors reached 100 in August or September. The Yi and Hani people are the main ethnic groups who inhabit these two counties. In recent years, local governments have paid great attention to the development of WEF resources marketing, and more mushroom markets have been established. Vendors in these markets were gatherers, merchants and some brokers, and the main age group was between 20 and 45. A small group of aged vendors (60+) spoke southwest Mandarin and could not use mobile phone apps to receive payments for the mushroom sale.

Lancang Street Market (Fig. 2d, e) had mostly Lahu and Hani people. The villagers in the surrounding towns bring a variety of products to Lancang Street Market on Sunday every week. Vendor’s main age group was between 40 and 65, 48% of which could not speak Mandarin, only Lahu language and southwest Mandarin. In addition, most of aged vendors accepted cash only.
Nearly all vendors in Lancang Street Market were gatherers, and most of them usually sell mushrooms along with vegetables, fruits or local products, so seller mobility in this market was not strong within market time.

Menglian and Ximeng Counties are not far from Lancang County. The Lahu, Dai and Wa people are the main ethnic groups in these two counties. Vendors here spoke Lahu, Dai and Wa languages and southwest Mandarin. Compared with other markets, fewer vendors sold mushrooms. However, some vendors said that many buyers from Lancang County or Pu’er Municipality came here to buy mushrooms to process or dry and then resell them, so many vendors collect mushrooms and sell them directly to wholesale buyers.

Mushroom species from five street-stalls which have 1 to 15 vendors by county highways or village roads were also recorded. These vendors come from nearby villages and most of them were aged people. They do not have transportation to go to markets to sell mushrooms, so they usually sell them on the side of the road after

Fig. 4 Typical edible wild mushrooms and their natural habitats. a–c Sampled vegetation types: a Pinus kesiya forest; b Coniferous and broad-leaved forest mixed forest; c Broad-leaved forest. d–i Representative abundant mushroom species: d Ramaria sp.; e Cantharellus cinnabarinus; f Lactifluus piperatus; g Craterellus cornucopioides; h Amanita caojizong; i Laccaria yunnanensis. j–l Some undescribed fungi: j Cortinarius sp.; k Phaeocollybia sp.; l Ramaria sp.
collecting them. As a consequence, only very fresh mushrooms were recorded (Fig. 2 g, i).

Gender of vendors

The male-to-female ratio of vendors showed that women outnumber men in markets. Female vendors were involved in every stage of mushroom utilization from collection to processing and marketing.

Mushroom prices in three years

The prices of popular mushrooms were similar in the six studied counties, and the price of each species did not fluctuate much over the three years (Table 5). However, a large fluctuation was recorded throughout the mushroom season mainly due to their availability and quality of the specimens. Overall, the prices of popular mushrooms, *Russula griseocarnosa* X.H. Wang, Zhu L. Yang & Knudsen, *Termitomyces* spp. (e.g., *T. globulus*, *T. striatus*) and *Thelephora ganbajun* were higher than those of other mushroom species. *Schizophyllum commune* Fr. was only recorded to be sold in a few stalls in each market, and its price was as high as to 200 yuan per kilogram. In each market, vendors carefully placed mushrooms on green banana leaves or in plastic bags, baskets or plates (Fig. 6) with a certain weight (generally 0.5 kg or 1 kg), which due to the arrangement always looked beautiful and clean.

Except for brokers, most collectors are farmers who grow tea and other crops or raise hogs and cattle. During the mushroom season, they usually collect wild mushrooms in the mountains near their homes and sell them for an extra income (3000–6000 yuan per family, approximately equivalent to USD$450 to 900) for their families.

The use and preparation methods of WEF

The main use of wild mushrooms is for food, and a few are medicinal species used to make medicinal liquor (Fig. 7, Table 6). The most common cooking preparation way among local people was to fry the mushrooms with fermented bamboo shoots or other local vegetables. *Lactifluus piperatus*, which has a spicy taste, is considered to be a perfect match for sour pickles. *Tylopilus neofelleus* is an interesting species considered toxic by some local people; however, other people enjoy its bitter flavor. They found a cooking method to remove toxic components, which was by drying slices of the mushroom and then deep frying them. For species of Boletaceae, local people had a common understanding of adding more garlic and cooking them for more than 30 min. Likewise, local people soak peeled *Scleroderma yunnanense* Y. Wang fruiting bodies or slices in water or saline water before cooking to remove some components to avoid any gastrointestinal upset.

Local people stored mushrooms by drying, pickling and frying, but they enjoy more to eat fresh mushrooms. Some dry mushrooms, like *Boletus* spp. (porcini), *Russula griseocarnosa*, *Russula virescens* (Schaeff.) Fr. and *Ramaria* spp., were usually sold to people from other cities.

![Fig. 5 Comparison of the most abundant edible wild mushrooms sampled in markets (black bars) and natural habitats (gray bars) of Pu’er Municipality and Lancang County during July to October. Numbers of black bars represent percentages of stalls sold the most abundant edible wild mushrooms to total stalls; numbers of gray bars represent percentages of numbers of collected the most abundant edible wild mushrooms to total collected mushrooms.](image)
Traditional recognition methods of WEF

The rich variety of mushroom species gathered by local people demonstrate that they have a rich traditional knowledge. Local mushroom names demonstrate a particular taxonomic knowledge. According to the color, shape, taste, texture, habitat and some special features of mushrooms or even local legends, interesting and vivid names have been given to mushrooms and people are able to make a local classification system for mushrooms (Table 7). Sometimes, mushrooms have more than one name, like *Scleroderma yunnanense*, which is named “bubble with horse skin” in most areas of Pu’er because of its shape and texture, but Lahu people call it “soil fruits” because of its habitat. *Lactifluus rugatus* (Schaeff.) Fr. is named “milk cap mushroom” because of the fluid it produces, and the names “monkey mushroom” (local monkeys are yellow) and “sweet yellow mushroom” come from its pileus color and taste. Experienced gatherers have a more impressive knowledge. Such as valuable *Russula griseocarnosa* could be distinguished from other similar or poisonous species by its thick pileus, light-gray context and solid stipe (they usually squeeze the stipe). *Amanita caojiizong* and poisonous *Amanita pseudoporporphyria* Hongo are locally distinguished by the stipe shape and smell. The knowledge of selecting mushrooms has usually passed from generation to generation. Moreover, some collectors have their own mental maps to find specific places where mushrooms, especially valuable ones, appear every year, and the information is usually kept within their family to avoid the collection by other people, which would affect their family’s income.

**Discussion**

A total of 310 wild mushroom species, varieties and some undescribed species were collected from markets and natural areas. Approximately 70% of the species were ectomycorrhizal. In the markets from the 91 edible species, about 80% were EMF. With the development of transportation infrastructures, Pu’er has become one of the main supply centers of WEF for central Yunnan, and WEF processing industries are becoming large scale. Yu et al. [33] surveyed markets in Pu’er from 2002 to 2009 and reported a sharp decline of WEF production of 43 species, such as *Lactifluus volemus*, *Russula griseocarnosa*, *Termitomyces* spp. and *Thelephora ganbajun* which were considered important in Yunnan. In our study, interviews with vendors showed that production of these species had declined even more in recent years and they had to travel farther to collect them. However, we also found that some mushrooms, that were not so common then, are now popular in Pu’er area, such as *Cantharellus cinnabarinus*, *Laccaria laccata* and *Boletus edulis* [33]. These species have a high market value and high production in the sites sampled in our study. This change might have due to the growing mycological knowledge of Pu’er people. The increase in mushroom species could reduce the pressure of collection of valuable species to some extent. But local people still act cautiously and even refuse eating some edible mushrooms that have only recently become mainstream edibles. In our study, 57 good edible species that we found in nature were not sold in markets. Very tasty species as *Amanita subhemibapha* Zhu L. Yang, Y.Y. Cui & Q. Cai, *Boletus violaceofuscus* W.F. Chiu and *Laccaria amethystina* Cooke have beautiful color and good production in the forests, but they were not recorded in the markets maybe due to the fact

| Species                     | Year 2019       | Year 2020       | Year 2021       |
|-----------------------------|-----------------|-----------------|-----------------|
| Boletus spp. (porcini group) | 30–90 yuan/kg   | 20–75 yuan/kg   | 30–85 yuan/kg   |
| Craterellus cornucopioides  | 20–70 yuan/kg   | 20–60 yuan/kg   | 20–70 yuan/kg   |
| Laccaria spp.               | 20–40 yuan/kg   | 15–40 yuan/kg   | 15–40 yuan/kg   |
| Lactifluus piperatus        | 10–30 yuan/kg   | 10–30 yuan/kg   | 10–30 yuan/kg   |
| Lactifluus volemus          | 30–90 yuan/kg   | 25–90 yuan/kg   | 30–90 yuan/kg   |
| Ramaria spp.                | 20–40 yuan/kg   | 20–40 yuan/kg   | 10–40 yuan/kg   |
| Russula griseocarnosa       | 45–120 yuan/kg  | 50–120 yuan/kg  | 40–130 yuan/kg  |
| Russula virescens           | 30–80 yuan/kg   | 30–90 yuan/kg   | 30–80 yuan/kg   |
| Scleroderma yunnanense      | 15–40 yuan/kg   | 15–40 yuan/kg   | 15–40 yuan/kg   |
| Termitomyces spp.           | 30–160 yuan/kg  | 30–160 yuan/kg  | 25–160 yuan/kg  |
| Thelephora ganbajun         | 90–180 yuan/kg  | 95–180 yuan/kg  | 90–195 yuan/kg  |
that they are preferred for self-consumption rather than commercialization. The utilization of WEF resources in Pu’er still has great potential to be developed. However, in the studied area the knowledge and implementation of strategies and actions in order to protect the decline of relevant WEF are its infancy. In general, fungi have historically been left out of conservation initiatives [51].

In addition, climate change, habitat loss, overexploitation and land pollution might be affecting the natural production of WEF. Therefore, it is urgent for the development of ecological studies and the implementation of comprehensive monitoring of natural production of WEF in the studied area along with cultivation of ectomycorrhizal edible fungi. These strategies would allow

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**Fig. 6** In each market, vendors place mushrooms on green banana leaves, plastic bags, baskets or cans with a defined weight (usually 0.5 kg or 1 kg), which facilitates the selling process

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**Fig. 7** Preparation way of wild fungi. **a** Termitomyces soup; **b** Stir-fried Cantharellus cinnabarinus; **c** Hot pot with Boletaceae, Lactarius, Lyophyllum, Russula and some artificial cultivated mushrooms
### Table 6  Local preferred preparations and storage methods for edible mushrooms

| Species | Preparation                                      | Note                                           | Storage                        |
|---------|--------------------------------------------------|------------------------------------------------|--------------------------------|
| Amanita caoijizong, A. sinensis | Make soup, stir-fry with little garlic | — | — |
| Boletaceae | Fried with garlic and chili (dry chili or fresh chili) | Cooking time must be longer | Slice and dry Fry and soak in oil |
| Cantharellus spp. | Stir-fried with little garlic | — | Dry |
| Craterellus cornucopioides | Stir-fry with garlic and chili | Cooking time is short to keep its crisp mouthfeel | — |
| Lactifluus piperatus | Chop mushrooms, then fry with garlic, dry chili and sour bamboo shoots or pickles | — | — |
| Lactifluus volemus | Fry with garlic, chili and meat | — | — |
| Ramaria spp. | Fry with garlic, dry chili and sour bamboo shoots or pickles | — | Dry |
| Russula griseocarnosa | Cook with chicken soup | — | Dry |
| Russula virescens | Stir-fry with garlic and fresh chili | — | Dry |
| Lactifluus piperatus | Frying and soaking in oil | — | — |
| Scleroderma yunnanense | Slice, fry with garlic and chili | Peel and soak in water before cooking to reduce bitter taste | Slice and pickle with salt |
| Termitomyces spp. | Make soup | — | — |
| Thelephora ganbajun | Fried with garlic, chili and bacon | — | — |
| Tylopilus neofelleus | Dry, slice and deep fry | — | — |

### Table 7  Interesting local name of popular commercial mushrooms in markets

| Species | Local name (in Chinese) | Local name (in English) | Origin of name                      |
|---------|-------------------------|-------------------------|------------------------------------|
| Amanita sinensis | 麻母鸡 | Pock chicken | Color and pulverulent to flocculent squamules |
| Amanita caoijizong | 鸭蛋菌 | Duck’s egg mushroom | Smooth and rounded pileus |
| Boletus spp. | 牛肝菌/羊肝菌 | Beef/lamb liver mushroom | Plump flesh |
| Cantharellus spp. | 见手青 | Turn to green when hands touch | Indigo color reaction after injury |
| Cortinarius tensipes | 黄栎窝 | Nest of yellow mushroom under the oak | Color, habitat and cluster |
| Craterellus spp. | 喇叭菌 | Trumpet mushroom | The shape of fruiting body |
| Hydnum spp. | 伞盖巴 | Goat’s cheek | Soft spines |
| Laccaria spp. | 鸡油菌 | Chicken ass mushroom | Shape of pileus |
| Lactifluus piperatus | 辣菌 | Spicy mushroom | Spicy taste |
| Lactifluus volemus | 奶浆菌 | Milk cap mushroom | Milk flowing out when cut |
| Panus tigrinus | 八担柴 | Eight loads of wood | Tough texture, need a lot of wood to cook |
| Ramaria spp. | 刷把菌 | Brush mushroom | Multiple-branch |
| Russula griseocarnosa | 大红菇 | Red mushroom | The color of fruiting body |
| Russula nigricans | 火炭菌 | Charcoal mushroom | The color of fruiting body |
| Russula virescens | 肾头菌 | Green head mushroom | The color of fruiting body |
| Scleroderma yunnanense | 马皮泡 | Horse skin bubble | Shape of fruiting body |
| Thelephora spp. | 干巴菌 | Jerky mushroom | Chewy flesh |
| Tricholoma equestre | 八面菌 | Buckwheat mushroom | Fruiting body’s color |
| Tylopilus neofelleus | 苦马肝 | Bitter horse liver | Bitter taste and plump flesh |
the development of codes of conduct and appropriate legislation related to the maximum amounts allowed to be collected for marketing, optimal harvesting methods and sustainable use of the relevant genetic resource constituted by WEF in the area.

In our study, some poisonous mushrooms were identified. Mushroom poisoning has always been an important food safety issue in China, and it recently has gained a conspicuous attention. Currently, the Chinese Centers for Disease Control and Prevention have developed a systematic technical support network supported by technical staff, doctors and mycologists. This has allowed to start a precise record of the mushroom species involved in mushroom poisoning in the country. Li et al. [52–54] identified using morphological and molecular characterization, approximately 74 poisonous mushrooms which originated hundreds mushroom incidents in 25 provinces up to now. The most dangerous mushrooms, Amanita exitialis, Lepiota brunneoincarnata and Russula subsections, showed the highest fatality rate. Seven different mycetism syndromes have been recorded worldwide [45]: acute liver failure, acute renal failure, rhabdomyolysis, gastroenteritis, psychoneurological disorder, erythrolysis and photosensitive dermatitis, all of which have been recorded in China [55, 56]. Despite the fact that very complete reviews have been published dealing with the mycetisms and their potential treatments [57, 58], the topic is far to be complete. With the advent of molecular techniques, new poisonous species continue being identified [59, 60]. Therefore, a more active role of scientists, doctors and policy-makers at local and national levels is urgently necessary in order to reduce mycetisms in China and worldwide.

A total of 11 markets from one municipality and 5 counties were visited during this study. Sales activities of wild mushrooms can be carried out uniformly in established markets, while local government strengthens the sales supervision of markets to make the sale of wild mushrooms more standardized and reduce the probability of wild mushroom poisoning. In each market, the male-to-female ratio of vendors showed that women outnumber men. It seems that in many regions of the world women are often the main collectors [61–63]. But women usually collected mushrooms closest to their houses, while men go farther to collect. For this reason, men usually have developed a deeper knowledge related to WEF compared to women. We recorded that the members of the local ethnic groups have developed a profound knowledge in order to distinguish edible species from those poisonous ones. This knowledge is based on accurate morphological characterization, ecological observations, association with vegetation types or even specific trees and phenological patterns of WEF. In addition, the age of collectors was mainly between 45 and 65 years old and only few young people were involved in mushroom collecting or selling. Traditional knowledge is being lost through economic change, modernization, urbanization and even formal education. Therefore, further research on ethnomycology is urgent to preserve the current knowledge before their lost forever.

Despite the fact that open-air markets in southeast Asia are relevant reservoirs of biocultural diversity in southeast Asia, they have been largely understudied. As far as useful mycological resources concerns, it has been shown that these markets are additionally an important source of traditional knowledge due to the fact that frequently the sellers are the current gatherers, recipients of ancestral mycological knowledge. Some areas in different parts of southwest Asia have shown to harbor a great biodiversity of edible mushrooms. For example, in the markets of Luang Prabang in north Central Laos, 54 species of fungi have been reported to be sold [64]. In this area, a large number of rare species of Russula, some probably new to science, are commercialized in local markets. Some of the species reported from markets of this region of Laos were also recorded to be sold in the Pu’er’s studied markets in our work including: Amanita princeps, Auricularia delicata, Boletus reticulatus, Lactifluus pinguis, Lentinula edodes, Lentinus squarrosulus, Macrocybe gigantea, Russula delica, R. virescens, Schizophyllum commune, Termitomyces fuliginosus, T. eukrizus, T. heimii and T. microcarpus [64]. Recently, a monograph of the useful fungi of Northern Laos, including edible and medicinal species has been published [65]. There are also a large number of species reported in this monograph with those sold in the markets of Pu’er in China. These include members of the genera Amanita, Auricularia, Boletus Cantharellus, Craterellus, Lactarius, Lactifluus, Lentinus, Lentinula, Lyophyllum, Ramaria, Russula, Thelephyora, Termitomyces, Tricholoma and Tylopilus, most of which are EMF. The situation of the ethnomycological understudy of open-air markets selling wild mushrooms is not exclusive of Southeast Asia, but it is a global issue. For example in Tanzania, 128 edible wild mushrooms are commercialized in 31 traditional markets. Among them the genera with the highest diversity were Termitomyces, Cantharellus and Russula with 21, 17 and 9 species, respectively [66]. In Mexico, in one single market located in the central part of the country, called Ozumba, 60 species of WEF were reported to be sold. In this market, with 411 stands selling WEF mainly during July and August, 90% of the vendors were women, and 64% were between 40 and 60 years old [62]. In southeastern Poland, 30 edible wild mushrooms were recorded to be sold [67]. A similar number of species have been recorded to be sold in western Black Sea region in Turkey, where 33
edible wild mushrooms are commercialized in 70 local markets [21]. In other areas, a smaller number of species have been recorded to be sold in open-air markets; for example, in Armenia located in Western Asia, only 12 edible wild species of mushrooms have been reported to be commercialized [68]. In fact, in general the open-air markets constitute cultural treasures, whose study should receive more attention in order to increase the knowledge related to the sustainable use and conservation of wild mushrooms as a paramount local source of food around the globe.

Conclusion
We recorded a wealth of ethnomycological knowledge through interviews and collected abundant wild mushroom samples from local markets and forests in three consecutive years. Mushroom harvesting is a challenging activity that requires a deep local environmental knowledge to achieve success. Local mushroom collectors in Pu’er have rich experience with the habitats where their WEF proliferate, their fruiting time and species identification which comes mainly from the previous generation, as well as special cooking and preservation methods. There are established markets, mobile markets and street-stalls for selling mushrooms in Pu’er area. In markets, men usually develop a more profound knowledge on WEF than woman, although the number of female vendors is larger than that of male vendors. Our current study provides useful documentation, which contributes to preserving ethnomycological knowledge in Pu’er Prefecture. In addition, the diversity of species of wild fungi, especially ectomycorrhizal fungi, in markets and natural areas has been updated and supplemented which helps us to recognize mushroom species accurately and detect valuable species. Local preference and acceptance of more mushroom species of WEF may reduce the pressure to collect traditional choice species. However, the rational management of WEF species with high yield in natural areas and the collection and use of ectomycorrhizal fungi germplasm resources for cultivation will benefit the sustainable utilization of local WEF. Finally, it is necessary to continue the research of ethnomycology in order to preserve existing knowledge, since knowledge of fungi remains mainly among the elderly population.

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Author contributions
RW conducted the investigation and experiment, analyzed the data and prepared the manuscript. MH conducted the investigation and edited the manuscript. WJX conducted the investigation and experiment. PZ conducted the investigation. JPM and CC guided in study plan and revised the manuscript. FQY supervised the research and edited the manuscript. All authors contributed to the article and approved. All authors read and approved the final manuscript.

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