An ethnobotanical survey of wild edible plants used by the Yi people of Liangshan Prefecture, Sichuan Province, China

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Abstract

Background: Due to historical perceptions of Liangshan Yi Autonomous Prefecture (Sichuan Province, China) as being a violent place, and due to its rugged terrain, cultural differences, and relative inaccessibility, few researchers have conducted in-depth ethnobotanical investigations in Liangshan. But wild edible plants (WEPs) are widely consumed by the Yi people of Liangshan, and their associated ethnobotanical knowledge remains relatively unknown, especially outside of China. This study aimed to (1) investigate the WEPs used by the Liangshan Yi, (2) document the traditional knowledge held about these plants, (3) analyze their special preparation methods and consumption habits, and (4) identify species with important cultural significance to the Liangshan Yi.

Methods: During 2016–2017, 396 Yi individuals were interviewed in 1 county-level city and 6 counties across Liangshan. Prior informed consent was obtained, and multiple ethnographic methods were utilized, including direct observation, semi-structured interviews, key informant interviews, informal discussions, and field visits. Market surveys were conducted in April, July, and August 2017 by interviewing 38 Yi merchants selling WEPs in 6 Liangshan traditional markets. We collected information about the parts consumed, preparation methods, consumption habits, growth pattern of species, collection months, market prices, and other uses of WEPs. Use values (UVs) were calculated to analyze the relative cultural importance of each WEP.

Results: In total, 105 plant species belonging to 97 genera and 62 families were recorded. Rosaceae was the family with the largest number of species (14), and herbs (58 species) were the dominant growth form reported. Fruits (34 species), roots (21 species), and tender shoots (20 species) were the primary plant parts used for snacking and cooking. There were 6 main preparation and consumption methods of WEPs reported, ranging from primary food, famine food, snack, spice, culinary coagulant, and medicine, among a few other uses. The Liangshan Yi mainly collect WEPs from March to October, seldom collecting from November to February. There were 35 species of WEPs sold in the markets we visited in Liangshan. The price of medicinal plants was much higher than the price of food and fruits. In total, we documented 49 species of edible medicinal plants in Liangshan, accounting for 44.7% of all WEPs. They can be used for treating 27 medical conditions, including cough, diarrhea, injury, and headaches. The plants with the highest UVs were Berberis jamesiana (1.92), Pyracantha fortuneana (1.87), and Artemisia capillaris (1.44) indicating that these species are the most commonly used and important to the Liangshan Yi’s traditional life and culture.

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Conclusions: The traditional knowledge of WEPs from the accumulated experience of the Yi people’s long period residing in Liangshan reflects the cultural richness of the Yi and the plant diversity of the region. Future research on the nutrition, chemical composition, and bioactivity of the WEPs are needed. Some species with high medicinal value but with sharp wild population decline should be surveyed for resource assessment, conservation, and domestication potential.

Keywords: Liangshan Yi Autonomous Prefecture, Yi people, Wild edible plants, Use values, Ethnobotany

Introduction

Adapting to continued human population growth and global climate change requires a diversity of food plants to ensure a safe and resilient food supply [1–7]. In particular, wild edible plants (WEPs) are of great significance in maintaining the productivity and stability of traditional agro-ecosystems [5, 8]. In times of famine and scarcity, these sources of nutrients and health-promoting compounds have received heightened attention in rural and suburban areas [9, 10]. WEPs remain essential components of the diets for many people in developing countries, especially in periods of seasonal food shortage [11]. Consequently, conserving WEPs is necessary to ensure the ongoing supply of diverse genetic resources that are critical to global food security [2, 4, 5, 12].

As living standards rise, there is also an increasing global demand for healthier and safer food [13]. Compared with cultivated vegetables, WEPs require less maintenance, are not dependent on chemical fertilizers or pesticides, and are richer sources of micronutrients [5]. Some WEPs have also been described as “functional foods” because they contain physiologically active ingredients capable of providing health benefits beyond basic nutrition [10]. Multiple authors have noted a continuum in many cultures between “food” and “medicine” plants, with species initially selected as medicine later used primarily for food (or vice versa), and the concepts of food and medicine themselves are infrequently differentiated, instead taken together as synonymous with “healthy eating” [9, 14–17]. Furthermore, whether a particular plant is perceived as a food, medicine, or even poison often depends on the part used or quantity ingested, as well as how and when it is collected/prepared [9, 16].

Since local cultures select edible species over time based on many years of experience, traditional ethnobotanical knowledge and associated practices about WEPs are highly dependent on the local context [10]. It is, therefore, increasingly important to carry out systematic ethnobotanical investigations to document WEPs utilized in rural communities and by the socio-cultural
groups that are dependent upon them [18]. Fortunately, in recent decades, focused studies of WEPs have proliferated worldwide, including in Africa [6, 19, 20], South Asia [4, 21], East Asia [5, 22, 23], Europe [10, 24], North America [17], South America [7, 11], and Oceania [25]. Nevertheless, the WEPs utilized by many unique socio-cultural groups in each of these diverse geographic regions remain understudied. Yet, in addition to documenting WEPs around the world, studies should also strive for theoretical rigor by testing hypotheses associated with the use, selection, and perception of WEPs in the local communities [26].

Liangshan Yi Autonomous Prefecture (Liangshan) is a mountainous rural jurisdiction in southwest Sichuan Province, China. It is the single largest settlement area for the Yi minority people in China, being the primary home of the most populous and geographically most widely distributed branch of Yi [27, 28]. For many centuries, Liangshan was considered by outsiders to be an especially dangerous place, with violent clashes and open warfare between the Yi and Han Chinese populations [29]. Liangshan was the last significant region of China to resist Communist control, so the people living there largely governed their own affairs until the Communist penetration of the area began in the 1950s. Before the 1956 reforms, the Yi people of Liangshan maintained a rigid slave-based feudal society, raiding neighboring Han communities and subjugating travelers as slaves. Despite the formal abolition of the system in the 1950s, the hierarchical classes, associated values systems, and other unique cultural characteristics have remained, largely intact, to this day [30]. Consequently, due to external perceptions about its remoteness, rugged terrain, cultural considerations, and relative inaccessibility, few ethnobotanists have conducted in-depth investigations in Liangshan.

Of note, few studies have specifically analyzed the WEPs harvested by the Liangshan Yi, and the only in-depth studies of this kind (all published in Chinese) have documented plants used for food by the Yi in a single county of Liangshan [31], as well as plants used for dye [32] and folk customs [33]. The richness of Liangshan’s traditional culture and biodiversity warrants deeper investigations. Therefore, this study sought to identify the WEPs used by Liangshan’s Yi people, document their uses, the plant parts used, and the traditional knowledge held about these plants. We also sought to assign plant use value scores to the WEPs utilized by the Liangshan Yi to identify the culturally most important taxa, which will help prioritize plants for conservation purposes. Based on the composition of the local flora, and because family tends to be a strong predictor of plant use value [26, 34], we hypothesized that (1) certain families (Compositae, Lamiaceae, Rosaceae) would have more species with higher use values as a result of their (a) greater abundance in Liangshan’s native flora and (b) global importance for food crop species. Although other globally important food-crop families (e.g., Solanaceae) are now commonly cultivated by the Liangshan Yi, they are relatively less common among the local flora. We also hypothesized that (2) fruit would be the plant part most frequently used, due to the local abundance of edible fruiting trees in the local flora; (3) most plants would be harvested during summer and fall, due to the seasonality of fruit maturation; and (4) given that there is no clear distinction in many cultures between the concepts of food and medicine, some WEPs would also have medicinal value.

Materials and methods
Liangshan’s ecology and climate
Liangshan Prefecture encompasses 60,423 km² and, located in the southwest of Sichuan Province, lies between 26° 03’ to 29° 18’ N latitude and 100° 03’ to 103° 52’E longitude. The region has a subtropical monsoon climate, with warm winters, dry springs, and ample sunshine year-round. The rainy monsoon conditions with passing clouds moderate the summer temperatures as well, with an average annual temperature of 16–17 °C. To the east, west, and south, Liangshan is surrounded on three sides by the Jinsha River, and, to the north, it is bounded by the Dadu River, thus forming a relatively closed geographical unit. With the Greater and Lesser Xiangling Mountains as the boundary, there is a distinct contrast of climates in Liangshan with dryer conditions to the south and west and moister conditions to the north and east.

Liangshan also constitutes the northern section of the Hengduan Mountain Range, which serves as a topographic bridge between the Sichuan Basin and the Yunnan-Guizhou Plateau [35], forming the core area of the Eastern Himalayan Biodiversity Hot Spot [36]. Consequently, Liangshan is dominated by mountains and plateaus, accounting for more than 90% of the entire area, with the remaining 10% being hills, basins, and plains. The altitude ranges from 325 m below sea level up to 5958 m above sea level. These elevational extremes, with warmer temperatures prevailing at lower altitudes and cooler conditions at higher altitudes, also create a wide diversity of microclimates in close proximity, with a great abundance of plant species and high endemism. The vegetation cover of Liangshan includes more than 2 million hectares of woodlands and grasslands with more than 4000 plant species [37]. Due to its rich plant resources, the people living in the region for generations, particularly the Yi, have accumulated a wealth of ethnobotanical knowledge [33, 38].
Liangshan demographics, language, and study site locations

The Yi comprise the seventh largest ethnic group in China, with a total population of about 9 million people primarily spread across the southwest Chinese provinces of Yunnan, Sichuan, and Guizhou. The Yi account for the majority of Liangshan’s total population, with the 2016 census indicating that of Liangshan’s 5,117,825 people, 2,647,791 were Yi (51.7%), followed by the Han (44.8%), Tibetan (1.41%), Mongolian (0.64%), and Hui

Table 1 Study site locations

| County/ city name | Fieldwork months | Area (ha) | Total population | Yi population | Percentage (Yi/total) | Annual per capita income (RMB) | Participants (F/M) | Market survey location (no. of participants) | Latitude and longitude (market) |
|-------------------|------------------|-----------|------------------|---------------|------------------------|--------------------------------|-------------------|-----------------------------------------------|-------------------------------|
| Butuo             | Apr., Jul., Aug., Oct. 2017 | 1685 | 191,213 | 184,128 | 96 | ¥6386 | 74 (33/41) | Butuo County Farmers Market (6) | 102.8109, 27.7078 |
| Meigu             | Apr., Jul., Aug. 2017 | 2515 | 268,739 | 265,689 | 99 | ¥6246 | 63 (32/31) | Jiukou Township Market, Meigu County (3); Meigu County Farmers Market (5) | 103.0252, 28.1722; 103.1307, 28.3311 |
| Mianning          | Jul., Aug. 2016; Apr., Jul., Aug. 2017 | 4422 | 398,071 | 160,098 | 40 | ¥11,156 | 73 (38/35) | Mianning County Farmers Market (8) | 102.1761, 28.5518 |
| Puge              | Oct., Nov., Dec. 2016 | 1905 | 198,982 | 165,786 | 83 | ¥7454 | 18 (7/11) | Xichang Binhe Market (8); Chang’an Village Farmers Market, Xichang City (2) | 102.2697, 27.8948; 102.2284, 27.3917 |
| Xichang           | Apr. 2017 | 2657 | 652,947 | 126,493 | 19 | ¥13,620 | 19 (5/14) | Xichang Binhe Market (8); Chang’an Village Farmers Market, Xichang City (2) | 102.2697, 27.8948; 102.2284, 27.3917 |
| Xide              | Oct., Nov., Dec. 2016; Jul., Aug. 2017 | 2202 | 229,690 | 208,604 | 91 | ¥6347 | 57 (26/31) | Xichang Binhe Market (8); Chang’an Village Farmers Market, Xichang City (2) | 102.2697, 27.8948; 102.2284, 27.3917 |
| Zhaojue           | Jul., Aug. 2017 | 2702 | 314,461 | 308,555 | 98 | ¥6675 | 92 (45/47) | Zhaojue Comprehensive Farmers Market (6) | 102.8374, 28.0157 |
| **Total**         |                  |         |                 |               |                      | **396 (186/210)**                  |                   |                                               |                                |
(0.42%), among a few others [39]. In total, Liangshan’s population consists of 14 ethnocultural groups with an estimated density of 0.85 people per square kilometer [40].

Administratively, Liangshan is comprised of 16 counties and one county-level city (Xichang City), which serves as the prefectural capital. Prior to 1978, Zhaojue County served as Liangshan’s capital. The Liangshan Yi belong to the northern dialect branch of the Yi (Nuosu) language, which is further subdivided into 4 dialects; these are often referred in published literature in Chinese as Sheng-za (圣乍), Yi-nuo (义诺), Suo-di (所地), and A-du (阿都) [28, 41, 42]. We chose study sites in six counties and Xichang City, representative of the geographic and cultural diversity of the Liangshan Yi (Fig. 1, Table 1). The Sheng-za dialect (Shyp nra hxop: ꭧ århus), based in Xide County and also widely spoken in Mianning County, Xichang City, and Zhaojue County, is considered the prestige or standard pronunciation for the Yi Language [41–43]. Butuo County represents the A-du dialect (A dar hxop: ꭩ reluctantly), Meigu County represents the Yi-nuo dialect (Yyp nyo hxop: ꭥly), and Puge County represents the Suo-di dialect (Suo ndip hxop: ꭥ ssentially). All Nuosu words in this paper and supporting materials follow the official Yi language phonetic alphabet, affixing a consonant symbol at the end of certain syllables to represent tones: (1) “t” for a high, flat register, (2) “x” for a mid to high register (mid-rising tone), and (3) “p” for a low-falling register. There is no mark for the mid-register tone [28, 44].

**Yi traditional culture**

The ancestors of the Liangshan Yi are believed to be the two ancient tribes of Guhou and Qunei, who once lived in Zizipu (Zhaotong area) of what is now Yunnan Province. They moved into Liangshan more than 2000 years ago, and their descendants gradually differentiated into the several tribes that are now spread throughout the Liangshan region [45]. Due to the historic physical and social isolation of the area, the Yi culture of Liangshan is quite different from the Yi living outside of Sichuan (other than a few border areas, including Ninglang County and Zhaotong in northern Yunnan), which have been much more deeply influenced by Han culture and religion [27, 28, 33, 46, 47].

The Liangshan Yi primarily subscribe to polytheistic animism, believing that their ancestors, spirits, and ghosts are able to influence the health of people, the success of their clan, the bounty of the harvest, the fertility of cattle, and the harmony of the community. Rituals serve as the main vehicle for the expression of their beliefs and traditional sentiments, being the primary means for balancing and adjusting the relationships between humans and supernatural beings. The Yi ritual specialists and traditional practitioners are called bimox ( букв), and sunyit ( букв), respectively [48]. Throughout these ceremonies, some WEPs are used for both the ritual concoctions themselves as well as for offerings.

**Field survey and data collection**

Between July 2016 and September 2017, we conducted field ethno-botanical surveys in the 7 jurisdictions (6 counties and 1 city) across Liangshan (Table 1). Following snowball sampling methods [49], we interviewed a total of 396 local Yi, of which 195 were female and 201 were male. Participants were between the ages of 12 and 84. The purpose of the study was briefly explained to each, and informed consent was obtained orally. Ethnobotanical data were collected using different ethnographic methods (direct observation, semi-structured interviews, key informant interviews, informal discussions, and field visits) with the assistance of native Yi language translators. Interviews took place in a location of each participant’s choice, often being their homes but sometimes in the field. Following established interview protocols [20, 49–51], participants were first asked to name the WEPs that they gather, then asked follow-up questions about the parts consumed, preparation methods, consumption habits, growth pattern of the species, collection months, and other uses of the WEPs. Demographic variables of each participant were also collected at the end of each interview, including their name, age, sex, level of education, and occupation.

During the investigation, we also conducted market surveys in April, July, and August 2017, interviewing 38 Yi merchants who sold WEPs in 7 traditional markets within 5 of the jurisdictions (Table 1, Fig. 1). We asked the same questions as those in the field interviews, including about WEPs that they regularly collect/sell even if they were not available at the time of the interview, and we also recorded their demographic variables. For the WEPs that were currently being sold at each stall, we recorded the prices of each.

We collected herbarium voucher specimens during field walks with participants, with initial identification being conducted on-site. Voucher specimens were later identified by J.W. and deposited in the Environmental Laboratory of Chengdu University (Table 2). Identification was carried out using keys, online plant databases, pictorial floras, plant dictionaries, and other taxonomic references, with accepted Latin names verified using the Plant List (www.theplantlist.org).

**Data analysis**

We grouped all WEPs into the following seven (non-exclusive) categories based on consumption pattern: primary food, famine food, snack, spice, culinary coagulant, medicine, and other uses. All data on participant demographics and the WEPs they identified were entered into a Microsoft Excel spreadsheet and organized for
| Scientific name                      | Family name           | Growth form | Part used (consumption pattern) | Medicinal uses(s)                        | Collection months | Sold as/price (¥/kg) | ΣUs UVs UV rank | Voucher no. |
|--------------------------------------|-----------------------|-------------|---------------------------------|------------------------------------------|-------------------|----------------------|----------------|------------|
| Actinidia kolomikta (Rupr. & Maxim.) Maxim. | Actinidiaceae          | Climber     | Fruit (snack)                   | Bone fracture, rheumatism                | 9–10              | 244 0.62 51          | LS0081         |
| Sambucus adnata Wall. ex DC.          | Adoxaceae             | Herb        | Fruit (snack), aboveground part (medicine, other use) | Bone fracture | 1–12              | 422 1.07 10          | LS0152         |
| Sambucus williamsii Hance             | Adoxaceae             | Shrub       | Leaf, bark (medicine)           | Bone fracture                           | 1–12              | 207 0.52 62          | LS0181         |
| Viburnum betulifolium Batalin         | Adoxaceae             | Shrub       | Fruit (snack, spice)            |                                        | 9–10              | 249 0.63 49          | LS0125         |
| Amaranthus blitum L.                  | Amaranthaceae         | Herb        | Tender shoot (primary food)     |                                        | 3–6               | 233 0.59 54          | LS0166         |
| Celasia argentea L.                   | Amaranthaceae         | Herb        | Seed (famine food)              |                                        | 7–10              | 99 0.25 99           | LS0093         |
| Chenopodium hybridum L.               | Amaranthaceae         | Herb        | Tender shoot (primary food)     |                                        | 4–6               | 287 0.72 38          | LS0016         |
| Allium macrostemon Bunge              | Amaryllidaceae        | Herb        | Whole plant (primary food, medicine, spice) | Gastrophy                              | 3–11              | 228 0.58 55          | LS0147         |
| Allium ovalifolium Hand.-Mazz.        | Amaryllidaceae        | Herb        | Leaf (primary food)             |                                        | 3–10              | 131 0.33 90          | LS0177         |
| Toxicodendron vernicifluum (Stokes) F.A. Barkley | Anacardiaceae | Tree       | Tender shoot (primary food), branch (other use) |                                        | 3–5               | 213 0.54 61          | LS0140         |
| Angelica sinensis (Oliv.) Diels       | Apiaceae              | Herb        | Root (primary food, medicine)   | Tonify                                  | 6–9               | 371 0.94 15          | LS0043         |
| Oenanthe javanica (Blume) DC.         | Apiaceae              | Herb        | Aboveground part (primary food) |                                        | 3–6               | 258 0.65 45          | LS0038         |
| Metaplexis japonica (Thuins.) Makino  | Apocynaceae           | Climber     | Fruit (snack)                   |                                        | 8–10              | 130 0.33 91          | LS0032         |
| Aralia chinensis L.                   | Araliaceae            | Tree        | Tender shoot (primary food), branch (other use) |                                        | 3–5               | 269 0.68 41          | LS0375         |
| Aristolochia versicolor S.M.Hwang     | Aristolochiaceae      | Climber     | Root (medicine)                 | Headache, injury, gastroenteritis       | 4–10              | 52 0.13 105          | LS0193         |
| Polygonatum cyrtosperma Hua           | Asparagaceae          | Herb        | Root (primary food, medicine)   | Tonify                                  | 5–8               | 334 0.84 29          | LS0536         |
| Begonia grandis subsp. sinensis (A.DC.) Irmsch. | Begoniaceae | Herb        | Stem (primary food)             |                                        | 4–10              | 140 0.35 85          | LS0151         |
| Berberis jamesiana Forrest & W.W.Sm.  | Berberidaceae         | Shrub       | Fruit (culinary coagulant, snack, spice), root (medicine) | Diarrhea                              | 9–12              | 761 1.92 1           | LS0248         |
| Mahonia bealei (Fortune) Pynaert       | Berberidaceae         | Shrub       | Fruit (snack), bark and root (medicine) | Diarrhea                              | 1–12              | 204 0.52 65          | LS0062         |
| Incanvilia diffusa Royle              | Bignoniaceae          | Herb        | Aboveground part (medicine)     | Hepatitis                               | 1–12              | 214 0.54 60          | LS0558         |
| Cynoglossum amabile Stapf & J.R.Drumm. | Boraginaceae          | Herb        | Root (medicine)                 | Hemorrhoid, enteritis                   | 3–10              | 198 0.50 68          | LS0013         |
| Capsella bursa-pastoris (L.) Medik.    | Brassicaceae          | Herb        | Tender shoot (primary food)     |                                        | 3–5               | 155 0.39 84          | LS0423         |
| Cardamine tangutorum O.E.Schulz        | Brassicaceae          | Herb        | Tender shoot (primary food, medicine) | Hypertension                            | 3–5               | 273 0.69 39          | LS0279         |
| Nasturtium officinale RRbr.            | Brassicaceae          | Herb        | Aboveground part (primary food) |                                        | 4–10              | 139 0.35 87          | LS0063         |
| Ronippa dubia (Pers.) H.Hara           | Brassicaceae          | Herb        | Tender shoot (primary food)     |                                        | 3–6               | 107 0.27 95          | LS0121         |
| Hylcereus undatus (Haw.) Britton & Rose | Cactaceae             | Shrub       | Flower (primary food)           |                                        | 7–11              | 98 0.25 100          | LS0162         |
| Opuntia ficus-indica                  | Cactaceae             | Shrub       | Stem (primary food), Tonsillitis |                                        | 1–12              | 294 0.74 37          | LS0346         |
| Scientific name                      | Family name          | Growth form | Part used (consumption pattern)             | Medicinal uses(s) | Collection months | Sold as/ price (¥/kg) | ΣUs UVs UV rank | Voucher no. |
|--------------------------------------|----------------------|-------------|-------------------------------------------|-------------------|-------------------|-----------------------|-----------------|-------------|
| (L.) Mill.                           |                      |             |                                           |                   |                   |                       |                 |             |
| Codonopsis pilosula subsp. tangshen (Oliv.) D.Y.Hong | Campanulaceae Herb | Root (primary food, medicine) | Tonify, gallstone | 4–8 | Medicine/50 | 342 | 0.86  | 27 LS0223 |
| Leycesteria formosa Wall.            | Caprifoliaceae Shrub | Tender shoot (medicine) | Measles | 3–10 | N | 132 | 0.33  | 89 LS0509 |
| Arctium lappa L.                     | Compositae Herb      | Root (primary food, medicine) | Tonify, detoxify | 3–5 | Medicine/20 | 382 | 0.96  | 14 LS0315 |
| Artemisia capillaris Thunb.          | Compositae Herb      | Tender shoot (famine food), aboveground part (medicine, other use) | Injury | 3–10 | N | 569 | 1.46  | 3 LS0256 |
| Cirsium shansiense Petr.             | Compositae Herb      | Root (primary food, medicine) | Tonify, nephrosis | 3–11 | Medicine/12 | 452 | 1.14  | 7 LS0362 |
| Eclipta prostrata (L.) L.            | Compositae Herb      | Whole plant (medicine) | Diarrhea, cough, pneumonia | 3–10 | N | 168 | 0.42  | 79 LS0033 |
| Kalimeris indica (L.) Sch.Bip.       | Compositae Herb      | Tender shoot (primary food), root (medicine) | Diarrhea | 3–10 | N | 140 | 0.35  | 86 LS0255 |
| Pseudognaphalium affine (D.Don) Anderb. | Compositae Herb    | Flower (famine food), whole plant (other use) | 2–5 | N | 190 | 0.48  | 71 LS0014 |
| Sonchusoleraceus (L.) L.             | Compositae Herb      | Tender shoot (primary food) | 3–6 | N | 201 | 0.51  | 67 LS0463 |
| Taraxacum mongolicum Hand-Mazz.     | Compositae Herb      | Leaf (primary food), whole plant (medicine) | Cough | 3–10 | Medicine/5 | 334 | 0.84  | 30 LS0410 |
| Cornus kousa subsp. chinensis (Osborn) Q.Y.Xiang | Cornaceae Tree      | Fruit (snack) | 9–10 | Snack/10 | 196 | 0.49  | 70 LS0407 |
| Trichosanthes kirilowii Maxim.       | Cucurbitaceae Climber | Flower (medicine) | Cough | 5–8 | N | 114 | 0.29  | 94 LS0058 |
| Ariaostegia divaricata var. formosana (Hayata) M. Kato | Davalliaceae Herb | Root (medicine) | Hypertension | 3–10 | N | 67 | 0.17  | 104 LS0579 |
| Pteridium aquilinum (L.) Kuhn        | Dennstaedtiaceae Herb | Tender shoot (primary food), root (famine food) | 3–6 | Food/10 | 536 | 1.35  | 4 LS0004 |
| Dioscorea polytachya Turcz.          | Dioscoreaceae Climber | Root (primary food), bulbil (snack) | 3–10 | N | 329 | 0.83  | 33 LS0376 |
| Diospyros lotus L.                   | Ebenaceae Tree       | Fruit (snack) | 10–11 | N | 170 | 0.43  | 78 LS0467 |
| Elaeagnus pungens Thunb.             | Elaeagnaceae Shrub   | Fruit (snack) | 8–9 | N | 346 | 0.87  | 23 LS0221 |
| Equisetum giganteum L.               | Equisetaceae Herb   | Whole plant (medicine) | Cold, headache, stomachache | 3–10 | N | 102 | 0.26  | 97 LS0303 |
| Vaccinium fragile Franch.            | Ericaceae Shrub     | Fruit (snack) | 7–10 | N | 224 | 0.57  | 57 LS0452 |
| Eucommia ulmoides Oliv.              | Eucommiaceae Tree   | Bark (primary food, medicine) | Nephropathy | 1–12 | N | 178 | 0.45  | 76 LS0199 |
| Quercus schottkyana Rehder & E.H.Wilson | Fagaceae Tree   | Seed (snack) | 10–11 | N | 156 | 0.39  | 83 LS0366 |
| Helwingia japonica (Thunb.) F.Dietr. | Helwingiaceae Shrub | Leaf (primary food) | 3–6 | N | 105 | 0.27  | 96 LS0319 |
| Iris forestii Dykes                  | Iridaceae Herb      | Root (medicine) | Cough | 3–10 | N | 178 | 0.45  | 77 LS0417 |
| Mentha canadensis L.                 | Lamiaceae Herb      | Tender shoot (primary food, medicine, spice) | Hyperthermia | 3–10 | Spice/10 | 393 | 0.99  | 12 LS0403 |
| Perilla frutescens (L.) Britton      | Lamiaceae Herb      | Tender shoot (primary food), seed (Spice) | 8–10 | N | 438 | 1.11  | 8 LS0292 |
| Akebia trifoliata                    | Lardizabalaceae Climber | Fruit (snack) | 7–8 | N | 236 | 0.60  | 52 LS0481 |
| Scientific name                  | Family name                  | Growth form | Part used (consumption pattern) | Medicinal uses(s) | Collection months | Sold as/price (¥/kg) | ΣUs UVs UV rank Voucher no. |
|----------------------------------|------------------------------|-------------|---------------------------------|-------------------|-------------------|---------------------|--------------------------|
| Decaisnea insignis (Griff.) Hookf. & Thomson | Lardizabalaceae Shrub Fruit (snack) | 10–11 | N | 167 0.42 80 | LS0200 |
| Litsea cubeba (Lour.) Pers.      | Lauraceae Tree Fruit and root (spice) | 7–10 | Spice/40 | 205 0.52 64 | LS0561 |
| Litsea pungens Hemsl.            | Lauraceae Tree Fruit and root (spice) | 7–10 | Spice/40 | 343 0.87 25 | LS0535 |
| Pueraria montana var. lobata (Willd.) Sanjappa & Pradeep | Leguminosae Climber Root (snack) | 7–10 | Snack/20 | 183 0.46 74 | LS0448 |
| Spatholobus suberec tus Dunn     | Leguminosae Climber Stem (medicine) | Heart disease | Medicine/40 | 89 0.22 102 | LS0457 |
| Vica SATIVA L.                   | Leguminosae Herb Tender shoot (primary food) | 1–12 | N | 189 0.48 72 | LS0252 |
| Fritillaria cirrhosa D.Don       | Liliaceae Herb Bulb (medicine) | Cough, injury | Medicine/2000(dry) | 261 0.66 44 | LS0471 |
| Huperzia squarrosa (G. Forst.) Trevis. | Lycopodiaceae Herb Whole plant (medicine) | Rheumatism, gastropathy | Medicine/50 | 78 0.20 103 | LS0532 |
| Lycopodium japonicum Thunb.      | Lycopodiaceae Herb Spore powder (medicine) | Rheumatism | Medicine/200 | 95 0.24 101 | LS0441 |
| Malva verticillata L.            | Malvaceae Herb Whole plant (medicine) | Delivery | Medicine/600 | 254 0.64 46 | LS0424 |
| Paris polyphylla Sm.             | Melanthiaceae Herb Root (medicine) | Muscle pain, injury | Medicine/200 | 254 0.64 46 | LS0424 |
| Toona sinensis (Juss.) M.Roem.   | Meliaceae Tree Tender shoot (primary food, medicine) | Diarrhea | Medicine/40 | 89 0.22 102 | LS0457 |
| Ficus pumila L.                  | Moraceae Climber Fruit (snack) | 6–8 | N | 115 0.29 93 | LS0161 |
| Ficus tikoua Bureau              | Moraceae Shrub Fruit (snack) | 7–8 | N | 295 0.74 36 | LS0148 |
| Morus australs Poir.             | Moraceae Tree Fruit (snack) | 4–5 | N | 253 0.64 47 | LS0389 |
| Musa bajoo Siebold & Zucc. ex linum | Musaceae Tree Flower (medicine), fruit(snack) | Heart disease | Medicine/200 | 95 0.24 101 | LS0441 |
| Myrica nana A. Chev.             | Myricaceae Shrub Fruit (snack) | 6–8 | Snack/10 | 198 0.50 69 | LS0225 |
| Matteuccia struthiopteris (L.) Tod. | Onocleaceae Herb Tender shoot (primary food) | 3–5 | Food/10 | 345 0.87 24 | LS0272 |
| Ophioglossum vulgatum L.         | Ophioglossaceae Herb Whole plant (primary food, medicine) | Tonify | Medicine/200 | 321 0.81 34 | LS0446 |
| Bulbophyllum odoratissimum (Sm.) Lindl. ex Wall. | Orchidaceae Herb Whole plant (medicine) | Cough | Medicine/40 | 100 0.25 98 | LS0569 |
| Gastrodia elata                  | Orchidaceae Herb Rhizome (primary food, medicine) | Headache | Medicine/100 (wet), 500 (dry) | 430 1.09 9 | LS0142 |
| Osmunda japonica Thunb.          | Osmundaceae Herb Tender shoot (primary food) | 3–5 | N | 332 0.84 32 | LS0367 |
| Oxalis corniculatea L.           | Oxalidaceae Herb Aboveground part (snack, spice, other use) | 1–12 | N | 461 1.16 6 | LS0343 |
| Plantago major L.                | Plantaginaceae Herb Aboveground part (primary food, medicine) | Dianrhea, cough | Medicine/5 | 416 1.05 11 | LS0007 |
| Fargesia spathacea Franch.       | Poaceae Shrub Tender shoot (primary food) | 3–5 | Food/14 | 357 0.90 17 | LS0087 |
| Imperata cylindrica (L.) Raeusch. | Poaceae Herb Root (primary food, medicine) | Nosebleed, cough | Medicine/40 | 222 0.56 58 | LS0549 |
| Reynoutria multiflora (Thunb.) Moldenke | Polygonaceae Herb Root (medicine), leaf (culinary coagulant) | Headache | Medicine/40 | 222 0.56 58 | LS0549 |
statistical analysis. Following the methods of Regassa et al. [20], we calculated the descriptive statistics on the number and percentage of species, genera, and families of WEPs, as well as their growth forms and the parts consumed. We calculated the use values for each species of WEP. The formula we used was adapted from Phillips and Gentry [52] by first considering a single participant interview [11]:

$$UV_s = \sum U_s / n$$

Where $UV_s$ refers to the use value of a particular species “s,” $n$ is the total number of respondents in the sample ($n = 396$), and $U_s$ refers to the number of citations of use mentioned by each participant for a particular species “s.” The use values for each species were compiled into a table for interpretation [11].
Results

Taxonomic diversity of WEPs
The interview participants reported 105 WEPs from 97 genera and 62 families (Table 2). The families with the largest representation were Rosaceae (14 species), followed by Compositae (8 species), Brassicaceae (4 species), and Adoxaceae, Amaranthaceae, Leguminosae, and Moraceae (3 species each). Amaryllidaceae, Apiaceae, Berberidaceae, Cactaceae, Lamiaceae, Lardizabalaceae, Lauraceae, Lycopodiaceae, Orchidaceae, Poaceae, and Polypodiaceae each had 2 species. The remaining 44 families were represented by a single species each. The majority of WEPs were herbs (58 species), followed by shrubs (21 species), trees (15 species), and climbing plants (11 species).

Due to the dialectal diversity in Liangshan and across our site locations, while documenting the WEPs utilized by the Liangshan Yi, we also documented multiple local names for certain species (Table 3).

The preparation and consumption pattern of WEPs

Primary foods
Of the 7 primary consumption patterns of WEPs in Liangshan, 40 species are used as primary foods, and of these, the most commonly consumed parts are tender shoots (18 species) and roots (8 species). Usually, the tender shoots, leaves, and flowers are made into soups (5 species), pickled (5 species), eaten raw as salad greens (2 species), or eaten after boiling in water (21 species) (Table 4). The roots tend to be stewed with pork or chicken (11 species), not only for nourishment, but also for the prevention and treatment of diseases. For example, the roots of Arctium lappa, Cirsium shansiense, Codonopsis pilosula subsp. tangshen, and Ophioglossum vulgatum are generally stewed with chicken or pork used as a tonic. Gastrodia elata is stewed to relieve headaches, Arctium lappa is also stewed for detoxification, and Imperata cylindrica is stewed to reduce cough.

One of the distinctive aspects of the traditional Liangshan Yi cuisine is sour soups, with a bowl of sour soup at almost every meal (Fig. 2). There are five species of WEPs used for making pickled (lacto-fermented) soup at almost every meal (Table 4). The roots tend to be boiled for 1–2 min, then placing them into a bucket, with the addition of some salt, sealed and left for about half a month. The fermented WEPs become sour in flavor, and they are then stewed with potatoes, beans, and chicken, or made alone into soup.

Chinese cabbage, kales, and mustard greens are fried then ground into powder and mixed with the strong meaty taste. The seeds of Perilla frutescens, and mint (Mentha canadensis) are used as spices to season cakes. The seeds of Pseudognaphalium affine are added to beef and/or mutton soup to enhance their flavor profiles by masking the strong meaty taste. The seeds of Perilla frutescens are fried then ground into powder and mixed with the flour of Fagopyrum tataricum to season cakes. The roots of Dioscorea polystachya and the seeds of Quercus schottkyana for snacks in the wild. The fresh roots of Pueraria montana var. lobata, which are also sold in the market for about ¥20 per kilogram, are cut into thin slices and eaten as snacks.

Spices
There are nine species of WEPs used as spices, among which six species are seasonings. These include Litsea chinensis, Elaeagnus pungens, Fragaria nilgerrensis, Pyracantha fortuneana, and Rubus sp. These are often consumed by Yi children when they are herding livestock. The Yi shepherd children also roast bulbils of Dioscorea polystachya and the seeds of Quercus schottkyana for snacks in the wild. The fresh roots of Pueraria montana var. lobata, which are also sold in the market for about ¥20 per kilogram, are cut into thin slices and eaten as snacks.

Famine foods
Five species of WEPs are eaten as food supplements in times of famine, including the seeds with pappus of Anemone vitifolia, tender shoots of Artemisia capillaris, seeds of Celosia argentea, flowers of Pseudognaphalium affine, and the ground-up fruits of Pyracantha fortuneana. Each of these can be mixed with buckwheat flour or cornmeal, which increases the volume of cakes for meals and increases their nutritive value as well. A single WEP is used to extract starch during famines. The roots of Pteridium aquilinum are crushed in water, and the starch is obtained through sedimentation and filtration. This starch is then used for making cakes after it is dried.

Snacks
Most of the WEPs eaten as snacks (38 species) are wild fruits, such as Akebia trifoliata, Cornus kousa subsp. chinensis, Elaeagnus pungens, Fragaria nilgerrensis, Pyracantha fortuneana, and Rubus sp. These are often consumed by Yi children when they are herding livestock. The Yi shepherd children also roast bulbils of Dioscorea polystachya and the seeds of Quercus schottkyana for snacks in the wild. The fresh roots of Pueraria montana var. lobata, which are also sold in the market for about ¥20 per kilogram, are cut into thin slices and eaten as snacks.

Culinary coagulants
There are two species used as culinary coagulants. The leaves of Reynoutria multiflora are crushed and put in
| Scientific name | Nuosu (Yi language) names: dialects and representative counties | Chinese name | Romanized pinyin | Characters |
|-----------------|---------------------------------------------------------------|--------------|------------------|------------|
| Actinidia kolomikta (Rupr. & Maxim.) Maxim. | Sheng-zha dialect (Xide County) | Ce le mop ce ap qy | Gǒu zào mǐn huó | 狗枣猕猴桃 |
| Sambucus adnata Wall. ex DC. | A-du dialect (Butuo County) | Qyp ndip | Xiè mǐn cǎo | 血满草 |
| Sambucus williamsii Hance | Suo-di dialect (Puge County) | Qyp ndip | Jiēgǔ mǔ | 接骨木 |
| Viburnum betulifolium (Stokes) F.A. Bailey | Yi-nuo dialect (Meigu County) | Qyp ndip | Huà yè jiā mí | 槭叶荚蒾 |
| Acanthus ilicifolius L. | | | Ao tóu xiàn | 四头苋 |
| Gelsemium sempervirens | | | Qīng xiāng | 青藤 |
| Chenopodium hybridum L. | | | Xuān lǐ | 小葵 |
| Allium macrostemon Bunge | | | Xièbái | 薰白 |
| Allium ovalifolium Hand.-Mazz. | | | Luān yè jiù | 陇叶韭 |
| Toxicodendron vernicifluum | | | Qī shù | 漆树 |
| Angelica sinensis (Oliv.) Diels | | | Dāngguì | 当归 |
| Gynura apiifolia (Blume) DC. | | | Shuí qín | 水芹 |
| Metaplexis japonica (Thunb.) Makino | | | Luò mò | 萝藦 |
| Aconitum chinense | | | Sōng mǔ | 森木 |
| Alkanna tinctoria (L.) Moench | | | Bàn sè mǎ dòu líng | 变色马兜铃 |
| Polygonatum multiflorum | | | Dù huā huàngjīng | 多花黄精 |
| Bergenia grandis subsp. sinensis (A.DC.) Irmsch. | | | Qīnhuángshāng | 秋黄裳 |
| Berberis jamesiana Forrest & W.W.Sm. | | | Chūn diàn xiǎo bái | 春殿小檗 |
| Mahonia bealei (Fortune) Pynaert | | | Kuò yè shì dà gōng lòu | 穴叶十大功劳 |
| Inarina oblongata | | | Liáng tóu máo | 两头毛 |
| Gynoglossum amabile Stapf & J.R.Drumm. | | | Dào tí hú | 倒提壶 |
| Capsella bursapastoris (L.) Medik. | | | Ji | 菊 |
| Cardamine tangutica O.E.Schulz | | | Zhī huā suí mǐ | 紫花碎米荠 |
| Nasturtium officinale R.Br. | | | Dòubàn cài | 豆瓣菜 |
| Scientific name | Nuosu (Nu language) names: dialects and representative counties | Characters | Chinese name | Romanized pinyin | Characters |
|----------------|---------------------------------------------------------------|------------|--------------|------------------|------------|
| Rorippa dubia (Pers.) Hara | vo ji | 罔Opacity | Wu bàn hán cài | 无瓣蔊菜 |
| Hylocereus undatus (Haw.) Britton & Rose | ho lop max ma (Xide County) | ho lop max ma | Liăng tiān shí | 芒天尺 |
| Opuntia ficus-indica (L.) Mill. | nyr cy bbu ga (Butuo County) | nyr cy bbu ga | Lì guǒ xiǎn rèn zhǎng | 梨果仙人掌 |
| Codonopsis pilosula subsp. tangshen (Oliv.) D.Y.Hong | wa mu nyi jix le pep ddu (Puge County) | wa mu nyi jix le pep ddu | Chūan dǎng shèn | 川党参 |
| Hylocereus undatus (Haw.) Britton & Rose | ho lop max ma (Xide County) | ho lop max ma | Liăng tiān shí | 芒天尺 |
| Opuntia ficus-indica (L.) Mill. | nyr cy bbu ga (Butuo County) | nyr cy bbu ga | Lì guǒ xiǎn rèn zhǎng | 梨果仙人掌 |
| Codonopsis pilosula subsp. tangshen (Oliv.) D.Y.Hong | wa mu nyi jix le pep ddu (Puge County) | wa mu nyi jix le pep ddu | Chūan dǎng shèn | 川党参 |
| Hylocereus undatus (Haw.) Britton & Rose | ho lop max ma (Xide County) | ho lop max ma | Liăng tiān shí | 芒天尺 |
| Opuntia ficus-indica (L.) Mill. | nyr cy bbu ga (Butuo County) | nyr cy bbu ga | Lì guǒ xiǎn rèn zhǎng | 梨果仙人掌 |
| Codonopsis pilosula subsp. tangshen (Oliv.) D.Y.Hong | wa mu nyi jix le pep ddu (Puge County) | wa mu nyi jix le pep ddu | Chūan dǎng shèn | 川党参 |
| Hylocereus undatus (Haw.) Britton & Rose | ho lop max ma (Xide County) | ho lop max ma | Liăng tiān shí | 芒天尺 |
| Opuntia ficus-indica (L.) Mill. | nyr cy bbu ga (Butuo County) | nyr cy bbu ga | Lì guǒ xiǎn rèn zhǎng | 梨果仙人掌 |
| Codonopsis pilosula subsp. tangshen (Oliv.) D.Y.Hong | wa mu nyi jix le pep ddu (Puge County) | wa mu nyi jix le pep ddu | Chūan dǎng shèn | 川党参 |
| Scientific name                  | Nuosu (Nu language) names dialects and representative counties | Chinese name               | Romanized pinyin | Characters |
|----------------------------------|---------------------------------------------------------------|-----------------------------|------------------|------------|
| Iris forrestii                   | mie ci                                                       | 鸢尾                        | yuán wěi         |                |
| Mentha canadensis L.             | ya zhet                                                       | 薄荷                        | bó hé            |                |
| Petilis frutescens (L.) Britton  | hivie zy mnp (mu)                                             | 山鸡                        | yān jī           |                |
| Alebia trifoliata (Thunb.) Koidz. | yax sse la bbo (yao re la bao)                               | 紫苏                        | zǐ sū             |                |
| Decaisnea imarginis (Griff.) Hook. & Thomson | la yot                                                        | 三叶木                       | sān yè mù tóng   |                |
| Utna cibebu (Laur.) Pers.        | mu suo                                                       | 木姜子                       | mù jiāng zǐ      |                |
| Utna pungens Hemsl.              | muk ku                                                       | 葛                           | gé               |                |
| Puurana montana var. lobata (Willd.) | ge wop nmp gu                                                | 花                           | huā              |                |
| Spathikbus suberectus Durrn      | nyp gu syr du                                                | 野豌豆                       | yě wān dòng dòu  |                |
| Vekz sativa L.                   | sha no mu re                                                 | 木通                        | mù tōng         |                |
| R.Mitilea dinosa D.Dan           | yyp syr                                                     | 木通                        | mù tōng         |                |
| Huparzla squamo (G. Forst.) Trevis. | ca na nyp gu                                                | 木通                        | mù tōng         |                |
| Lycopodium jepom (Thunb)         | shyp nyp gu                                                  | 木通                        | mù tōng         |                |
| Makva venticillata L.            | ax yie                                                       | 木通                        | mù tōng         |                |
| Paris polyphylla Sm.             | map bup                                                      | 木通                        | mù tōng         |                |
| Toma shwaris (Juss.) M Roem       | syr wo                                                       | 木通                        | mù tōng         |                |
| Rucus punifi L.                  | si jie le bi                                                 | 木通                        | mù tōng         |                |
| Rucus klava Bureu                | lek six vay six (si le wu si)                                | 木通                        | mù tōng         |                |
| Marus australis Poir.            | ax jh bbb za                                                 | 木通                        | mù tōng         |                |
| Musa basjoo Siebold & Zucc. ex Iinuma | bia jo                                                     | 木通                        | mù tōng         |                |
| Myrica nano A. Chev.             | syr yě                                                       | 木通                        | mù tōng         |                |
| Matteuccia strathpevere (L.) Tod. | ndax y (nda yi)                                              | 木通                        | mù tōng         |                |
| Ophioglossum vulgaturn L.         | a mat va hua                                                | 木通                        | mù tōng         |                |
| Bulbophyllum odontostatum (Sm) Lindl. ex Wall. | jux ha (ju ha)                                            | 木通                        | mù tōng         |                |
| Gastrodia elata                  | bbup shy                                                     | 木通                        | mù tōng         |                |
| Scientific name          | Nuosu (Yi language) names: dialects and representative counties | Chinese name                  | Characters | Romanized pinyin | Characters |
|--------------------------|---------------------------------------------------------------|-------------------------------|------------|------------------|------------|
| Osmunda japonica Thunb.  |                                                              |                               |            | ndap jjop        |            |
| Oxalis corniculata L.    |                                                              |                               |            | a zhat wop ji    |            |
| Plantago major L.         |                                                              |                               |            | Píng chěn qí     |            |
| Fargesia spathacea Franch.|                                                              |                               |            | Jiànzhú jīcūn    |            |
| Imperata cylindrica (L.) Raeusch. |                                                        |                               |            | Báimáo hēshǒu   |            |
| Reynoutria multiflora (Thunb.) Moldenke |                                                |                               |            | Héshǒu jījīuán   |            |
| Lemmaphyllum carnosum (J. Sm. ex Hook.) C. Presl |                                            |                               |            | Ròuzhì fúshí jué|            |
| Pyrrosia lingua (Thunb.) Farw. |                                                        |                               |            | Shí wéi jīgū    |            |
| Lysimachia congestiflora Hemsl. |                                                |                               |            | Jù huā guòlù huáng|            |
| Anemone vitifolia Buch.-Ham. ex DC. |                                                  |                               |            | Yěmiánhuā yā bāo|            |
| Hovenia dulcis Thunb.     |                                                              |                               |            | Běi jī jījīuán   |            |
| Agrimonia pilosa Ledeb.   |                                                              |                               |            | Lóng yá cǎo bāo  |            |
| Crataegus scabrifolia (Franch.) Rehder |                                              |                               |            | Yúnnān shān zhā   |            |
| Duchesnea indica (Jacks.) Focke |                                                  |                               |            | Shé méi huā bāo  |            |
| Fragaria nilgerrensis Schltdl. ex J.Gay |                                               |                               |            | Huáng máo cāo bāo|            |
| Potentilla discolor Bunge |                                                              |                               |            | Fān bāo fān bāo  |            |
| Prunus trichostoma Koehne |                                                              |                               |            | Chūn xīngshā bāo |            |
| Pyracantha fortuneana (Maxim.) H.L.Li |                                             |                               |            | Huǒ jī hū māo bāo|            |
| Pyrus pashia Buch.-Ham. ex D.Don |                                                |                               |            | Chūn xīngshā bāo |            |
| Rosa omeiensis Rolfe |                                                              |                               |            | Èméi qiángwū bāo |            |
| Rosa roxburghii Tratt.    |                                                              |                               |            | Dān bàn sū huá   |            |
| Rubus ellipticus var. obcordatus (Franch.) Focke |                           |                               |            | Huáng máo cāo bāo|            |
| Rubus inopertus (Focke) Focke |                                                |                               |            | Hóng huā yā bāo  |            |
| Rubus mesogaeus Focke |                                                              |                               |            | Xǐ yīn xuán gōu  |            |
### Table 3 Comparison of names used for WEPs across Liangshan. Alternative spellings for plant names from the same dialect are given in parentheses (Continued)

| Scientific name | Nuosu (Yi language) names: dialects and representative counties | Chinese name | Romanized pinyin | Characters |
|-----------------|---------------------------------------------------------------|--------------|-----------------|-----------|
| **Rubus wallichianus** Wight & Am. | a nyie sit sip (Oxide County) | Hong mao xuan gouzi | 宏毛悬钩子 |
| **Houttuynia cordata** Thunb. | zyp vo (Butuo County) | Ji cai | 药菜 |
| **Schisandra rubriflora** Rehder & E.H.Wilson | yox sse syp yo (Puge County) | Hong hua wuwazi | 红花五味子 |
| **Smilax stans** Maxim. | ax gai la qu (Puge County) | Qiao bing ba qian | 落柄菝葜 |
| **Physalis alkekengi** L. | nyit a mu se (Meigu County) | Suin jiang | 蒲浆 |
| **Vitis heyneana** Roem. & Schult. | vot mop syp hxo (Meigu County) | Mao puta | 毛葡萄 |
| **Hemerocallis citrina** Baroni | pop vie | Huanghua cai | 黄花菜 |
Table 4 The primary consumption patterns of WEPs in Liangshan

| Consumption pattern | Mode of consumption | Species |
|---------------------|---------------------|---------|
| Primary food        | Boiled in water     | (1) Allium ovalifolium, (2) Amaranthus blitum, (3) Aralia chinensis, (4) Chenopodium hybridum, (5) Fargesia spathacea, (6) Hemsyocalis citrina, (7) Hylocereus undatus, (8) Kalimeris indica, (9) Matteuccia struthiopteris, (10) Oenanthia javanica, (11) Opuntia ficus-indica, (12) Osmonuda japonica, (13) Penilla frutescens, (14) Plantago major, (15) Pteridium aquilinum, (16) Smilax stans, (17) Sonchus oleraceus, (18) Taraxacum mongolicum, (19) *Toona sinensis, (20) Toxicodendron vernicifluum, (21) Vicia sativa |
| Made into pickles   | (1) Begonia grandis subsp. sinensis, (2) Nasturtium officinale, (3) Oenanthia javanica, (4) Renippa dubia, (5) Smilax stans |
| Made into soup      | (1) Capsella bursa-pastoris, (2) *Cardamine tangutorum, (3) Helwingia japonica, (4) Nasturtium officinale, (5) Renippa dubia |
| Raw as salad greens | (1) *Allium macrostemon, (2) *Houttuynia cordata |
| Steamed with pork or chicken | (1) *Angelica sinensis, (2) *Arctium lappa, (3) *Cirsium shansiense, (4) *Codonopsis pilosula subsp. tangshen, (5) Dioscorea polyestachya, (6) *Eucnemis ulmoides, (7) *Gastridia elata, (8) *Imperata cylindrica, (9) *Musa basjoo, (10) *Ophioglossum vulgatum, (11) *Polygonatum cyrtomenum |
| Famine food         | Food supplement     | (1) Anemone vitifolia, (2) Artemisia capillaris, (3) Celosia argentea, (4) Pseudognaphalium affine, (5) Pyracantha fortuneana |
| Starch extraction   | (1) Pteridium aquilinum |
| Snack               | Eaten raw           | (1) Actinidia kolomikta, (2) Akebia trifoliata, (3) Berberis jamesiana, (4) Cornus kousa subsp. chinensis, (5) Crataegus scabriolia, (6) Decaisnea insignis, (7) Diospyros lotus, (8) Duchesnea indica, (9) Elaeagnus pungens, (10) Ficus pumila, (11) Ficus tikoua, (12) Fragaria nilgerrensis, (13) Hovenia dulcis, (14) Mahonia bealei, (15) Morus australis, (16) Metaplexis japonica, (17) Morus australis, (18) Myrica nana, (19) Musa basjoo, (20) Opuntia ficus-indica, (21) Oxalis corniculata, (22) Physalis akekejia, (23) Prunus trichostoma, (24) Pueraria montana var. lobata, (25) Pyracantha fortuneana, (26) Pyrus pashia, (27) Rosa ameiensis, (28) Rosa roxburghii, (29) Rubus ellipticus var. ochardus, (30) Rubus inopertus, (31) Rubus mesogaeus, (32) Rubus wallichianus, (33)Sambucus adnata, (34) *Schiandra rubriflora, (35) Vaccinium fragile, (36) Viburnum betulifolium, (37) Vitis heyeana |
| Spice               | Seasoning           | (1) Allium macrostemon, (2) Houttuynia cordata, (3) Litsea cubeba, (4) Litsea pungens, (5) Mentha canadensis, (6) Penilla frutescens |
| Sour flavor enhancer| Roasted or cooked   | (1) Dioscorea polyestachya, (2) Quercus schottkyana |
| Culinary coagulant  | Making cheese       | (1) Reynoutria multilora |
| Medicine            | Making tofu         | (2) Berberis jamesiana |
| Eaten raw           | (1) Fritillaria cirrhosa, (2) Gastridia elata |
| External use        | (1) Artemisia capillaris, (2) Fritillaria cirrhosa, (3) Opuntia ficus-indica, (4) Paris polyphylla |
| Medicinal soup      | (1) Leyceaster harmsa, (2) Malva verticillata, (3) Sambucus adnata, (4) Sambucus williamsii |
| Medicinal tea       | (1) Agrimonia pilosa, (2) Berberis jamesiana, (3) Bulbophyllum adoratissimum, (4) Cynoglossum amabile, (5) Eclipta prostrata, (6) Huperzia squarrosa, (7) Imperata cylindrica, (8) Incarvillea diffusa, (9) Iris forestii, (10) Kalimenis indica, (11) Lemnophyllum camosum, (12) Lycopus japonicum, (13) Lysimachia congestiflora, (14) Mahonia bealei, (15) Mentha canadensis, (16) Plantago major, (17) Potentilla discolor, (18) Pyrosia lingua, (19) Spaltholus suberectus, (20) Taraxacum mongolicum, (21) Trichosanthes kiowii |
| Tincture            | (1) Acanesia digarica var. harmsana, (2) Aristolochia versicolor, (3) Crataegus scabriolia, (4) Eclipta prostrata, (5) Equisetum giganteum, (6) Gastridia elata, (7) Hovenia dulcis, (8) Lysimachia congestiflora, (9) Reynoutria multilora, (10) Paris polyphylla, (11) Potentilla discolor |
| Other use           | Hedge               | (1) Pyracantha fortuneana |
| Honey collection    | (1) Pseudognaphalium affine |
| Kindling            | (1) Pseudognaphalium affine |
| Rituals             | (1) Aralia chinensis, (2) Artemisia capillaris, (3) Sambucus adnata, (4) Toxicodendron vernicifluum |
| Silver jewelry polish| (1) Oxalis corniculata |

*With medicinal effect

goat’s milk. The milk then solidifies, and its smell is effectively masked. It can be eaten directly or made into cheese that can be preserved longer and is considered more delicious than fresh milk. To prepare the cheese, fern leaves are placed on the top and bottom of the milk block, then most of the water is squeezed out with a spoon. Similarly, the Yi people put the juice of Berberis jamesiana into soy milk, and the soy milk solidifies and becomes tofu.
Fig. 2 Typical examples of Liangshan Yi cuisine. a Suāncài tāng or pickle soup (center bowl; Zhaojue County). b From top left corner clockwise: Suāncài tāng (pickle soup), sausage, tūduitōu ròu (lump pork), boiled potatoes, ham, tūduitōu jī (lump chicken), and bitter buckwheat cakes (Butuo County). c A meal with two types of Suāncài tāng (pickle soup), tūduitōu ròu (lump pork), and bitter buckwheat cakes (Zhaojue County). Photo credits: a, b JW; c BCS

Fig. 3 Before and after. a, b The young shoots of bamboo (*Fargesia spathacea*) are used in many dishes, including bamboo shoots and braised beef (Xichang City). c, d The chopped roots of *Houttuynia cordata* are used in many Liangshan Yi dishes, including in this cold salad (Puge County). Photo credits: a, c JW; b–d BCS
Medicinal edible plants

According to our survey, the Liangshan Yi use at least 49 species of medicinal edible plants. Of these, several of them have multiple medical applications, with 21 species used to make medicinal tea, 11 species for tinctures, 4 species each for medicinal soups or used externally, and 2 species consumed raw as medicine. Overall, including 13 non-overlapping species from the 15 used as primary foods (the “Primary foods” section) or snacks (the “Snack” section) with secondary medicinal effects, the Liangshan Yi use WEPs to treat 27 ailments (Table 5), including cough, diarrhea, injury, rheumatism, and headaches. There are 10 species used to treat cough, 8 each for treating diarrhea and for tonification, 5 to treat injuries, and 4 each for treating rheumatism and headache.

The WEPs used as medicinal teas are prepared by putting the plant materials into boiling water for about 5–10 min. For example, the aboveground parts of Agrimonia pilosa, the whole plant of Potentilla discolor, and the roots of Mahonia bealei and Berberis jamesiana are used to cure diarrhea; the roots of Imperata cylindrica are used to stop nosebleeds and suppress coughing; and the flowers of Trichosanthes kirilowii are also used to treat cough. The aboveground portion of Incarvillea diffusa prepared as a tea and mixed with honey and rice wine can treat hepatitis. These teas are usually consumed when someone shows symptoms, drinking approximately 500 ml at a time, 3–5 times a day, until the illness is relieved or cured.

Tinctures are made by putting the plant materials in liquor (ethanol concentration of about 50–65%) and

| Number | Symptom       | Species                                                                 |
|--------|---------------|-------------------------------------------------------------------------|
| 1      | Bone fracture | Sambucus adnata (142), Sambucus williamsii (207)                        |
| 2      | Cold          | Equisetum giganteum (56)                                               |
| 3      | Cough         | Bulbophyllum odoratissimum (100), Crataegus scabrifolia (45), Eclipta prostrata (89), Fritillaria cinnosa (258), Imperata cylindrica (112), Iris forestii (178), Lepidum virginicum (263), Lepidium virginicum (236), Trichosanthes kirilowii (114) |
| 4      | Delivery      | Malva verticillata (270)                                               |
| 5      | Detoxification| Arctium lappa (78)                                                     |
| 6      | Diarrhea      | Agrimonia pilosa (179), Berberis jamesiana (126), Eclipta prostrata (153), Kalimeris indica (34), Mahonia bealei (53), Planta giga (56), Potentilla discolor (201), Toona sinensis (23) |
| 7      | Dyspepsia     | Houttuynia cordata (34)                                                |
| 8      | Enteritis     | Cynoglossum amabile (198)                                              |
| 9      | Gallstone     | Codonopsis pilosa subsp. tangshen (15), Lysimachia congestiflora (220), Pyrosia lingua (138) |
| 10     | Gastroenteritis| Aristolochia versicolor (12)                                          |
| 11     | Gastropathy   | Allium macrostemon (27), Huperzia squarrosa (35), Potentilla discolor (137) |
| 12     | Headache      | Aristolochia versicolor (38), Equisetum giganteum (78), Gastrodia elata (134), Reynoutria multiflora (159) |
| 13     | Heart disease | Musa basjoo (109), Spatholobus suberectus (89)                          |
| 14     | Hemorrhoid    | Cynoglossum amabile (107)                                              |
| 15     | Hepatitis     | Incarvillea diffusa (214)                                              |
| 16     | Hypertension  | Araliaexia var. formosana (67), Cardamine tangutorum (56)              |
| 17     | Hyperthermia  | Mentha canadensis (43)                                                 |
| 18     | Injury        | Aristolochia versicolor (52), Artemisia capillaris (156), Fritillaria cinnosa (189), Lepidum virginicum (253), Papaver rhoeas (253), Papaver rhoeas (253) |
| 19     | Measles       | Lycoriseringia formosa (132)                                           |
| 20     | Muscle pain   | Paris polyphylla (121)                                                 |
| 21     | Nephropathy   | Eucommia ulmoides (89), Cirsium shansiense (62)                         |
| 22     | Nosebleed     | Imperata cylindrica (45)                                               |
| 23     | Pneumonia     | Eclipta prostrata (54)                                                 |
| 24     | Rheumatism    | Allium macrostemon (27), Huperzia squarrosa (78), Lycopodium japonicum (95), Sambucus adnata (53) |
| 25     | Stomachache   | Equisetum giganteum (74)                                               |
| 26     | Tonification  | Angelica sinensis (135), Arctium lappa (93), Cirsium shansiense (126), Codonopsis pilosa subsp. tangshen (56), Hovenia dulcis (75), Ophiopogonulosum vulgatum (108), Polygonatum cyrtostoma (167), Schisandra rubriflora (75) |
| 27     | Tonsillitis   | Opuntia ficus-indica (21)                                              |
waiting at least half a month before drinking. For treatment, about 50–100 ml is consumed two to three times a day until symptoms subside. For example, Paris polyphylla tinctures are used to cure injuries (e.g., bruises caused by a fall or sprains), Potentilla discolor tinctures are used to treat diarrhea and gastropathy, Gastrodia elata tinctures are used to relieve headaches, and Lysimachia congestiflora tinctures are used to treat gallstones.

To make medicinal soups, the plant materials are cooked for a while in a fried egg soup, then the patient consumes the soup. For example, the egg soup of Malva verticillata can be used to aid childbirth, the egg soups of Sambucus adnata and S. williamsii can help heal bone fractures, and the egg soup of Leycesteria formosa can cure measles.

Of the two species of WEPs eaten raw as medicine, Fritillaria cirrhosa bulbs are collected, sun dried, and stored. The bulbs are then crushed into a powder and ingested orally to treat cough. The powder of dried Gastrodia elata rhizomes can be eaten directly to relieve headache.

For the plants used externally, the powder of Fritillaria cirrhosa and the ground pulp of Paris polyphylla or Artemisia capillaris can be applied directly to trauma wounds to quickly stop the bleeding and help wounds heal more rapidly. Some Yi cut the prickly pear cactus’s epidermis (Opuntia ficus-indica) and put it on the cheek to treat tonsillitis. It is, however, important to note there are many other medicinal plants used externally by the Liangshan Yi that are not recorded here because they are not WEPs.

Other uses
We found that seven species of WEPs also had other non-eating uses. For example, four species are used as ritual plants. Artemisia capillaris is used in cleansing rituals. Heated stones are placed in a container with A. capillaris and water, causing a white steam to arise filled with the plant’s aromatic oil. The person or thing passing through the steam is considered ceremonially clean. The branches of Aralia chinensis are used in the ritual of installing ancestral spirits (i.e., assisting the souls of deceased relatives to reach the spiritual realm). The branches of both Toxicodendron vernicifluum and Sambucus adnata are used in exorcism rituals.

Liangshan Yi collect and dry Pseudognaphalium affine as a type of kindling. Some elder Yi often carry steel, flint, and kindling in their pouches. When they want to smoke, they strike the steel against the flint to generate a spark, setting the prepared kindling on fire to ignite the pipe. Secondly, when Yi hunters find a wild beehive, in order to collect honey, the dried vegetation of P. affine is ignited under the hive, and the resulting smoke dispels the bees and/or stuns them, so that the hunter can easily obtain the honey. Yi women use Oxalis corniculata to scrub, de-tarnish, and polish silver jewelry (earrings, rings, bracelets, etc.), which are important items in Yi traditional attire (Figs. 4 and 5). Pyracantha fortuneana is a very common hedge plant and is planted around the yard perimeters in many Yi villages.

Months of collection
The Liangshan Yi mainly collect WEPs from March to October (Fig. 6). The greatest number of species can be collected in August (95 species), followed by May (91), September and October (90 each), July (87), April (86), June (85), and March (78). Due to inclement weather and frost, the number of WEPs collected during late autumn and winter is much fewer. For instance, only 34 species are collected in November, 29 species in December, 24 species in February, and only 23 species in January.

Most of the WEPs used for food are collected from March to June, with the total number gradually declining through October, with only four species collected year-round. Wild fruits consumed as snacks as well as spices are most often collected from July to October. Medicinal plants are mainly collected from March to October. For culinary coagulants, the leaves of Reynoutria multiflora.
are collected all year-round, but the fruits of *Berberis jamesiana* are only collected when mature (September to December). All seven WEPs in the “other uses” category are collected year-round.

**Commercial valuation**

Many Liangshan Yi collect certain species of WEPs to sell at the market to augment their household incomes. We found 35 species of WEPs sold in the markets we surveyed, with 8 species sold as food, 18 species as medicinal herbs, 6 species as wild fruits (including the roots of *Pueraria montana* var. *lobata* eaten as a snack), and 3 species as spices (Table 2).

The prices of medicinal WEPs (¥40–2000 RMB/kg; note: $1 USD = ¥6.8 RMB) were much higher than the price of foods and fruits (¥5–20 RMB/kg; Table 2). *Fritillaria cirrhosa, Paris polyphylla, Gastrodia elata, Reynoutria multiflora, Angelica sinensis, Spatholobus suberectus, Huperzia squarrosa,* and *Ophioglossum vulgatum* were targets of commercial acquisition, so their prices were particularly high. For example, dry *Fritillaria cirrhosa* sold for ¥2000 RMB/kg and *Paris polyphylla* sold for ¥600 RMB/kg. Fresh *Gastrodia*
elata) sold for approximately ¥100 RMB/kg, while the dried form sold for ¥500 RMB/kg. In contrast, because of their ample supply and wide distribution, the price of *Taraxacum mongolicum* and *Plantago major* was much lower (¥10 RMB/kg).

*Fritillaria cirrhosa* and *Paris polyphylla* are important raw materials for many traditional Chinese medicine (TCM) preparations. *F. cirrhosa* is a key herb used to make a popular cough syrup called *Chuan běi pi pá gāo* (川柿枇杷膏), which is used by the Chinese diaspora worldwide, including in East Asia, Europe, and North America. *F. cirrhosa* is also one of the most important ingredients in a couple famous Chinese proprietary medicines, including *Yúnmǎn Bái yào* (云南白药), used for treating injuries and stopping bleeding, and *Gōng Xué Nǐng* (宫血宁), used for curing excessive menstruation. It is well-documented that *P. polyphylla* has near-miraculous medicinal properties to cure wounds. External application of the powdered roots can rapidly stop bleeding, reduce inflammation, and even treat venomous snake bites [53–56]. Since the 1980s, many pharmaceutical companies began establishing local branches in Liangshan to acquire *Paris polyphylla*. Consequently, interviewees reported that the wild resources of this plant have been so greatly depleted that it is now very difficult to collect them for local medical needs. Therefore, many locals in Liangshan have begun purchasing wild seedlings of *P. polyphylla* to plant in their courtyards for convenient access when someone is wounded (Fig. 7). They will also sell them after they have grown to maturity. During one of our field surveys in Liangshan (Meigu County, April 2017), we met a local team whose sole aim was to collect wild *P. polyphylla* seedlings. They said that about 2000 individuals could be collected each day, and each plant could be sold to villagers for about ¥0.2 RMB.

**Use value**
The five species with the highest use values (UVs) were *Berberis jamesiana* (1.92), *Pyracantha fortuneana* (1.87), *Artemisia capillaris* (1.44), *Peridium aquilinum* (1.35), and *Houttuynia cordata* (1.26). The species with the lowest UVs were *Lycopodium japonicum* (0.24), *Spatholobus suberectus* (0.22), *Huperzia squarrosa* (0.20), *Araioostegia divaricata var. formosana* (0.17), and *Aristolochia versicolor* (0.13) (Tables 2 and 6).

**Discussion**

**Yi Culture of WEPs in Liangshan**

Although the Liangshan Yi people have their own traditional written language, historically, it was not widely learned by the general public. Instead, it was primarily used only by their traditional ritual specialists, the bimox. With the broader Yi population being largely illiterate throughout much of Liangshan’s history, their cultural knowledge and traditional customs were instead transmitted through oral communication techniques [57], including knowledge of WEPs. One way this information was organized for easy memory and transmission was through traditional Yi cultural sayings. These sayings often included information about the WEPs’ flavors, proper collection times, and medical uses. For example, one traditional saying about the good flavor of soup made from *Cardamine tangutorum* says “I should share the vegetable of *Cardamine tangutorum* with my mom but not the soup” ( Gord o yuè hǎi shì yǐn wǒ mā ma bù yīng hǎi fàn wǒ shì yǐn zhī shì yǐn mā ma shì yǐn bù yīng hǎi fàn wǒ shì yǐn zhī shì yǐn). Another saying states, “Eating *Toona sinensis* prevents diarrhea if collected before the cuckoo chirps in spring” ( 罐罐松可以治腹泻 乌勃达可以治腹泻). Realizing that *Houttuynia cordata* has the effect of promoting rapid digestion, a traditional Yi saying warns not to eat it during times of famine. It states, “a satiated people will be hungry soon after eating *Houttuynia cordata*, but hungry people never try it because they will starve” (吃饱了马上饿, 吃不饱了从来不吃).

**Climate, lacto-fermentation, and collection season**

In contrast to the Han people, who primarily settled in river valleys, most Yi people live in mountainous areas in Liangshan, with limited arable land, colder weather, and longer winters, so this has greatly influenced their cultural traditions, preferred WEPs, and associated knowledge. Since there is a shorter time period to cultivate crops and vegetables, to ensure year-round food
supplies, the Liangshan Yi preserve vegetables through lacto-fermentation techniques by making pickles. Lacto-fermentation is a food preservation technique shared by many other people groups around the world [58, 59], as well as elsewhere in China, such as Tibetans in Gansu Province [23], who live in northern latitude and high altitude areas with long winters. The Liangshan Yi believe these pickles are not only appetizing but aid their digestion, which is a well-documented benefit of eating lacto-fermented foods as probiotics [58, 59]. These cultural beliefs are also similar to those of the people living in the eastern part of Gilan Province (North Iran), who use pickled sour orange fruits to fortify their stomachs [60]. The overall nutritive value of lacto-fermented foods and drinks is also recognized by diverse people groups across Eastern Europe, Turkey, and the Caucasus [58]. In addition, Liangshan Yi cuisine is heavily soup-based, because the staple food is dense, high-carbohydrate buckwheat cakes, which require soup to

| Species with the highest UVs | Family | Scientific name | Usage 1 (frequency) | Usage 2 (frequency) | Usage 3 (frequency) | Usage 4 (frequency) | ΣUs | UVs |
|-----------------------------|--------|----------------|--------------------|--------------------|--------------------|--------------------|-----|-----|
| Berberidaceae | *Berberis jamesiana* Forrest & W.W.Sm. | Snack (314) | Spice (209) | Medicine (126) | Culinary coagulant (112) | 761 | 1.92 |
| Rosaceae | *Pyracantha fortuneana* (Maxim.) H.L.Li | Snack (379) | Other use (196) | Famine food (166) | 741 | 1.87 |
| Compositae | *Artemisia capillaris* Thunb. | Other use (346) | Medicine (156) | Famine food (67) | 569 | 1.44 |
| Dennstaedtiaceae | *Pteridium aquilinum* (L.) Kuhn | Primary food (379) | Famine food (157) | | 536 | 1.35 |
| Saururaceae | *Houttuynia cordata* Thunb. | Primary food (357) | Spice (109) | Medicine (34) | 500 | 1.26 |
| Oxalidaceae | * Oxalis corniculata* L. | Snack (250) | Spice (198) | Other use (13) | 461 | 1.16 |
| Compositae | *Cirsium shanensi* Petr. | Primary food (326) | Medicine (126) | | 452 | 1.14 |
| Lamiaceae | *Penilla frutescens* (L.) Britton | Spice (289) | Primary food (149) | | 438 | 1.11 |
| Orchidaceae | *Gastrodia elata* Blume | Medicine (296) | Primary food (134) | | 430 | 1.09 |
| Adoxaceae | *Sambucus adnata* Wall. ex DC. | Snack (235) | Medicine (142) | Other use (45) | 422 | 1.07 |
| Species with the lowest UVs | Family | Scientific name | Usage 1 (frequency) | Usage 2 (frequency) | Usage 3 (frequency) | Usage 4 (frequency) | ΣUs | UVs |
| Helwingiaceae | *Helwingia japonica* (Thunb.) F.Dietr. | Primary food (105) | | | | 105 | 0.27 |
| Equisetaceae | *Equisetum giganteum* L. | Medicine (102) | | | | 102 | 0.26 |
| Orchidaceae | *Bulbophyllum odoratissimum* (Sm.) Lindl. ex Wall. | Medicine (100) | | | | 100 | 0.25 |
| Amaranthaceae | *Celosia argentea* L. | Famine Food (99) | | | | 99 | 0.25 |
| Cactaceae | *Hylocereus undatus* (Haw.) Britton & Rose | Primary food (98) | | | | 98 | 0.25 |
| Lycopodiaceae | *Lycopodium japonicum* Thunb. | Medicine (95) | | | | 95 | 0.24 |
| Leguminosae | *Spatholobus suberectus* Dunn | Medicine (89) | | | | 89 | 0.22 |
| Lycopodiaceae | *Huperzia squarrosa* (G. Forst.) Trevis. | Medicine (78) | | | | 78 | 0.20 |
| Davalliaceae | *Araistegia divaricata var. formosana* (Hayata) M. Kato | Medicine (67) | | | | 67 | 0.17 |
| Aristolochiaceae | *Aristolochia versicolor* S.M.Hwang | Medicine (52) | | | | 52 | 0.13 |
help swallow (Fig. 2). Consequently, a traditional Yi proverb states, “Soup can nourish people for seven days, but meat only for three days” ([2020] 16:10 Page 23 of 27), indicating their preference for soup [61]. Nevertheless, the pickle soup, a quintessential component of the Liangshan Yi people’s traditional diet finds a cultural parallel with the Eastern European (e.g., Poland, Lithuania, and Belarus) tradition of preparing sour pickle soups from the lacto-fermented shoots and leaves of hogweed (Heracleum sphondylium) [58].

We found that the collection dates for most WEPs are concentrated between March and October. The collection of tender shoots, leaves, and aboveground plant parts for food most often occur between March and June, but, as we predicted, the collection of wild edible fruits (food, snack, and spice categories) tend to be collected later in the growing season (summer and autumn). Due to the seasonal ontogeny in high-elevation Liangshan, these collection seasons are similar to those recorded elsewhere in Northern Hemisphere temperate [22] and high-elevation subtropical regions [4, 5]. However, the collection of famine foods, culinary coagulants, and the most valuable medicinal plants, driven more by the interests of necessity, weather, and economics, were less closely related to the growth and reproduction characteristics of the WEPs. Similarly, the collection of all seven “other use” WEPs (including all four ritual plants) is not affected by season, because the parts collected are mostly branches.

**WEP diversity, use values, and cultural significance**

In keeping with our expectations, the families Rosaceae (14 species) and Compositae (8 species) had the highest representation of species in this study, but Lamiaceae was only represented by 2 species (Table 2). The greater number of collected WEPs from these families is similar to the patterns documented elsewhere [5, 22, 23, 62], but unlike those studies, other common families (e.g., Asparagaceae, Caprifoliaceae, Liliaceae, and Polygonaceae) were each represented by a single species in our study. This suggests that the relative abundance of a family within a particular area is not reason enough for its species to be collected for food or medicine. In this sense, although we did not specifically test the theory of non-random plant selection [17, 26], our data lends further support for this widely tested theory. For example, if the selection/collection of WEPs were truly random or “placebo” (rather than based on many years of experience and local knowledge of the flora), every common/abundant family would be expected to have greater representation among the utilized WEPs.

We might also expect that the common families would have more species with greater UVs, but, instead, we found that species from 9 different families had the top 10 highest UVs (Table 6). Although all 3 families (Compositae, Lamiaceae, and Rosaceae) had species within the top 10 highest UVs, only Compositae had more than 1 (#3 and #6). However, this may be due to the particularly high species diversity in Liangshan, in that despite stiff competition, these species have proven over time to be the most versatile [26, 63]. Nevertheless, when looking at plant UVs, the relative cultural importance of the collective taxa from each family is better appreciated. For example, of the top 20 UVs (Table 2), the proportion of taxa from the 3 families increases: Compositae (3/8 taxa; 37.5%), Lamiaceae (2/2 taxa; 100%), and Rosaceae (6/14; 42.9%), and of the top 30 UVs: Compositae (4/8 taxa; 50.0%), Lamiaceae (2/2 taxa; 100%), and Rosaceae (9/14; 64.3%). So, according to the UVs, a majority of the collected WEPs from all 3 families are among the most culturally important species, and only 2 species (both Compositae) fall within the bottom 30 UVs (#79 and #86; Table 2).

As Gaoue et al. [26] point out, plant use values are essential measures of plant versatiltiy. Thus, not only are the high-UV WEPs widely distributed with large populations throughout Liangshan, the Yi people have found these particular species to be very useful in their daily lives. For example, many Yi people since childhood have consumed the fruit of Berberis jamesiana (highest UV) and Pyracantha fortuneana (UV #2) raw as snacks between meals while collecting firewood or herding. Most adults also know that the juice of B. jamesiana can be used as a culinary coagulant to make tofu or as a flavor enhancer (spice) to increase the sourness of pickle soups. Similarly, the dense growth and thorns of P. fortuneana, beautiful white flowers, edible red fruit, and long fruiting period make it commonly planted as a hedge.

Nevertheless, historical events and outside influences may have amplified the relative importance of some of these plants. For example, in the 1950s, the National Pharmaceutical Company began commercial acquisition in Liangshan of the root bark of Berberis jamesiana and related species (Berberidaceae) to extract and refine the bioactive compound (berberine), which is medically valuable for treating diarrhea and other ailments. The large volume of acquisitions of B. jamesiana root bark for extraction of berberine deeply affected the perception (including the local name) of this plant by many Liangshan Yi [28]. This may contribute to why it has the highest UV in our survey. Similarly, Pyracantha fortuneana is an important famine food remembered by elderly Yi people who had experienced severe famine years. The fruit was ground into pulp and mixed into Tartary buckwheat (Fagopyrum tataricum) flour or cornmeal to make cakes, augmenting the nutrition of the flours and increasing their volumes.
Our results also demonstrate large differences between the economic/commercial valuation and cultural evaluation (UVs) for particular species (Tables 2 and 6). For example, although we found that medicinal WEPs sell at the market for much higher prices than those used for other purposes, of the three most economically valuable medicinal WEPs, only the use value of *Gastrodia elata* (Y100 RMB/kg wet; Y500 RMB/kg dry) is in the top ten (UV #9). In contrast, *Fritillaria cirrhosa* (Y2000 RMB/kg) and *Paris polyphylla* (Y600 RMB/kg) were more expensive, but they had much lower cultural significance overall (UV #44 and #46, respectively). However, both of these species are only used for medicine, while *Gastrodia elata* is also an important food plant widely sold in the markets. Incidentally, because of children’s good eyesight and flexible bodies, they more easily fit in and around bushes. Thus, during the flowering period of this orchid (when it briefly appears above ground), many Yi children are encouraged to participate in collection activities, so children, in particular, tend to be very knowledgeable about this species.

This demonstrates the need for longitudinal studies to measure plant use values within the same cultural context over time (across differing demographic variables) in order to more robustly test ethnobotanical theories. Cultures are dynamic and resilient, constantly adapting to changing conditions, including the introduction of new species and decline of formerly common species [26]. Unlike the cultural keystone species theory, which is hard to quantify beyond cultural perceptions of foundationally important species [26, 64, 65], plant use values do not seek to measure absolute importance of particular species within a culture, but instead measure their relative cultural importance at a given moment (or “snapshot”) in time [26, 66]. Thus, the rank order of UVs should be interpreted with this in mind.

For example, we found that the tender shoots of *Pteridium aquilinum* (UV #4) are widely eaten by the Liangshan Yi as vegetables, but its roots are also used as a famine food. This species is representative of an important cultural reverence more broadly applied by the Yi people to multiple species of ferns, including *Matteuccia struthiopteris* (UV #24). For thousands of years, ferns like these have been an important source of regular nourishment, medicine, and famine food for the Liangshan Yi. The ancient Yi scriptures *Zuò zhù xiàn yào gōng shēng jīng* (作斋献药供牲经) describe the fern fiddleheads as representative of abundant and prosperous descendants. Therefore, fiddleheads are common decorative motifs on the Liangshan Yi’s clothing, textiles, and other material culture items (Figs. 4 and 5), which highlight their cultural veneration and gratitude to ferns for providing food in times of famine. At the same time, these fern motifs are expressions of hope that their children will also flourish like the ferns [67].

### Edible medicinal plants and conservation

As we hypothesized, many of the WEPs primarily consumed by the Liangshan Yi as food also have medicinal effects. Some of these are intentionally ingested for their healthful effects as part of an overall “healthy diet.” For example, the rhizomes of *Gastrodia elata* (UV #9), whole plant of *Houttuynia cordata* (UV #5), and roots of *Cirsium shansiense* (UV #7) are eaten as vegetables, understanding their medicinal effects. This further supports the argument put forward by various authors that there is no clear distinction between the concepts of *food* and *medicine* in many cultures [16, 17, 19]. This is also similar to the documented use of medicinal edible plants (e.g., ginger, buckwheat, and bitter melon) as dietary staples among the Yi people of Guizhou Province, particularly in their ancient medical text *Qǐ gōu shǔ* (启谷著) [68]. In addition, the Yi that live in Xishuangbanna (Lancang River Basin), in southern Yunnan Province, also have the custom of using medicinal edible plants to strengthen their physical health and prevent disease. They collect many medicinal WEPs for meals and stew them with pork every year during the Dragon Boat Festival [69], which is a holiday adopted from the Han Chinese. Similarly, the Yi, Lahu, and Han people in the Simao area of Yunnan Province, as well as the Zhuang people of Guangxi, have related traditions of eating meals of medicinal roots during the Dragon Boat Festival [70].

Nevertheless, our data on medicinal WEPs also reveal some of the most common diseases and general health concerns that afflict the Liangshan Yi communities (Table 5). In total, taxa from 37 out of the 62 families of WEPs in our study were used for medicine, and, as documented elsewhere [9, 16, 71], for a given species, the medicinal plant parts often differed from those collected for food or other uses (Table 2). For example, *Artemisia capillaris* (UV #3) is an important ritual plant, with its aboveground parts used in almost all cleansing rituals as well as for medicine, but only the tender shoots are used as a famine food. Similarly, the fruit of *Sambucus adnata* (UV #10) is used as a snack, but the aboveground portions have medicinal and ritual uses.

We also documented an interesting preparation method utilized by the Liangshan Yi for four medicinal WEPs, in which plant parts are prepared in fried egg soups for ingestion by the patient. This preparation method is intentional and only used for certain plant parts from particular species to treat known ailments. This appears to be similar to the preparation methods of certain medicinal plants ingested by the Yi people of Chuxiong Prefecture in Yunnan Province [72], but more research is required to understand the significance of the egg preparation technique on the bioactivity of these plant compounds.

Seven out of the ten WEPs with the lowest UVs (Tables 2 and 6) are medicinal plants (with high medicinal value...
but less cultural significance overall), and none of them is WEPs traditionally used by the Liangshan Yi, except for *Equisetum giganteum* and *Bulbophyllum odoratissimum*. Due to improvements in the transportation and communications infrastructure in the Liangshan region in recent years, the Liangshan Yi now interact with other cultures more frequently and widely than ever before. Consequently, some Yi people have learned about these medicinally valuable species through interacting and trading herbs with the Han Chinese [28].

In recent years, however, the Liangshan Yi have struggled to find certain species of medicinal WEPs as their great economic value has led to commercial exploitation and overharvest, leading to an overall sharp decline in wild populations. For example, commercial acquisition of *Paris polyphylla* across Sichuan was about 300 t in the 1990s, but as the slow-growing wild populations diminished, the commercial collection declined to less than 100 t by 2010 [73]. The overall quality of the collected WEPs has also reportedly declined. Therefore, the Liangshan Yi people started collecting wild seedlings of certain valuable WEPs to plant in their courtyards. As we found, many Liangshan Yi either began collecting seedlings of *Paris polyphylla* from the wild or purchasing seedlings from collecting teams in order to plant in their courtyards (Fig. 7). With 2–3 years of growth, the plants grow large enough to be sold at significantly higher prices, providing a relatively stable cash income supply for the largely subsistence-based farmers. The same situation has been documented among the Lisu people in Nuijiang, northwest Yunnan, China, who have similarly begun cultivating medicinal plants with high economic values [74].

This highlights the beginning steps of local domestication for these high-value medicinal edible plants, but this phenomenon also has implications on the biodiversity conservation as well. Essentially, there exists a significant pool of wild-collected germplasm spread out across a relatively extensive network of rural villages with specific knowledge of their provenance. In light of decimated wild populations, these household collections of wild-collected species collectively function as a germplasm bank that could potentially be tapped by conservation organizations wishing to re-establish healthy, genetically diverse, wild populations of these threatened species. *Rosa roxburghii* presents another example of WEP domestication in Liangshan with conservation implications. Originally harvested from the wild as a snack, *Rosa roxburghii* is now widely planted in many Yi courtyards, where specimens have been selected to produce larger and more evenly maturing fruit. The market price of cultivated *Rosa roxburghii* fruit is now eight to ten times that of the fruit directly collected from the wild [31]. Consequently, further domestication of cultigens may also help alleviate collection pressures on some WEPs.

**Conclusion**

Our survey documented 105 WEPs in Liangshan Autonomous Prefecture. The traditional knowledge held about these plants is the result of the accumulated experience by the Liangshan Yi people’s long-term presence living in the local environment. With the rise of functional foods and edible medicinal plants, there is a need to further analyze the nutrition, chemical composition, and bioactivity of the WEPs. For sustainable utilization, some species with high medicinal value but sharp declines in wild populations should be further studied for resource assessment, sustainable use, domestication possibilities, and genetic conservation.

**Acknowledgements**

We are grateful to all the field assistants (particularly Ercong Aba) and interviewees who provided information in the ethnobotany surveys in Liangshan.

**Authors’ contributions**

All authors contributed substantively to this project, either through data collection (KA, JW), translation and analysis (BCS, JW, KA, YZ), and/or writing, revising, and editing (BCS, JW, TT). The first author, JW, has been the primary researcher involved at each stage of this project, culminating in this manuscript. All authors have approved this manuscript in its current and final form.

**Funding**

This research was funded by the Biodiversity Survey and Assessment Project of the Ministry of Ecology and Environment, China (#Z2019HJ0096001006); the National Natural Science Foundation of China (#31600253); and the China Scholarship Council (201708515018).

**Availability of data and materials**

The dataset supporting the conclusions of this article is included within the article (and its tables).

**Ethics approval and consent to participate**

The authors assert that all procedures contributing to this work comply with the applicable ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008. All interviews were conducted only after oral informed consent was obtained.

**Consent for publication**

Not applicable.

**Competing interests**

The authors declare that they have no competing interests.

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Received: 23 June 2019 Accepted: 5 December 2019

**Published online**: 26 February 2020

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