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Ethnobotanical study on wild edible plants used by Dulong people in northwestern Yunnan, China

Zhuo Cheng[1,2,3†], Xiaoping Lu[1,2,3†], Fengke Lin[1,2,3], Abid Naeem[4] and Chunlin Long[1,2,3,5*]

Abstract

Background: Dulong (Drung people) are one of the ethnic minorities of China, consisting of a small population living in remote and mountainous regions with limited facilities. Over the years, the Dulong have maintained their livelihood by collecting wild medicinal and edible plants. Therefore, through their experience and understanding, they had accumulated sufficient traditional knowledge about local plant resources. Since ancient times, wild edible plants have been essential to the food security of the Dulong people. However, there is almost no comprehensive report available on WEPs consumed by the Dulong people. The objectives of this study were to: (1) make a systematic study of WEPs used by Dulong people, (2) record traditional knowledge related to WEPs, (3) analyze multiple uses of WEPs, and (4) evaluate species with significant cultural significance to Dulong people.

Methods: Ethnobotanical survey including free listing, semi-structured interviews, key informant interviews and participatory observations was conducted in Dulongjiang Township, Gongshan County, Yunnan Province, Southwest China. A total of 127 informants were selected using the snowball method and information about WEPs, including vernacular name, food categories, parts used, mode of consumption, collection season, and other local uses were collected. The RFC and CFSI were calculated to identify the most culturally significant WEPs. One-way analysis of variance was performed to evaluate whether the four reference variables (gender, age, occupation, and education) significantly influenced the number of plant species mentioned by the respondents.

Results and discussion: A total of 148 species of WEPs consumed by the Dulong people belonging to 58 families were collected, including wild vegetables (71), wild fruits (52), staple food substitutes (15), spices (7), nuts (4), tea substitute (2), liquor making materials (3) oils and fats (3), and culinary coagulants (1). WEPs are used in a number of different ways, including as fuelwood, feed, and medicine. Food substitute plants accounted for the majority of the top 27 wild food plants identified by RFC and CFSI. It was observed that farmers have more knowledge of WEPs, and moderate education level informants reported less WEPs used.

Conclusion: The WEPs used by the Dulong people are diverse and abundant in the Dulongjiang region. In the future, WEPs such as *Maianthemum atropurpureum*, *Caryota obtusa*, *Cardiocrinum giganteum*, and *Angiopteris esculenta* with economic potential can be developed to provide a source of income for the residents. More studies of the nutritional value, chemical composition, and biological activities of WEPs are needed. The demands and development of local

*Correspondence: long@mail.kib.ac.cn; long.chunlin@muc.edu.cn
†Zhuo Cheng and Xiaoping Lu contributed equally to this work
[1] Key Laboratory of Ecology and Environment in Minority Areas (Minzu University of China), National Ethnic Affairs Commission of China, Beijing 100081, China
Full list of author information is available at the end of the article

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communities can be realized under the premise of protecting WEPs and the associated traditional knowledge. More attention should be paid to the value of WEP and underutilized plants during future rural development.

Keywords: Dulong people, Dulongjiang area, Ethnobotany, Wild edible plants, Traditional knowledge

Background

China is classified among the countries with the richest biodiversity of plants in the world and has a wide variety of wild edible plants (WEPs) with abundant reserves and a wide distribution [1]. WEPs refer to species that are not artificially planted and domesticated but are collected from the natural environment and used as food sources [2–4]. The collection and consumption of WEPs are an important part of livelihood strategies throughout the world. Furthermore, considered an integral part of local culture, WEPs satisfy the food requirement of different communities [5, 6]. WEPs can not only be used to fill the food gap during droughts or resource scarcity, but also play an important role in maintaining the livelihood security of many people in developing countries and balancing the nutritional value of the diet [7–10]. WEPs are rich in nutrients and have high nutritional value. They can be used as a primary food source by residents and as a food supplement for non-local residents, which guarantees food security in poor communities [10]. WEPs can also be collected in large quantities for processing and sales. Furthermore, it is also one of the main sources of income for residents in poor communities and plays an essential role in helping communities eliminate poverty [11]. They can also serve as a source of domesticated species and provide valuable genetic resources for the development of new crops through hybrid screening [12, 13].

With the development of the social economy and the modernization of agricultural science and technology, human utilization of WEPs has never decreased [14]. Collecting and eating WEPs has become a way of life for modern people, which not only enriches the culture of modern diet, but also satisfies the requirements of a green and nutritious diet [15]. It is estimated that there are about 300,000–500,000 plant species on the planet, of which 30,000 are considered edible, and only 7000 are planted or collected as food. Currently, only 20 crops provide 90% of the world's food demand [16, 17]. On the one hand, large-scale cultivation of a limited number of crops, coupled with the industrial revolution, lifestyle changes, and lack of contact with nature, has led to the underutilization of WEPs [18]. However, due to the loss of traditional culture and the conversion of forest ecosystems to other types of land use types has also resulted in the loss of traditional knowledge which may be lost completely. The role of WEPs in developing countries has been largely neglected and underestimated [19]. To adapt to continuous population growth and global climate change, diverse food plants are needed to ensure a safe and resilient food supply [20]. In-depth investigations of WEPs and their related traditional knowledge recording are important, (1) to promote the conservation and sustainable use of WEPs, (2) to enable future generations to acquire traditional knowledge associated with WEPs, (3) to help economically backward and low-living areas to uplift themselves out of poverty and food insecurity, and (4) to get germplasm resources with better quality.

Currently, conducting ethnobotanical surveys of wild edible plant resources has attracted the interest of many ethnobotanists and has become the focus of research [21–24]. There are many studies on WEPs in China, mainly focused on the use of plants by ethnic minorities, such as Naxi, Hani, Mongolian, Tibetan, Yi, etc. [3, 6, 25–30]. These studies played an essential role in protecting traditional knowledge and the sustainable use of WEPs and finding the most widely consumed varieties and analyzing their nutritional value [8, 31]. The results of the nutritional analysis will provide clues for the search for excellent germplasm resources, help ensure the diversity of the diet and achieve food security [8, 32, 33].

Drung, or Dulong in Chinese *pinyin*, one of the smallest ethnic groups in China and containing only 6930 people, is mainly concentrated in the Dulongjiang area of northwest Yunnan. Dulong people live near water and choose forests as habitats. In the long process of interaction with the living environment, many WEPs were consumed, and traditional ecological knowledge about them has been accumulated due to unique topography, rainy stereoscopic weather, closed traffic conditions, and abundant natural resources [34–41].

In the past, there have been only sporadic reports on the research of WEPs of the Dulong people, and no comprehensive research and quantitative research has been conducted [34, 41]. From slash-and-burn cultivation to poverty alleviation for the entire tribe, it seems that the traditional knowledge associated with the WEPs of Dulong people will be impacted or even lost. So, it is very necessary to study WEPs from the Dulong ethnic group. The purposes of this study were to (1) conduct a comprehensive study of WEPs used by Dulong people, (2) record the traditional knowledge associated with WEPs, and (3) identify species of important cultural significance to Dulong people.

Methods

Study area

As the only known settlement of the Dulong in China, Dulongjiang Township is located west of Gongshan Dulong and Nu Autonomous County, Nujiang Lisu Autonomous Prefecture, Yunnan Province, China (Fig. 1). Dulongjiang Township (27° 40′ to 28° 50′ N, and 97° 45′ to the 98° 30′ E) is adjacent to Bingzhongluo and Cikai townships in the east, Chayu County of the Tibetan Autonomous Region to the north, and the Kachin State of Myanmar in the west and south [40]. Dulongjiang Township belongs to the typical alpine gorge landform with a large altitude gradient from 1172 to 3400 m. The Dulongjiang region has historically been isolated for a very long time, not being able to communicate with the outside world from December to June of the following year. It remains the most remote, poor, backward and closed region in China. The Dulongjiang area receives an abundance of rainfall (average rainfall of 3672 mm per year), and it is one of the regions with the highest rainfall in China [42]. Dulongjiang Township is an important part of the Gaoligongshan National Nature Reserve and the Three Rivers Parallel World Natural Heritage Site. It still preserves dense virgin forests and is one of the places that have the highest level of biodiversity in China, with 275 species in 41 families of ferns and 2003 species in 158 families of spermatophytes [36, 37, 39]. The diversity of sperm per square kilometer in Dulongjiang is 1.09, which is much higher than that of the autonomous prefecture of Xishuangbanna Dai Autonomous Prefecture (0.19), a very rich area in biodiversity [43]. Dulong ethnic group is one of 55 minority ethnic groups in China, and it has the smallest population in Yunnan province. The Dulong people are considered to be the last seasonal foragers in China [44–46]. The number of Dulong people in Dulongjiang Township represents 99% of the total population (with 6930 people only). Most people speak the Dulong language and only young people can speak Mandarin Chinese. These locals have very low income, with the average annual income of 596 RMB in 2005 and 6122 RMB in 2018, which is lower than the national average level [47].

Field survey and data collection

From local chronicles, maps and flora, a preliminary understanding was established, including topography,

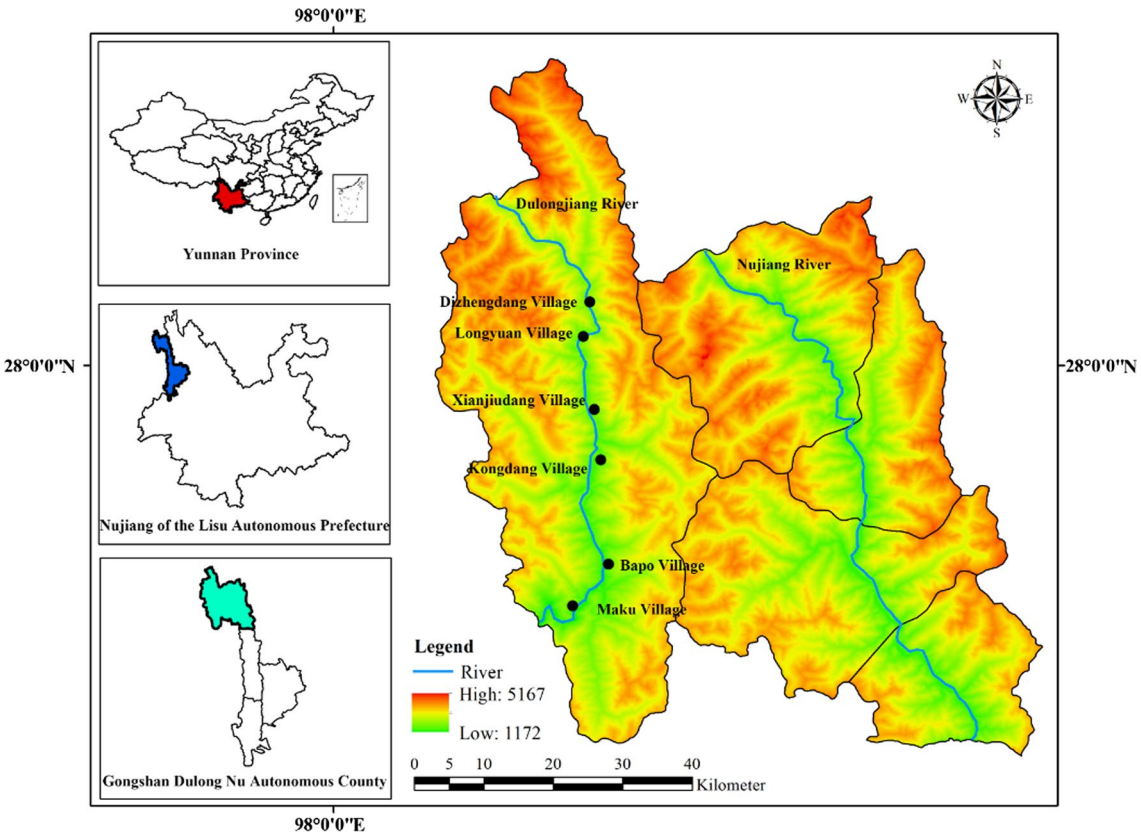

Fig. 1 Sketch map of the study area

Table 1 Study site locations and demographic characteristics of respondents

Village	Gender		Age				Education level				Occupation				Location		
	Male	Female	≤ 19	20–39	40–59	≥ 60	Illiterate	Primary	Secondary	High school and above	Farming	Salary work	Trading	Student	Latitude (north)	Longitude (east)	Distance to the Township (km)
Dizheng-dang	11	8	2	5	7	5	6	3	7	3	14	2	2	1	27° 44′ 9″	98° 20′ 58″	Far (23.44)
Longyuan	15	8	0	15	6	2	3	5	13	2	19	4	0	0	27° 52′ 18″	98° 20′ 25″	Far (16.75)
Xianjiudang	14	8	3	8	6	5	2	10	5	5	13	6	0	3	28° 4′ 35″	98° 19′ 33″	Near (7.37)
Kongdang	11	10	0	9	7	5	6	5	7	3	16	5	0	0	28° 0′ 51″	98° 18′ 48″	Near (0)
Bapo	12	10	1	9	9	3	4	2	11	5	14	5	1	2	27° 55′ 9″	98° 20′ 59″	Far (15.07)
Maku	12	8	2	13	4	1	5	2	12	1	12	6	0	2	27° 41′ 18″	98° 17′ 53″	Far (21.36)
Total	75	52	8	59	39	21	26	27	55	19	88	28	3	8			

climatic conditions, and vegetation of the Dulongjiang area, history, customs, religious beliefs, and social culture of the Dulong people, before the ethnobotanical investigation, which helped to choose suitable sites and times for the survey. Ethnobotanical surveys were carried out three times in Dulongjiang Township from August 2019 to September 2020, and the entire study covered six villages in Dulongjiang Township (Fig. 1). The data of latitude, longitude and elevation of the six villages are listed in Table 1.

Field surveys included free listing, semi-structured interviews, key informant interviews and participatory observation, and a total of 127 informants were selected using the snowballing method. During the field investigation, every informant was invited to list all wild plants that are still regularly used or have been used in the past. The interviews consisted of two parts, the first part was about the basic situation of the informants (ethnicity, age, education, occupation), and the other part included questions related to recording detailed information on WEPs, including the local name, availability, use part, processing method, frequency of use, mouthfeel, whether it is used as a medical diet, months of collection, and other uses. Data were used for quantitative analysis are listed in Table 2.

For the identification of plants, the voucher specimens were studied and compared with reference books (*Flora Rpublicae Popularis Sinicae*, *Flora of China*, *Flora of Yunnan*, *Flora of Dulongjiang Region*) and electronic online resources (http://www.iplant.cn/ and http://www.theplantlist.org/). The nomenclature of all vascular plants follows *Flora of China*, Prof. Chunlin Long identified all plant species, and the voucher specimens were deposited in the herbarium of the ethnobotany laboratory of the College of Life and Environmental Sciences, Minzu University of China, in Beijing.

Demographic characteristics of the respondents

A total of 127 Dulong respondents were selected (19 from Dizhengdang, 23 from Longyuan, 22 from Xianjiudang, 21 from Kongdang, 22 from Bapo, and 20 from Maku). And 75 of the respondents were male, and 52 were female. The age of the respondents ranges from 9 to 106, and most of the people were in the age group of 20 to 39. The overall education level was poor and young people had a higher education level than the elders. The occupations of the informants included farmers, wage workers, traders, and students, among which the farmers account for the majority (Table 1).

Relative frequency of citation (RFC)

The RFC was used to quantify the frequency of use of certain species, which was determined using the following formula:

$$\mathrm{RFC} = \frac{FC}{N}$$

FC refers to the number of respondents who mentioned a particular wild edible plant and N represents the number of all respondents participating in the survey.

The RFC values vary from 0 to 1, and the higher the RFC value, the more important and valuable the plant is in the area. The importance of each wild edible plant was indicated by its FC value, which allowed all WEPs mentioned in importance survey to be listed in the order of importance [48, 49].

Cultural food significance index (CFSI)

The CFSI index considers a wide variety of factors in the evaluation of a specific wild edible plant. CFSI was calculated to evaluate the cultural significance of wild edibles using the formula given by Pieroni [50].

$$\mathrm{CFSI} = \mathrm{QI} \times \mathrm{AI} \times \mathrm{FUI} \times \mathrm{PUI} \times \mathrm{MFFI} \times \mathrm{TSAI} \times \mathrm{FMRI} \times 10^{-2}$$

The CFSI includes quotation frequency (QI, frequency of quotation index), availability (AI, availability index), typology of the used parts (PUI, parts used index), frequency of use (FUI, frequency of utilization index), kind and a number of food uses (MFFI, multifunctional food use index), taste appreciation (TSAI, taste score appreciation index) and perceived role as food medicine (FMRI, food-medicinal role index). The use of this index allows for exploring potential wild greens, as they exist in different climatic zones [6].

Jaccard index (JI)

JI can reflect the similarity between samples. We evaluated similarities between our studies with previous ethnobotanical studies carried out in other parts of China, as well as those from neighboring countries.

$$\mathrm{JI} = \frac{C}{A + B - C} \times 100$$

A is the recorded number in species of the current study area a, B is the documented number in species of another study area b, and C is the number of species common to both areas a and b [51].

Table 2 Questions used for semi-structured interviews

No.	Questions
(1)	What wild plants have you eaten?
(2)	What is the local name of the plant?
(3)	Where do you collect the plant?
(4)	Which part of the plant do you eat?
(5)	How do you process the plant?
(6)	What is the utilization frequency of this plant?
(7)	How does this plant taste?
(8)	Can this plant be used as medicinal food?
(9)	Is there any other use for this plant?
(10)	When is this plant collected?

Data processing

For the analysis, four factors (gender, age, education level, and occupation of the respondents) were used as reference variables [52]. One-way analysis of variance (one-way ANOVA) was performed to evaluate whether the four reference variables had a significant impact on the number of plants mentioned by the respondents. All analysis was performed with SPSS (version 20).

Results

Diversity of wild edibles

Dulong people use different varieties of WEPs, and 127 informants reported a total of 148 WEPs. Botanical and ethnobotanical information about these plants, including scientific names, vernacular names, families, life forms, food categories, used parts and mode of consumption, collection season, other local uses, specimen numbers, RFC, and CFSI are listed in Table 3.

The types of WEPs used by Dulong people include angiosperms, gymnosperms, ferns, and lichens. Most of the documented species were angiosperm, with 138 species belonging to 50 families. Rosaceae were found to be the largest family with 16 species, followed by Poaceae with 10 species (Fig. 2b). Fern was the second largest group containing 8 species representing 7 families, while Gymnosperm and Lichen both have one species (one family). The life forms of these WEPs are mostly herbaceous (69) and trees (22) (Fig. 2a).

Many parts of plants are edible, such as stems, leaves, fruits, seeds, flowers, roots, and tubers, among which the most commonly consumed parts are fruits, followed by stems and leaves (Fig. 2d). Wild vegetables and fruits are the two main categories of WEP, and the used parts of wild vegetables include tender stems and leaves, while the parts used parts of wild fruits utilized are fruits.

WEPs used by Dulong people can be collected throughout the year. The collection time of WEPs depends on the maturation of the parts used, but most of them are collected from March to October. The collection time for wild vegetables is mainly from March to June, and the collection time for wild fruits is from July to October (Fig. 3).

The WEPs used by Dulong people include wild vegetables (Wv), wild fruits (Wf), food substitutes (Fs), nuts (Nu), spices (Sp), tea substitutes (Ts), liquor brewing (Lb), oils and fats (Of) and culinary coagulants (Cc). Among these, wild vegetables are the most commonly used (71), followed by the consumption of wild fruits (52) (Fig. 2c).

Wild vegetables

Wild vegetables were the most extensively used in the food category with 71 edible species, and the main edible parts of wild vegetables are tender stems and leaves. Wild vegetables are consumed by boiling or stir-frying, or as ingredients in soups or stewed with pork/chicken. The most frequently reported species were *Maianthemum atropurpureum*, *Cardamine tangutorum*, and *Aralia elata*, which are the most popular potherbs in the Dulongjiang region (Fig. 4). These results are in line with previous studies conducted in Sichuan Province and northwest Yunnan Province. These species are also the most popular potherbs of the Yi, Tibetan, and Naxi people [3, 6, 53, 54]. These three species usually grow in the mountains at higher altitudes. Due to the similarity of the leaves of *Maianthemum atropurpureum* with the bamboo leaves, it was called "竹叶菜" (Zhu-ye-cai), and Dulong people collected it from March to May annually. The collection time of *Cardamine tangutorum* is much longer than that of *Maianthemum atropurpureum* and can be eaten until September. In addition, *Aralia elata* is cultivated in home gardens. Many studies have shown that these medicinal plants in the diet have high nutritional value and medicinal value [55–58]. There are also other types of abundant potherb sold in local markets of the Dulongjiang region, which have become a source of economic income and have the potential to become important and economically valuable vegetables.

Wild fruits

Wild fruits are the second largest food category of WEPs used by Dulong people, with 52 species. All wild fruits have no market value; they were consumed within families as fresh fruits like snacks. Studies have shown that the nutritional value of wild fruits is higher than that of cultivated fruits [59]. Wild fruits were popular with children as vitamins and minerals supplement, mostly during periods when cultivated fruits were not readily available. The most frequently reported species were *Cornus capitata* and *Saurauia napaulensis* (Fig. 5a, b). *Cornus*

Table 3 List of wild edible plants used by Drung

	Scientific name	Family	Chinese name	Vernacular name	Habit	Food categories	Part used and mode of consumption	Collection months	Additional local use(s)	F	RFC	CSFI	Voucher number
Angiosperma													
1	*Asystasiella neesiana* (Wall.) Lindau	Acanthaceae	白接骨	se you can	H	Wv	Tender stem and leaf, boiled or stir-fried	6–11		40	0.31	218.8	DLZ0086
2	*Actinidia pilosula* (Finet & Gagnep.) Stapf ex Hand.Mazz.	Actinidiaceae	贡山猕猴桃	——	L	Wf	Fruit, eaten freshly	9–10		1	0.01	0.012	
3	Saurauia napaulensis DC.	Actinidiaceae	尼泊尔水东哥	da bu qiu	T	Wf	Fruit, eaten freshly	6–12	Leaves used as fodder; Stems used as fuelwood	46	0.36	48.3	DLZ0046,DXB0013
4	*Saurauia polyneura* C. F. Liang et Y. S. Wang	Actinidiaceae	多脉水东哥	da bu rong	T	Wf	Fruit, eaten freshly	9–11	Leaves used as fodder; Stems used as and fuelwood	16	0.13	14.7	DXB0012
5	*Chenopodium album* L.	Amaranthaceae	藜	si na	H	Wv	Tender stem and leaf, boiled or stir-fried	3–5		5	0.04	9.375	DXB0102
6	*Allium macranthum* Baker	Amaryllidaceae	大花韭	na ga su	H	Wv	Whole plant, made into soup	3–5	Used as ornamental plant	23	0.18	2.588	DLZ0021
7	*Allium hookeri* Thwaites	Amaryllidaceae	宽叶韭	su ceng	H	Wv	Whole plant, made into soup	3–5		30	0.24	1.688	DXB0120
8	*Allium wallichii* Kunth	Amaryllidaceae	多星韭	ge zi	H	Wv	Whole plant, made into soup	3–7		33	0.26	1.856	
9	*Toxicodendron vernicifluum* (Stokes) F.A. Barkley	Anacardiaceae	漆	de ki	T	Of, Wv	Seed, used as urushoil and making buttered tea; Tender stem and leaf, stir-fried	9–11	Stems used as fuelwood	9	0.07	60.75	DLZ0172,DXB0014
10	*Heracleum hemsleyanum* Diels	Apiaceae	独活	xi wa an	H	Wv	Tender stem and leaf, boiled or stir-fried	3–5	Root used as medicine, anti - inflammation and pain	43	0.34	604.7	DLZ0020
11	*Oenanthe javanica* (Blume) DC.	Apiaceae	水芹	——	H	Wv	Aerial part, boiled or stir-fried	3–5		8	0.06	11.7	DLZ0062, DLZ0063
12	*Eryngium foetidum* L.	Apiaceae	刺芹	——	H	Sp	Aerial part, used as spice	4–12		1	0.01	0.39	DXB0154
13	*Angelica dahurica* (Hoffm.) Benth. & Hook.f. ex Franch. & Sav.	Apiaceae	白芷	ben de wang	H	Wv	Tender stem and leaf, boiled or stir-fried	3–6	Whole plants used as fodder	7	0.06	11.48	DLZ0041
14	*Colocasia esculenta* (L.) Schott	Araceae	芋	gui	H	Wv, Fs	Leaf stalk and flower used as wild vegetable (stir-fried); Tuber used as food substitute	2–11	Whole plants used as fodder	45	0.35	1191	DLZ0135
15	*Aralia elata* (Miq.) Seem.	Araliaceae	楤木	bang a	S	Wv	Tender stem and leaf, boiled or stir-fried	3–6	Leaves used as fodder	73	0.57	273.8	DLZ0166
16	*Macropanax undulatus*(Wall.)Seem.	Araliaceae	波缘大参	de ge lang	T	Wv	Leaf, boiled	3–7		3	0.02	0.585	DLZ0087
17	*Panax japonicus* (T. Nees) C. A. Meyer	Araliaceae	竹节参	——	H	Wv	Rhizome, stewed with pork or chicken	1–12	Rhizome used as medicine	2	0.02	0.281	
18	*Panax japonicus* var. *bipinnatifidus* (Seem.) C.Y.Wu & Feng	Araliaceae	疙瘩七	——	H	Wv	Rhizome, stewed with pork or chicken	1–12	Rhizome used as medicine	2	0.02	0.281	
19	*Panax japonicus* var. *major* (Burkill) C.Y.Wu & Feng	Araliaceae	珠子参	——	H	Wv	Rhizome, stewed with pork or chicken	1–12	Rhizome used as medicine	2	0.02	0.281	
20	*Calamus acanthospathus* Griffith	Arecaceae	云南省藤	——	L	Wf	Friut, eaten freshly	12–2	Stems used in manufacturing handicrafts	17	0.13	0.128	
21	*Caryota obtusa* Griff.	Arecaceae	董棕	a lei	T	Wv, Fs	Stem used as food substitute (processed into flour); Tender stem and leaf used as wild vegetable (stir-fried)	1–12	Stems and leaves used as building materials	61	0.48	1962	DLZ0005
22	*Maianthemum atropurpureum* (Franch.) LaFrankie	Asparagaceae	高大鹿药	dong qi	H	Wv	Aerial part, boiled or stir-fried	3–5		89	0.7	4088	DXB0090
23	*Maianthemum fuscum* (Wall.) LaFrankie	Asparagaceae	西南鹿药	dong	H	Wv	Aerial part, boiled or stir-fried	3–5		13	0.1	24.38	DXB0089
24	*Maianthemum henryi* (Baker) LaFrankie	Asparagaceae	管花鹿药	dong	H	Wv	Aerial part, boiled or stir-fried	3–5		6	0.05	11.25	
25	*Maianthemum oleraceum* (Baker) LaFrankie	Asparagaceae	长柱鹿药	dong	H	Wv	Aerial part, boiled or stir-fried	3–5		4	0.03	7.5	
26	*Maianthemum purpureum* (Wall.) LaFrankie	Asparagaceae	紫花鹿药	dong ka	H	Wv	Aerial part, boiled or stir-fried	3–5		54	0.43	1266	
27	*Maianthemum tatsienense* (Franch.) LaFrankie	Asparagaceae	窄瓣鹿药	dong	H	Wv	Aerial part, boiled or stir-fried	3–5		4	0.03	7.5	
28	*Polygonatum cirrhifolium* (Wall.) Royle	Asparagaceae	卷叶黄精	me ru xia	H	Wv	Rhizome, boiled or stir-fried	1–12	Rhizome used as medicine for coughing	5	0.04	2.813	DXB0101
29	*Begonia acetosella* Craib	Begoniaceae	无翅秋海棠	ba sa	H	Sp	Tender stem and leaf, used as spice	3–11		5	0.04	11.25	DLZ0084
30	*Corylus ferox* Wall.	Betulaceae	刺榛	ri long	T	Nu	Seed, roasted	7–9		3	0.02	0.585	DLZ0033, DXB0044
31	*Cardamine tangutorum* O.E.Schulz	Brassicaceae	紫花碎米荠	a ga	H	Wv	Tender stem and leaf, made into soup	3–9		65	0.51	73.13	DXB0118
32	*Capsella bursa-pastoris* (L.) Medik.	Brassicaceae	荠	——	H	Wv	Aerial part, boiled or stir-fried	3–4		1	0.01	1.688	DXB0080
33	*Codonopsis spp*	Campanulaceae	党参属	dang shen	H	Wv	Rhizome, stewed with pork or chicken	1–12	Rhizome used as medicine	4	0.03	0.75	DXB0157
34	*Stellaria aquatica* (L.) Scop.	Caryophyllaceae	鹅肠菜	——	H	Wv	Tender stem and leaf, boiled or stir-fried	3–5	Whole plants used as fodder	5	0.04	3.516	DXB0084
35	*Garcinia esculenta* Y.H.Li	Clusiaceae	山木瓜	me ren	T	Wf	Fruit, eaten freshly	6–8		12	0.09	0.45	DXB0158
36	*Garcinia nujiangensis* C.Y.Wu & Y.H.Li	Clusiaceae	怒江藤黄	xie di	T	Wf	Fruit, eaten freshly	8–9		12	0.09	0.45	
37	*Bidens pilosa* L.	Compositae	鬼针草	——	H	Wv	Tender stem and leaf, boiled or stir-fried	1–12		2	0.02	2.438	DXB0123

capitata is distributed only in Dizhengdang and Longyuan Village, upstream of the Dulongjiang region, while, *Saurauia napaulensis*, also called "鼻涕果" (Bi-ti-guo), is distributed throughout the township (Fig. 5c). People in Bapo and Maku Village also eat another "鼻涕果" with leaves like brown hairs (*Saurauia griffithii*).

Due to the unique landscape and climate, there are many special wild fruit species (in genera such as *Rubus*,

Table 3 (continued)

38	*Cirsium interpositum* Petrak	Compositae	披裂蓟	——	H	Wv	Rhizome, boiled or stir-fried	1–12		4	0.03	1.463	DLZ0061
39	*Crassocephalum crepidioides* (Benth.) S.Moore	Compositae	野茼蒿	ga la xing	H	Wv	Tender stem and leaf, boiled or stir-fried	3–7		5	0.04	6.094	
40	*Pseudognaphalium affine* (D.Don) Anderb.	Compositae	拟鼠麴草	wen	H	Wv	Tender stem and leaf, boiled or stir-fried	1–4	Whole plants used as fodder	6	0.05	8.438	DLZ0085
41	*Taraxacum mongolicum* Hand.-Mazz.	Compositae	蒲公英	ba ko er jia	H	Wv	Aerial part, boiled or stir-fried	2–4		3	0.02	2.925	DLZ0016
42	*Galinsoga parviflora* Cav.	Compositae	牛膝菊	——	H	Wv	Tender stem and leaf, boiled or stir-fried	3–7		3	0.02	2.438	DLZ0109
43	*Cornus capitata* Wallich	Cornaceae	头状四照花	de ji er	T	Wf	Fruit, eaten freshly	9–10		57	0.45	16.03	DXB0155
44	*Davidia involucrata* var. *vilmoriniana* (Dode) Wanger	Cornaceae	光叶珙桐	ru ra	T	Wf	Friut, eaten freshly	10	Used as ornamental plant	1	0.01	0.075	DLZ0003
45	*Gynostemma pentaphyllum* (Thunb.) Makino	Cucurbitaceae	绞股蓝	kang reng	H	Ts	Tender stem and leaf, use for making tea	3–11	Whole plants used as fodder	5	0.04	1.625	
46	*Hodgsonia macrocarpa* var. *capniocarpa* (Blume) Cogn.	Cucurbitaceae	油渣果	——	L	Wv	Fruit, eaten freshly	6–10		1	0.01	0.028	DXB0095
47	*Momordica cochinchinensis* (Lour.) Spreng.	Cucurbitaceae	木鳖子	deng gu le leng	L	Wv	Fruit, stir-fried	8–10		3	0.02	0.253	DXB0159
48	*Momordica subangulata* Blume	Cucurbitaceae	凹萼木鳖	cang ren	L	Wv	Fruit, stir-fried	8–11		3	0.02	0.253	DLZ0045
49	*Dioscorea alata* L.	Dioscoreaceae	参薯	reng dong	L	Fs	Rhizome and bulbel, boiled or roasted	10–11		12	0.09	108	DXB0082
50	*Dioscorea bulbifera* L.	Dioscoreaceae	黄独	ki	L	Fs	Rhizome and bulbel, boiled or roasted	10–11	Whole plants used as fodder	22	0.17	173.3	DXB0114
51	*Dioscorea polystachya* Turcz.	Dioscoreaceae	薯蓣	na ba	L	Fs	Rhizome and bulbel, boiled or roasted	10–11	Used for dyeing cloth	77	0.61	606.4	DLZ0169
52	*Dioscorea pentaphylla* L.	Dioscoreaceae	五叶薯蓣	e jing	L	Fs	Rhizome and bulbel, boiled or roasted	10–11		16	0.13	126	DXB0105
53	*Dioscorea velutipes* Prain & Burkill	Dioscoreaceae	粘毛薯蓣	ying	L	Fs	Rhizome and bulbel, boiled or roasted	10–11		38	0.3	399	DLZ0007
54	*Hippophae rhamnoides* subsp. yunnanensis Rousi	Elaeagnaceae	云南沙棘	me long	S	Wf	Fruit, eaten freshly	9–10		1	0.01	0.024	DXB0153
55	*Elaeagnus umbellata* Thunb.	Elaeagnaceae	牛奶子	——	S	Wf	Fruit, eaten freshly	7–8		1	0.01	0.056	
56	*Elaeocarpus lacunosus* Wall. ex Kurz	Elaeocarpaceae	多沟杜英	me li	T	Wf	Fruit, eaten freshly	8–11		17	0.13	0.414	DXB0160
57	*Gaultheria fragrantissima* Wall.	Ericaceae	芳香白珠	qia k dou xi	S	Wf	Fruit, eaten freshly	8–11	Used as ornamental plant	13	0.1	2.925	DLZ0151, DXB0023
58	*Gaultheria leucocarpa* var. *erenulata* Sleumer	Ericaceae	滇白珠	——	S	Wf	Fruit, eaten freshly	10–11	Used as ornamental plant	1	0.01	0.113	DLZ0018
59	*Gaultheria griffithiana* Wight	Ericaceae	尾叶白珠	qia k dou xi	S	Wf	Fruit, eaten freshly	8–10	Used as ornamental plant	16	0.13	3.6	DXB0161
60	*Vaccinium dunalianum* Wight	Ericaceae	樟叶越橘	qiang ma	S	Wf	Fruit, eaten freshly	9–12	Used as ornamental plant	9	0.07	1.755	DXB0113
61	*Vaccinium dunalianum* var. *urophyllum* Rehder & E.H. Wilson	Ericaceae	尾叶越橘	qiang ma	S	Wf	Fruit, eaten freshly	9–12	Used as ornamental plant	9	0.07	1.755	
62	*Vaccinium gaultheriifolium* (Griff.) Hook. f. ex C.B. Clarke	Ericaceae	软骨边越橘	k rei	S	Cc	Fruit and leaf, use for making tofu	9–12	Used as ornamental plant and fodder	16	0.13	10.8	DXB0112
63	*Ribes glaciale* Wall.	Grossulariaceae	冰川茶藨子	——	S	Wf	Fruit, eaten freshly	7–9		1	0.01	0.049	DLZ0002
64	*Ribes alpestre* Wall. ex Decne.	Grossulariaceae	长刺茶藨子	——	S	Wf	Fruit, eaten freshly	6–9		1	0.01	0.049	
65	*Ribes longiracemosum* Franch.	Grossulariaceae	长序茶藨子	——	S	Wf	Fruit, eaten freshly	7–8		1	0.01	0.049	
66	*Ribes tenue* Jancz.	Grossulariaceae	西藏茶藨子	——	S	Wf	Fruit, eaten freshly	8–9		1	0.01	0.049	DXB0162
67	*Molineria capitulata* (Lour.) Herbaceous.	Hypoxidaceae	大叶仙茅	xie wo	H	Wv	Tender stem and leaf, made into soup	5–9	Whole plants used as fodder. Rhizome used as medicinal, anti-inflammatory and analgesic effects	3	0.02	0.731	
68	*Juglans sigillata* Dode	Juglandaceae	泡核桃	me li bu	T	Nu, Of	Seed used as nuts or making buttered tea	9–10	Stems used as fuelwood and building material	9	0.07	7.594	DXB122
69	*Juglans regia* L.	Juglandaceae	胡桃	bu	T	Nu, Of	Seed used as nuts or making buttered tea	9–10	Stems used as fuelwood and building material	9	0.07	12.15	
70	*Elsholtzia ciliata* (Thunb.) Hyl.	Lamiaceae	香薷	beng ji go	H	Sp	Tender stem and leaf, used as spice	3–7	Used as nectariferous plant	4	0.03	1.95	DLZ0160, DXB0055
71	*Mentha canadensis* L.	Lamiaceae	薄荷	——	H	Sp	Tender stem and leaf, used as spice	3–9	Used as nectariferous plant	3	0.02	1.463	DXB0081
72	*Perilla frutescens* (L.) Britton	Lamiaceae	紫苏	si leng	H	Ts	Leaf, use for making tea	3–9		2	0.02	0.9	DXB0180
73	*Leucosceptrum canum* Sm.	Lamiaceae	米团花	xing dong	S	Wv	Flower, boiled	11–3	Used as nectariferous plant and fodder	6	0.05	1.17	DLZ0171
74	*Decaisnea insignis* (Griff.) Hook.f. & Thomson	Lardizabalaceae	猫儿屎	ri lei	T	Wf	Fruit, eaten freshly	7–8	Fruits used to glue birds	12	0.09	0.585	DXB0150
75	*Holboellia angustifolia* Wall.	Lardizabalaceae	五月瓜藤	go leng	L	Wf	Fruit, eaten freshly	8–10		16	0.13	3.6	DXB0116
76	*Litsea cubeba* (Lour.) Pers.	Lauraceae	山鸡椒	chun	S	Sp	Seed, used as spice	7–8		1	0.01	0.26	DLZ0037
77	*Litsea pungens* Hemsl.	Lauraceae	木姜子	neng bing	S	Sp	Seed, used as spice	7–9		3	0.02	0.9	DLZ0042
78	*Pueraria peduncularis* (Benth.) Benth.	Leguminosae	苦葛	b ri	L	Fs, Lb	Tuber, food substitute, liquor brewing	10–3		57	0.45	638.4	DLZ0006
79	*Pueraria montana* var. *thomsonii* (Benth.) Wiersema ex D.B. Ward	Leguminosae	粉葛	meng	L	Fs, Lb	Tuber, food substitute, liquor brewing	10–3	Whole plants used as fodder	56	0.44	823.2	DXB0104

Gaultheria, *Ribes*, and *Ficus*) in the Dulongjiang region. These species can be used as new genetic resources for the breeding various fruits, such as *Actinidia pilosula*, *Syzygium gongshanense, and Hovenia acerba* var. *kiukiangensis*, *Elaeocarpus lacunosus*, *Garcinia esculenta*, and *Garcinia nujiangensis* (Fig. 5).

Table 3 (continued)

80	*Cardiocrinum giganteum* (Wall.) Makino	Liliaceae	大百合	a bo	H	Fs, Lb	Bulb, food substitut (processed into flour), liquor brewing	9–12	Used as ornamental plant	81	0.64	1837	DLZ0029
81	*Lilium davidii* Duch. ex Elwes	Liliaceae	川百合	ge luo	H	Fs	Bulb, processed into flour	9–12	Flower used as medicine, have the effect of calming god	1	0.01	0.27	
82	*Sarcopyramis napalensis* Wall.	Melastomataceae	楮头红	nang ke reng	H	Wv	Flower, eaten freshly	8–10		7	0.06	0.683	DXB0108
83	*Toona sinensis* (Juss.) M.Roem.	Meliaceae	香椿	zong	T	Wv	Tender stem and leaf, boiled or stir-fried	3–5	Stems used as fuelwood and building material	42	0.33	78.75	DXB0043
84	*Ficus auriculata* Lour.	Moraceae	大果榕	——	T	Wf	Friut, eaten freshly	5–8		2	0.02	0.338	
85	*Ficus oligodon* Lour.	Moraceae	苹果榕	——	T	Wf	Friut, eaten freshly	5–8		3	0.02	0.146	
86	*Ficus semicordata* Buch.-Ham. ex Sm.	Moraceae	鸡嗉子榕	——	T	Wf	Friut, eaten freshly	5–8		4	0.03	0.563	DXB0182
87	*Morus mongolica* (Bureau) C.K. Schneid.	Moraceae	蒙桑	——	T	Wf	Friut, eaten freshly	4–5	Stems used as crossbow	3	0.02	0.338	DLZ0152
88	*Morus macroura* Miq.	Moraceae	奶桑	——	T	Wf	Friut, eaten freshly	4–5		3	0.02	0.338	
89	*Musa rubra* Wall. ex Kurz	Musaceae	阿希蕉	ke long	H	Wf, Wv	Friut, eaten freshly; Flower and stem, used as wild vegetable (Boiled)	7–9	Used as ornamental plant. Pith part used as fodder	6	0.05	3.038	DXB0096
90	*Ensete wilsonii* (Tutcher) Cheesman	Musaceae	象头蕉	——	H	Wf, Wv	Friut, eaten freshly; Flower and stem, used as wild vegetable (Boiled)	7–10	Used as ornamental plant. Pith part used as fodder	4	0.03	2.025	DLZ0145
91	*Syzygium gonshanense* P.Y.Bai	Myrtaceae	贡山蒲桃	pu tao	T	Wf	Friut, eaten freshly	8–9		5	0.04	0.188	
92	*Bletilla striata* (Thunb.) Rchb.f.	Orchidaceae	白及	bai ji	H	Wv	Bulb, stewed with pork or chicken	1–12	Bulbs used as medicine	12	0.09	4.05	DLZ0104
93	*Plantago asiatica* L.	Plantaginaceae	车前	——	H	Wv	Aerial part, boiled	3–8	Whole plant used as medicine, have the effect of removing phlegm and clearing heat, bright eyes	2	0.02	0.78	DLZ0130
94	*Plantago major* L.	Plantaginaceae	大车前	wa gui	H	Wv	Aerial part, boiled	3–8	Whole plant used as medicine, have the effect of removing phlegm and clearing heat, bright eyes	3	0.02	14.04	DLZ0001
95	*Chimonobambusa armata* (Gamble) Hsueh & T.P.Yi	Poaceae	缅甸方竹	gu er	B	Wv	Tender stem, boiled or stir-fried	7–8	Stems used in manufacturing fence	23	0.18	17.25	DLZ0032, DXB0063
96	*Dendrocalamus fugongensis* Hsueh & D.Z.Li	Poaceae	福贡龙竹	de wa	B	Wv	Tender stem, boiled or stir-fried	5–6	Stems used in manufacturing handicrafts	51	0.4	178.5	DLZ0034, DXB0065
97	*Fargesia pleniculmis* (Hand.-Mazz.) T.P.Yi	Poaceae	皱壳箭竹	de ma	B	Wv	Tender stem, boiled or stir-fried	5–6	Stems used in hunting and weaving	3	0.02	7.875	DLZ0035, DXB0046
98	*Fargesia declivis* T.P.Yi	Poaceae	斜倚箭竹	ri leng	B	Wv	Tender stem, boiled or stir-fried	5–6	Stems used in hunting and weaving	12	0.09	4.5	
99	*Fargesia praecipua* T.P.Yi	Poaceae	鸄刀箭竹	si rang	B	Wv	Tender stem, boiled or stir-fried	5–6	Stems used in hunting	4	0.03	7.5	DXB0045
100	*Fargesia sagittatinea* T.P.Yi	Poaceae	佤箭竹	wa	B	Wv	Tender stem, boiled or stir-fried	5–6	Stems used in hunting	14	0.11	5.25	DXB0115
101	*Cephalostachyum mannii* (Gamble) Stapleton	Poaceae	独龙江玉山竹	si meng	B	Wv	Tender stem, boiled or stir-fried	5–6	Stems used in weaving	11	0.09	24.75	
102	*Phyllostachys sulphurea* (Carr.)A. et C.Riv	Poaceae	金竹	xin na gan	B	Wv	Tender stem, boiled or stir-fried	5–6	Stems used in manufacturing handicrafts	47	0.37	17.63	DLZ0043, DXB0042
103	*Coix lacryma-jobi* L.	Poaceae	薏苡	——	H	Fs	Seed, used as food substitute	6–12		1	0.01	0.113	
104	*Imperata cylindrica* (L.) Raeusch.	Poaceae	白茅	a ji	H	Wv	Root, eaten freshly	1–12	Plants used as building materials	2	0.02	0.9	DLZ0111, DXB0061
105	*Fagopyrum dibotrys* (D. Don) Hara	Polygonaceae	金荞麦	yang bu rai	H	Wv	Tender stem and leaf, boiled	3–6	Whole plants used as fodder	5	0.04	1.406	DLZ0089
106	*Fagopyrum esculentum* Moench	Polygonaceae	荞麦	b lei	H	Wv	Tender stem and leaf, boiled	3–11	Whole plants used as fodder	13	0.1	11.7	DLZ0014
107	*Rumex nepalensis* Spreng.	Polygonaceae	尼泊尔酸模	——	H	Wv	Tender stem and leaf, stir-fried	3–11	Whole plants used as fodder	5	0.04	6.75	DLZ0175
108	*Persicaria chinensis* (L.) H. Gross	Polygonaceae	火炭母	beng gen	H	Wv	Tender stem and leaf, boiled	3–9	Whole plants used as fodder	7	0.06	2.275	DLZ0073
109	*Hovenia acerba* var. *kiukiangensis* (Hu & W.C. Cheng) C.Y. Wu ex Y.L. Chen & P.K. Chou	Rhamnaceae	俅江枳椇	me qi	T	Wf	Friut, eaten freshly	9–10		1	0.01	0.024	DXB0100
110	*Prunus conradinae* Koehne	Rosaceae	华中樱桃	gen xing	T	Wf	Friut, eaten freshly	4–5		4	0.03	1.8	DXB0092
111	*Cerasus tomentosa* (Thunb.) Wall. ex T.T. Yu & C.L. Li	Rosaceae	毛樱桃	gen xing	T	Wf	Friut, eaten freshly	6–9		5	0.04	2.25	
112	*Pyrus pashia* Buch.-Ham. ex D.Don	Rosaceae	川梨	si li	T	Wf	Friut, eaten freshly	8–9		5	0.04	1.463	
113	*Chaenomeles speciosa* (Sweet) Nakai	Rosaceae	皱皮木瓜	——	T	Wf	Friut, eaten freshly	9–10		2	0.02	0.195	DLZ0124
114	*Rubus corchorifolius* L.f.	Rosaceae	山莓	qiong gei	H	Wf	Friut, eaten freshly	4–6		12	0.09	2.7	DLZ0022
115	*Rubus lineatus* Reinw. ex Blume	Rosaceae	绢毛悬钩子	na bong	L	Wf	Friut, eaten freshly	9–10	Whole plantsused as fodder	10	0.08	6.75	DLZ0024
116	*Rubus wallichianus* Wight & Arn.	Rosaceae	红毛悬钩子	——	L	Wf	Friut, eaten freshly	5–6		1	0.01	0.113	DXB0163
117	*Rubus ellipticus* Sm.	Rosaceae	椭圆悬钩子	xi bei qiong gei	L	Wf	Friut, eaten freshly	4–5	Whole plantsused as fodder	7	0.06	1.575	DXB0121
118	*Rubus hypopitys* Focke	Rosaceae	滇藏悬钩子	beng he bu leng	L	Wf	Friut, eaten freshly	6–7		6	0.05	1.35	

Food substitutes

Due to the topography and the rainy climate of the mountain valleys in the Dulongjiang region, it is not suitable for crop cultivation of crops [36]. In the past, the Dulong people relied on food substitutes to deal with food shortages. The Dulongjiang region is rich in plant species that can be used as food substitutes, and Dulong people have a unique mode of consumption of food

Table 3 (continued)

119	*Rubus niveus* Thunb.	Rosaceae	红泡刺藤	——	L	Wf	Friut, eaten freshly	7–9		9	0.07	2.025	
120	*Rubus subornatus* Focke	Rosaceae	美饰悬钩子	——	L	Wf	Friut, eaten freshly	8–9		9	0.07	2.025	
121	*Rubus parvifolius* L.	Rosaceae	茅莓	ya wen	L	Wf	Friut, eaten freshly	7–8		9	0.07	2.025	DXB0151
122	*Rubus sumatranus* Miq.	Rosaceae	红腺悬钩子	na ke rei pu sa	L	Wf	Friut, eaten freshly	7–8		8	0.06	5.4	DXB0107
123	*Fragaria vesca* L.	Rosaceae	野草莓	xia jiu	H	Wf	Friut, eaten freshly	6–9		27	0.21	8.1	DLZ0009
124	*Fragaria pentaphylla* Losinsk.	Rosaceae	五叶草莓	deng gang xia jiu	H	Wf	Friut, eaten freshly	5–6	Whole plantsused as fodder	20	0.16	4.5	DXB0087
125	*Fragaria nubicola* (Lindl. ex Hook.f.) Lacaita	Rosaceae	西藏草莓	xi bei xia jiu	H	Wf	Friut, eaten freshly	5–8	Whole plantsused as fodder	14	0.11	3.15	
126	*Zanthoxylum bungeanum* Maxim.	Rutaceae	花椒	ze bu	T	Sp	Seed, used as spice	8–10		5	0.04	0.469	DLZ0143
127	*Houttuynia cordata* Thunb.	Saururaceae	蕺菜	wu se b	H	Wv	Aerial part, made into soup	4–7		12	0.09	5.4	DLZ0023
128	*Schisandra spp*	Schisandraceae	五味子属	——	L	Wf	Friut, eaten freshly	7–10	Fruit used as medicine	6	0.05	1.688	DLZ0039
129	*Boehmeria penduliflora* Wedd. ex D.G.Long	Urticaceae	长叶苎麻	ya me song	S	Wv	Leaf, boiled	3–9	Whole plants used as fodder	4	0.03	1.365	DLZ0080
130	*Debregeasia longifolia* (Burm.f.) Wedd.	Urticaceae	长叶水麻	qia bu ren	S	Wf	Friut, eaten freshly	5–9	Whole plantsused as fodder	4	0.03	1.05	DXB110
131	*Debregeasia orientalis* C.J.Chen	Urticaceae	水麻	qia bu ren	S	Wf	Friut, eaten freshly	5–9	Whole plantsused as fodder	4	0.03	1.05	DXB111
132	*Elatostema lineolatum* Wight	Urticaceae	狭叶楼梯草	xie ri keng jiang	H	Wv	Tender stem and leaf, boiled	3–9	Whole plants used as fodder	3	0.02	1.706	DLZ0076
133	*Elatostema platyceras* W.T.Wang	Urticaceae	宽叶楼梯草	keng jiang	H	Wv	Tender stem and leaf, boiled	3–9	Whole plants used as fodder	3	0.02	1.706	DLZ0079
134	*Gonostegia hirta* (Blume ex Hassk.) Miq.	Urticaceae	糯米团	de gong	H	Wv	Tender stem and leaf, boiled	5–7	Whole plants used as fodder	3	0.02	1.706	DLZ0013
135	*Lecanthus peduncularis* (Wall. ex Royle) Wedd.	Urticaceae	假楼梯草	wan duo ke xing	H	Wv	Tender stem and leaf, boiled	3–9	Whole plants used as fodder	2	0.02	1.138	DLZ0077
136	*Viola sumatrana* Miq.	Violaceae	光叶堇菜	——	H	Wv	Aerial part, boiled or stir-fried	3–5		1	0.01	0.975	DXB0184
137	*Vitis flexuosa* Thunb.	Vitaceae	葛藟葡萄	bu reng	L	Wf	Friut, eaten freshly	7–11		14	0.11	2.363	
138	*Vitis bellula* (Rehder) W.T. Wang	Vitaceae	美丽葡萄	ben me	L	Wf	Friut, eaten freshly	7–8		13	0.1	2.194	DXB0190
Gymnospermae													
139	*Gnetum montanum* Markgr.	Gnetaceae	买麻藤	ku sa	L	Nu	Seed, roasted	8–9		4	0.03	2	DXB0098
Fern													
140	*Diplazium dilatatum* Blume	Athyriaceae	毛柄双盖蕨	lian bian	H	Wv	Aerial part, boiled or stir-fried	5–8		5	0.03	1.875	DXB0099
141	*Athyrium sinense* Rupr.	Dennstaedtiaceae	中华蹄盖蕨	dao	H	Wv	Aerial part, boiled or stir-fried	3–5		70	0.55	262.5	DLZ0027
142	*Cibotium barometz* (L.) J.Sm.	Cibotiaceae	金毛狗	de bu	H	Fs	Rhizome, processed into flour	1–10	Rhizome used as medicine to stop bleeding	10	0.08	7.313	
143	*Cyathea spinulosa* Wall. ex Hook.	Cyatheaceae	桫椤	se eng	H	Fs	Stem, processed into flour	1–12		26	0.2	7.605	
144	*Pteridium revolutum* (Blume) Nakai	Dennstaedtiaceae	毛轴蕨	de leng	H	Wv	Aerial part, boiled or stir-fried	3–6		24	0.19	29.25	DXB0086
145	*Angiopteris esculenta* Ching	Marattiaceae	食用观音座莲	mei leng	H	Fs	Rhizome, processed into flour	3–11		99	0.78	579.2	DXB0103
146	*Matteuccia struthiopteris* (L.) Tod.	Onocleaceae	荚果蕨	ceng	H	Wv	Aerial part, boiled or stir-fried	3–5		13	0.1	48.75	DXB0083
147	*Osmunda japonica* Thunb.	Osmundaceae	紫萁	na bu gan	H	Wv	Aerial part, stir-fried	5–7		50	0.39	87.75	DXB0106
148	*Ramalina fastigiata* (Pers.) Ach.	Ramalinaceae	丛生树花	——	H	Wv	Aerial part, stir-fried	7–9		2	0.02	0.293	

substitutes. Most are processed to starch from tubers, rhizomes, or bulbs and then eaten as Baba (local cake). There are also processed pulp parts, such as *Caryota obtusa* (Fig. 6g, h, i). The most frequently reported species were *Angiopteris esculenta*, *Cardiocrinum giganteum*, *Dioscorea polystachya*, and *Caryota obtusa* (Fig. 6). *Angiopteris esculenta*, an endemic species in NW Yunnan, bears the rhizomes weigh more than 20 kg and the diameter can reach 30–40 cm. In the old days, Dulong people extracted starch from its rhizomes as food [60]. Five *Dioscorea* species were cultivated in home gardens by Dulong people (*Dioscorea alata*, *Dioscorea bulbifera*, *Dioscorea polystachya*, *Dioscorea pentaphylla*, and *Dioscorea velutipes*). The cultivation and management of food substitute plants (such as *Caryota obtusa* and *Cardiocrinum giganteum*) helps Dulong people in surviving the food shortage period.

Other categories (spices, beverages, liquor brewing, fats and oils, nuts and culinary coagulant)

In total, 18 WEPs from other food categories, including spices, beverages, liquor making, oils and fats, nuts, and culinary coagulants, were present. A total of seven edibles were used as spices, and the most frequently reported species were *Begonia acetosella* (Fig. 7a), which is a sour seasoning commonly used by Dulong people and is distributed on the roadsides of both Bapo and Maku villages. Two species (*Gynostemma pentaphyllum* and *Perilla frutescens*) were used as a source of beverages.

The seeds of *Toxicodendron vernicifluum* are used to make oils and fats, which are often used as an excellent tonic during the confinement of pregnant women in Nujiang Prefecture, and comprise approximately 60% unsaturated fatty acids [61]. Locals also pour the melted wax of seed into heated liquor to make wine or tea, which

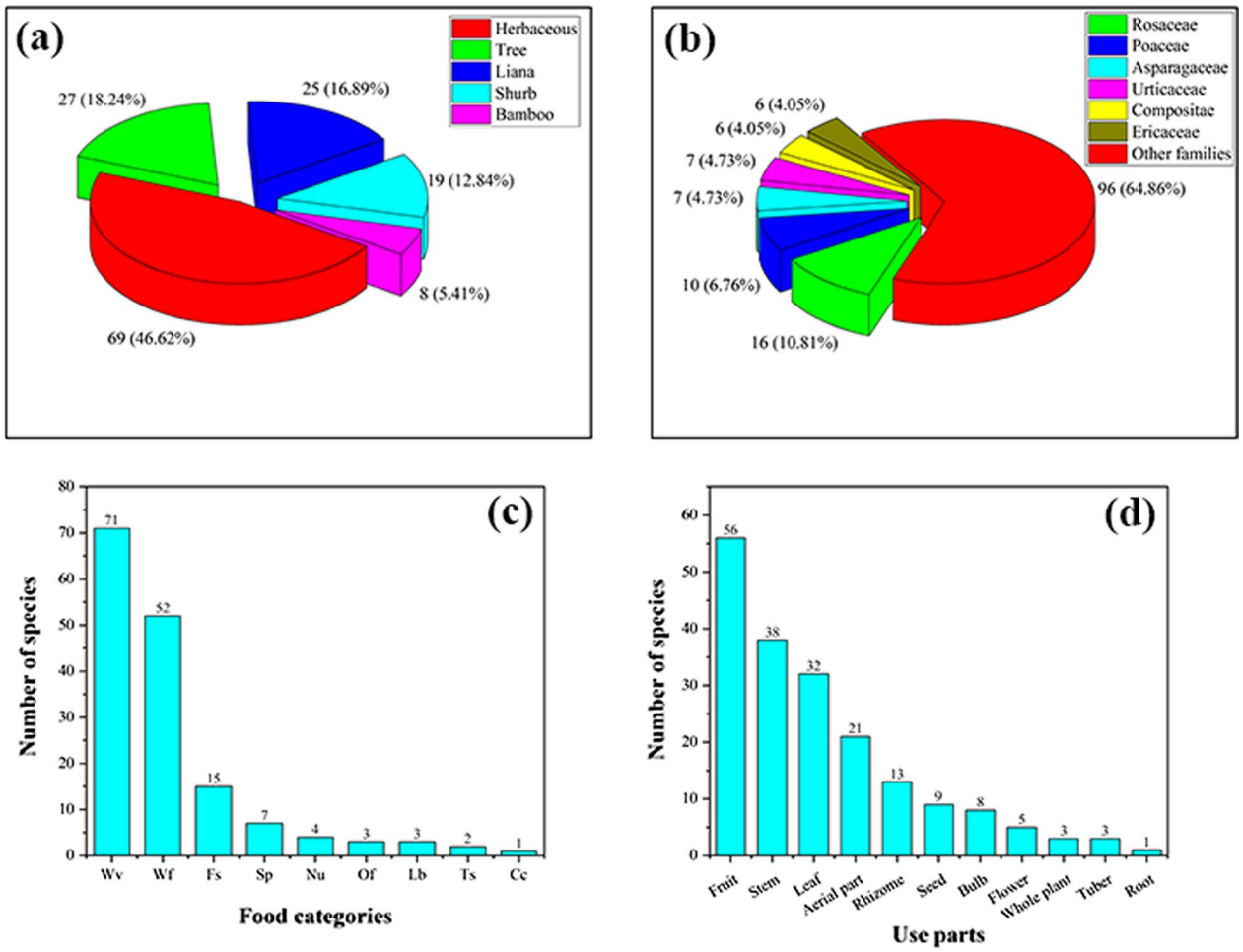

Fig. 2 **a** Life forms of WEPs used by Dulong people; **b** Family distribution of WEPs species of angiosperm category; **c** Food categories of WEPs species; **d** Edible parts

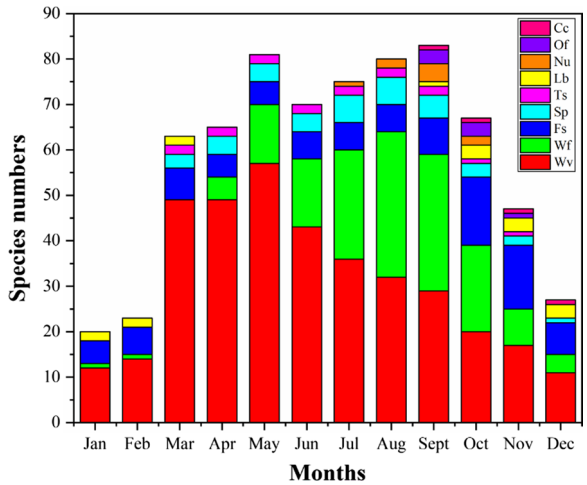

Fig. 3 Months of collection for WEPs

can treat stomach problems [62]. Many people are afraid of lacquer tree, because it contains urushiol, which can easily cause allergies. But few people in the Nujiang area are allergic to lacquer trees or lacquer oil. They even like the lacquer tree very much and have accumulated a lot of traditional knowledge. For example, young leaves of the lacquer tree are used as vegetables, and the trunk of the lacquer tree can be used to make bee barrels and musical instruments, and the management of the lacquer tree based on agroforestry system, etc. [34, 63, 64].

A total of four edibles were used as nuts and the most frequently reported species is *Gnetum montanum* (Fig. 7d). Furthermore, *Vaccinium gaultheriifolium* is a type of culinary coagulant used by the Dulong people to make tofu (Fig. 7e).

A total of three species were used to make wine by Dulong people, including *Pueraria peduncularis*, *Pueraria montana* var. *thomsonii* and *Cardiocrinum*

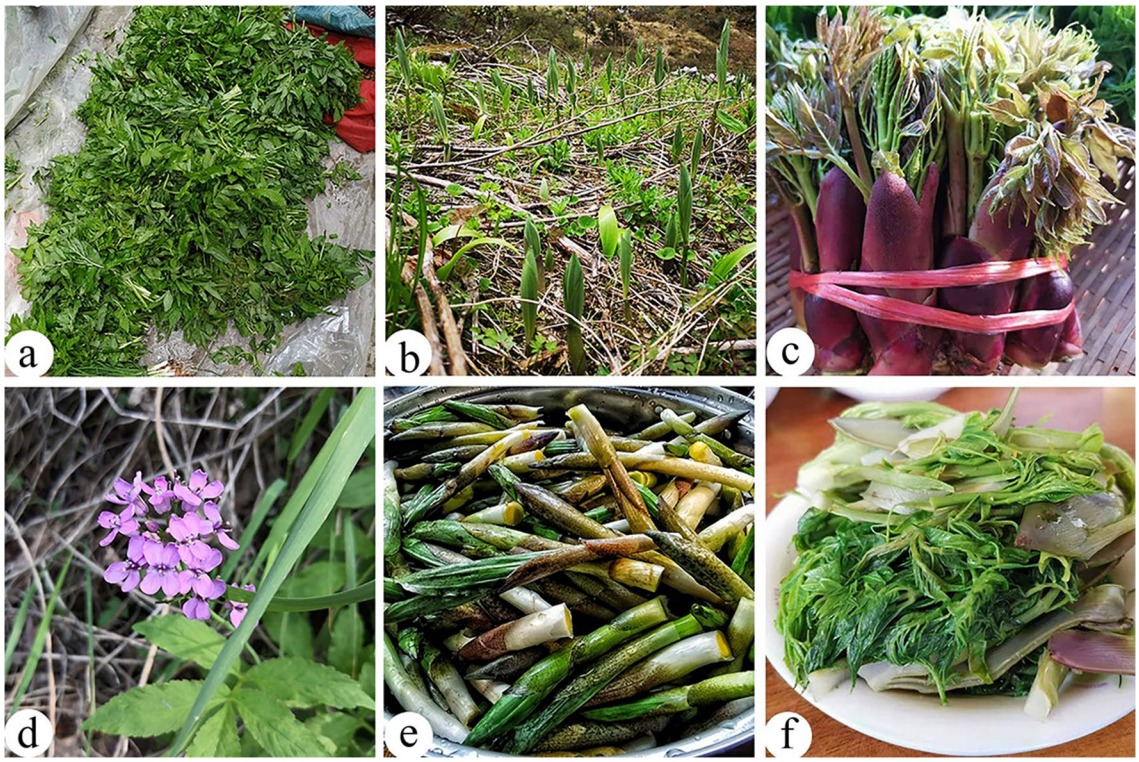

Fig. 4 Some wild vegetables in the study area. **a**, **d** *Cardamine tangutorum*; **b**, **e** *Maianthemum atropurpureum*; **c**, **f** *Aralia elata*

giganteum. *Cardiocrinum giganteum*, also called "大百合" (Da-bai-he), is a plant that grows in higher altitudes and barren regions, but is also cultivated by some people (Fig. 6d, e, f). Many excellent agricultural genetic resources are very suitable for cultivation at higher altitudes and barren areas. These high-quality agricultural genetic resources must be protected from extinction.

Multiple uses of WEPs

In addition to edible purposes, Dulong people also used 69 plants for other multiple uses (Fig. 8a). Multipurpose uses indicate the importance of wild plant resources to the livelihood and culture of residents [65].

A total of 12 species were found to have medicinal value and are used to treat inflammation, analgesia, hemostasis, cough, and snake bites. These medicinal dietary plants are important for residents to improve health and prevent diseases and can provide raw materials for the development of healthy food [29]. Among medicinal dietary plants, the parts used parts of nine species were underground parts (roots, rhizomes, and bulbs). This pattern of utilization, coupled with overharvesting by local people, has resulted in a massive reduction in plant resources. Therefore, the protection and sustainable use of these medicinal plants should be considered and valued.

Thirty species were used as fodder, of which *Saurauia polyneura*, *Debregeasia orientalis*, and *Rubus lineatus* are excellent fodder for *Bos frontalis* (Gayal) [42]. Dulong women think that *Fagopyrum dibotrys* is good feed for livestock, and they often collect forage plants on the roadside. *Fagopyrum dibotrys* was proven to have a higher protein content than other wild fodders [66]. Eleven species are ornamental plants, most of which belong to Ericaceae (Fig. 6f).

There were twelve plants used to manufacture the tool. The Dulongjiang region is rich in wildlife, and the Dulong people used to survive hunting in the old days. The fruit of *Decaisnea insignis* can be used to stick birds, and *Morus mongolica* was used to make bows, while the stems of four bamboo species were used to make arrows (*Fargesia pleniculmis*, *F. declivis*, *F. praecipua*, and *F. sagittatinea*).

Evaluation and selection of wild edibles based on RFC and CFSI values

The values of the cultural food significance index (CFSI) varied considerably from one species to another, with a minimum of 0.01 and a maximum of 4088.44 (Additional file 1, Appendix A). When considering the values of this index, according to Pieroni [24], it was possible

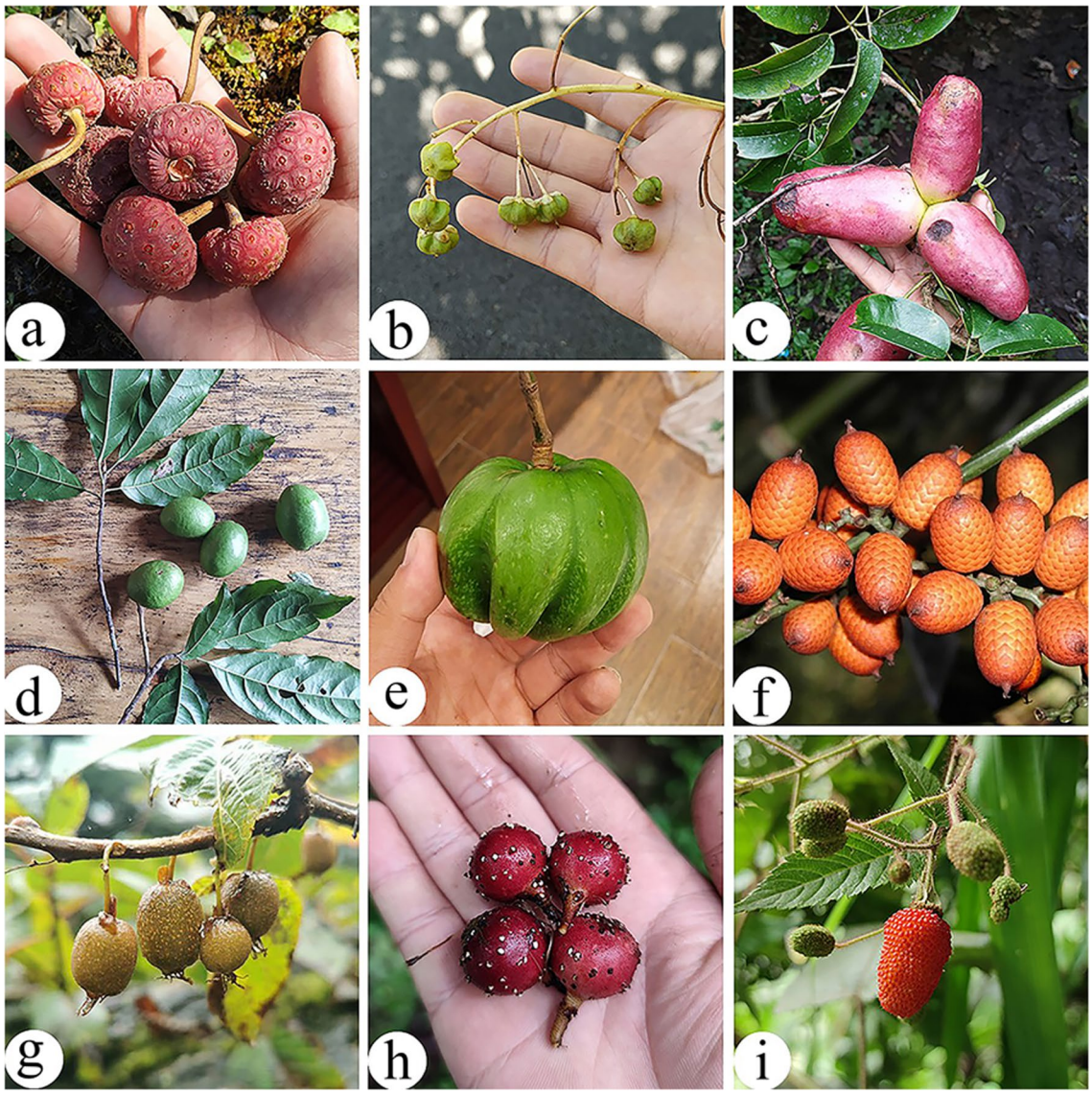

Fig. 5 Some wild fruits in the study area. **a** *Cornus capitata*; **b** *Saurauia napaulensis*; **c** *Holboellia angustifolia*; **d** *Elaeocarpus lacunosus*; **e** *Garcinia esculenta*; **f** *Calamus acanthospathus*; **g** *Actinidia pilosula*; **h** *Ficus semicordata*; **I** *Rubus sumatranus*

to classify the plants cited plants into six groups: species with very high significance (CFSI = 300 and above), high significance (CFSI = 100–299), moderate significance (CFSI = 20–99), low significance (CFSI = 5–19), very low significance (CFSI = 1–4) and negligible significance (CFSI < 1). These groups vary in size, with most of them belonging to the very low significance group (48) and negligible group (45) (Fig. 8b).

Twenty-five species of wild edibles [very high group (11), high group (7), and moderate group (9)] were selected using quantitative indices (CFSI). The higher the CFSI value, the more important the role this plant plays in the diet [6]. The corresponding RFC value and ranking of each plant are also listed in Table 4. Furthermore, 20 of 27 wild food plants screened by the two indexes are the same, indicating that the plants screened by the two indexes are very consistent. The ranks of some species based on different indices were different, indicating that different indices assigned diverse importance to various attributes, such as medicinal use and taste appreciation.

Eleven food substitute species were evaluated and selected based on FC and CFSI. In the past, the Dulong people had poor living conditions and often faced a lack of clothing and food, so many plants were used as

Fig. 6 Some staple food substitutes in the study area. **a–c** *Angiopteris esculenta*; **d–f** *Cardiocrinum giganteum*; **g–i** *Caryota obtusa*

a substitute for food. These grain substitute plants have been gradually introduced into their home gardens for cultivation in the previous wild state.

Caryota obtusa is a secondary protected plant species distributed mainly distributed in its Maku village, and the cultivation and management of it have a stronger position in the development history of the Dulong people. After processing one mature tree, about 100–300 kg of sago starch can be obtained. Therefore, as an important food substitute plant, it helped Dulong people manage the resource shortage food gap during the period of resource shortages and played an important role in maintaining the livelihood security of the Drung and the nutritional value of a balanced diet. During their farm work, Dulong people will remove weeds for *C. obtusa* or cultivate some seedlings near their houses from the mountains. Generally, when there are major events, such as building a house or celebrating a marriage, *C. obtusa* will be planted in the home gardens in case of unexpected needs. To adapt to the harsh environment, a special cultivation and management mode for *C. obtusa* was generated by Dulong people. This traditional knowledge is related not only to the local biophysical environment but also to the traditional culture, which helped to maintain the population of *C. obtusa* and guaranteed regional food security. There are several ecological concepts in

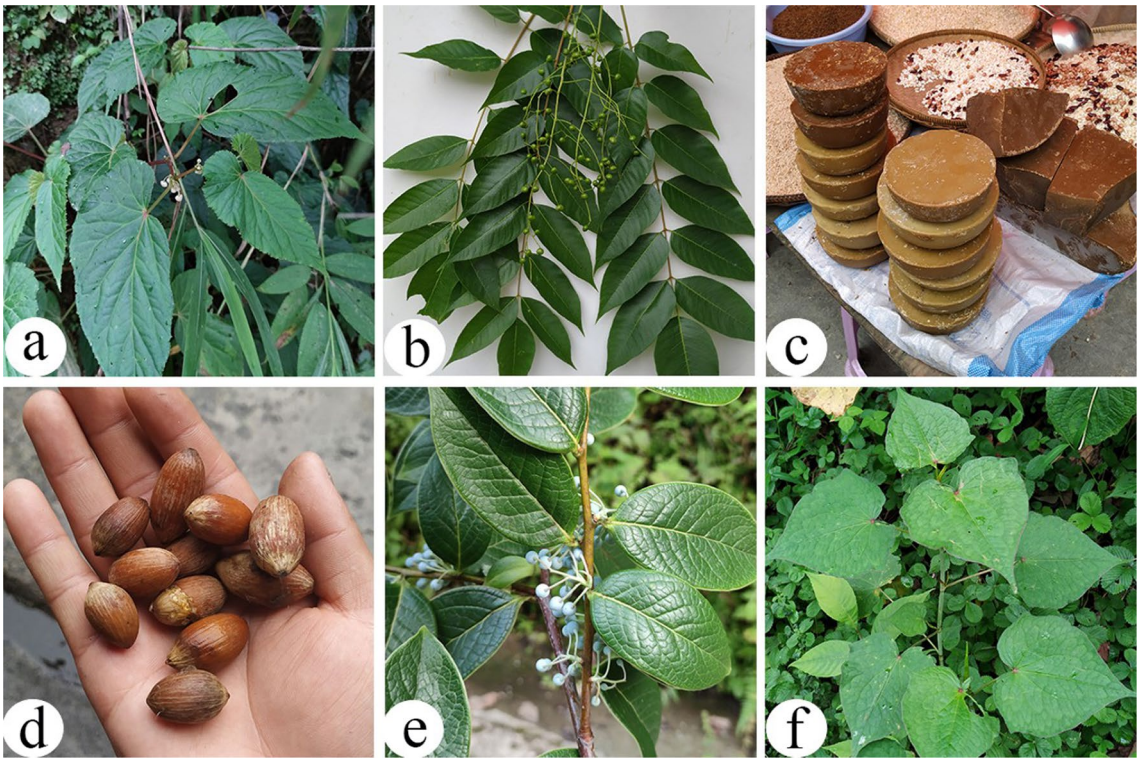

Fig. 7 Miscellaneous WEPs in the study area. **a** *Begonia acetosella*; **b**, **c** *Toxicodendron vernicifluum*; **d** *Gnetum montanum*; **e** *Vaccinium gaultheriifolium*; **f** *Fagopyrum dibotrys*

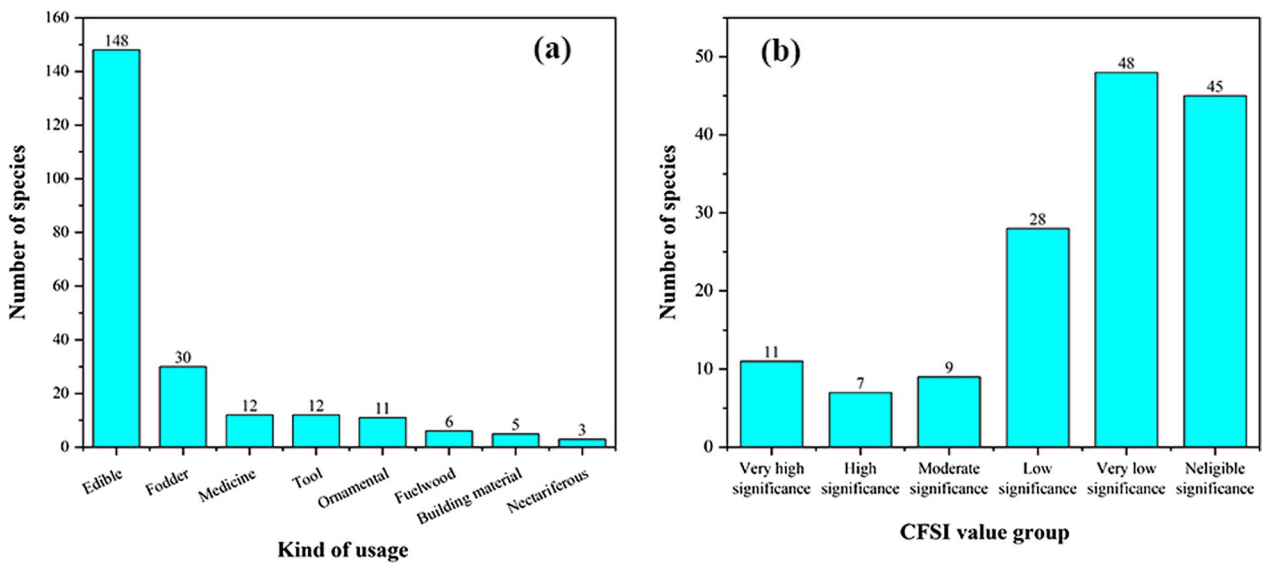

Fig. 8 **a** Multiple uses of WEPs; **b** Number of plant species for each CFSI groups

the mode of managing and utilizing *C. obtusa* by Dulong people, which provides a reference method for the cultivation and protection of *C. obtusa* resources.

Comparison of WEPs between Dulong people and other ethnic groups in different areas

To illustrate the homogeneity of WEPs between different places, the JI was used to compare our study with

Table 4 Evaluation of wild edibles using CFSI and RFC index

Species names	Vernacular name	Indices		Ranking	
		CFSI	RFC	CFSI	RFC
Maianthemum atropurpureum	dong qi	4088	89	1	2
Caryota obtusa	a lei	1961	61	2	8
Cardiocrinum giganteum	a bo	1837	81	3	3
Maianthemum purpureum	dong ka	1265	54	4	12
Colocasia esculenta	gui	1190	45	5	17
Pueraria montana var. *thomsonii*	meng	823.2	56	6	11
Pueraria peduncularis	b ri	638.4	57	7	10
Dioscorea polystachya	na ba	606.4	77	8	4
Heracleum hemsleyanum	xi wa an	604.7	43	9	18
Angiopteris esculenta	mei leng	579.2	99	10	1
Dioscorea velutipes	ying	399.0	38	11	21
Aralia elata	bang a	273.8	73	12	5
Athyrium sinense	dao	262.5	70	13	6
Asystasiella neesiana	se you can	218.8	40	14	20
Dendrocalamus fugongensis	de wa	178.5	51	15	13
Dioscorea bulbifera	ki	173.3	22	16	29
Dioscoreapentaphylla	e jing	126.0	16	17	34
Dioscorea alata	reng dong	108.0	12	18	47
Osmunda japonica	na bu gan	87.75	50	19	14
Toona sinensis	zong	78.75	42	20	19
Cardamine tangutorum	a ga	73.13	65	21	7
Toxicodendron vernicifluum	de ki	60.75	9	22	56
Matteuccia struthiopteris	ceng	48.75	13	23	44
Saurauia napaulensis	da bu qiu	48.30	46	24	16
Pteridium revolutum	de leng	29.25	24	25	26
Cephalostachyum mannii	si meng	24.75	11	26	53
Maianthemum fuscum	dong	24.38	13	27	40

eight previous investigations in China and neighboring countries [3, 6, 7, 67–71]. In total, the JIs of four regions were calculated in China, with Shangri-la emerging as the most similar to our study area with JI = 12.06, followed by the Mêdog County and Lijiang area (JI = 7.21, and 5.25, respectively), while the lowest JI (2.53) was found with the study conducted in Longzi County. The high JI may reflect that the study area is located in the same geological zone, with similar socioeconomic and cultural characteristics. On the other hand, among three neighboring countries (Myanmar, Nepal, and Pakistan), the similarities in these four places were very low (Table 5).

To explore WEPs differences in the use of WEPs between the Dulong and several other ethnic groups in northwest Yunnan, China, we used a Venn diagram to visualize WEPs used by the five ethnic groups (Dulong, Tibetan, Naxi, Lhoba and Monpa). There is only one plant species, namely *Chenopodium album*, used by all 5 ethnic groups (Fig. 9). There are two species (*Elaeagnus umbellata* and *Cornus capitata*) used by Dulong and other three ethnic groups.

There are 13 species (*Ribes alpestre*, *Rubus ellipticus*, *Rubus niveus*, *Capsella bursa-pastoris*, *Zanthoxylum bungeanum*, *Galinsoga parviflora*, *Taraxacum mongolicum*, *Houttuynia cordata*, *Pyrus pashia*, *Plantago asiatica*, *Mentha canadensis*, *Fagopyrum dibotrys*, and *Debregeasia orientalis*) used by Dulong and other two ethnic groups. Dulong, Tibetan, and Monba showed higher similarities of consuming WEPs, which may be related to their living habits and types of surrounding plants.

Table 5 Jaccard similarity index (JI) for local and neighboring countries

Nationality	Study area	Indices			JI	References
		A	B	C		
China						
Tibetan	Shangri-la region	148	168	34	12.06	[3]
Naxi	Lijiang area	148	173	16	5.25	[6]
Lhoba	Longzi County	148	55	5	2.53	[62]
Monpa	Mêdog County	148	194	23	7.21	[63]
Neighboring countries						
——	Nepal	148	132	4	1.45	[65]
——	Western Nepal	148	72	15	7.32	[67]
——	Myanmar	148	81	6	2.69	[64]
——	Lesser Himalayas-Pakistan	148	44	2	1.05	[66]

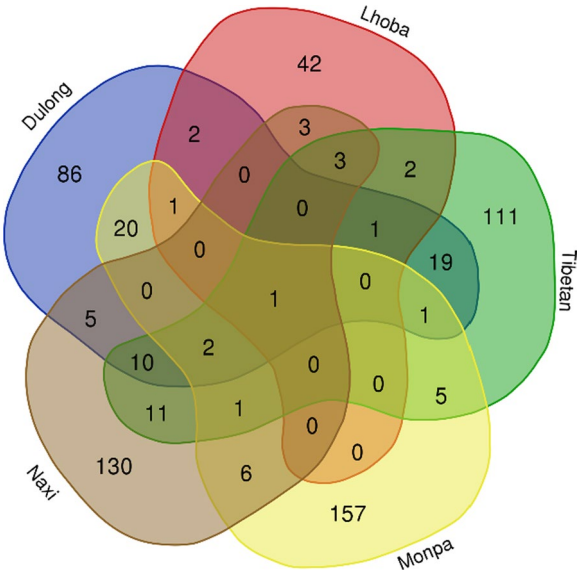

Fig. 9 Comparison of WEPs between Dulong and other ethnic groups in China

Discussion

Effects of gender, age, education level, occupation and remoteness on traditional edible plant knowledge

Human factors are critical to the inheritance of wild edible plant knowledge. Age, gender, education level, and occupation of informants are factors commonly considered in research [52, 53]. In this study, there is a significant correlation between the amount of knowledge of wild edible plant knowledge mastered by Dulong people with the occupation and education level of informants. However, there is no significant correlation between those numbers and the gender and age of the respondents (Additional file 1, Appendix B).

Among the 127 respondents, men and women represented 59.06% (75) and 40.94% (52) of the total, respectively. Previous studies have shown that gender is a critical variable that influences the distribution of local knowledge, and women often have more traditional knowledge because they are usually unemployed in rural areas and dedicate themselves to household and subsistence activities [6]. However, there are no significant difference between the male and female groups in the Dulongjiang region. This finding is similar to some previous some research [30, 72]. Khakurel et al. also noted that there was no significant difference between genders in terms of total number of species, while categorically analyzing vegetable and fruit groups, there was a significant difference between genders [71]. Due to the harsh geographical and climatic conditions, women are more responsible for collecting near plants and cooking and are generally unable to participate in filed gathering, and men mostly collect wild plants.

The average number of species is 6.1 mentioned by respondents under 19 years of age, 18.0 by the respondents between 20 and 39, 22.9 by respondents between 40 and 59, and 29.9 by respondents over 60. There is no homogeneity of variance in the one-way analysis of variance (<0.05) (Table 6). A previous study of Naxi people in northwest Yunnan shows that older people play an important role in maintaining knowledge of WEPs [6].

From the education point of view, the uneducated group had the highest knowledge of WEPs (average number of species mentioned is 25.1) and had more traditional knowledge than other groups ($p<0.05$, compared to other groups). Maybe it is because uneducated people are more dependent on agricultural activities, while educated people generally choose non-agricultural jobs. With the development of the economy and the improvement of living conditions, many people are willing to choose non-agricultural activities, which is one of the reasons for the loss of knowledge retention and transmission of WEPs (Fig. 10b).

From a occupation perspective, the number of WEPs in the hands of agricultural workers represents the most considerable portion (average 22.6), 14.5 by respondents with other occupations. There is a significant correlation with other occupations (Fig. 10a). An important reason is that the Dulongjiang region has always been a remote and backward area with inconvenient transportation, so farmers have been involved in agricultural work and are very familiar with local WEPs. Farmers retain more knowledge of WEPs than people engaged in other occupations (salary work, trade, and students) in the Dulongjiang region.

For the remoteness of the village, the average number of species mentioned by the respondents in the vicinity of the village is 18.7 and 21.8 by the respondents in the far village. However, there are no significant differences between the far village and the nearby village in the Dulongjiang region (Table 6).

Opportunities and challenges of WEPs

The Dulong people have invaluable knowledge of WEPs, the use of which is generated under a specific cultural and ecological background. Due to the unique topography, climatic conditions, and extremely high biodiversity of the Dulongjiang region, it has generated abundant wild edible plant resources, which is its ecological foundation [36]. Although Dulong people is an ethical group whose main livelihood is collecting, fishing, hunting, and slash-and-burn; they worship the fire pond culture and have a long history of using WEPs and therefore have accumulated a lot of traditional knowledge of WEPs for a long time, which is its cultural foundation.

Table 6 One-way analysis of variance

Characters	Total number of respondents	Average WEPs no. mentions	df	Homogeneity of variance test	*P* value
Gender			1	0.977	0.055
Male	75	21.9			
Female	52	19.0			
Age range			3	0.041	–
≤ 19	8	6.10			
20–39	59	18.0			
40–59	39	22.9			
≥ 60	21	29.9			
Education level			3	0.269	0.006
Illiterate	26	25.1			
Primary	27	17.9			
Secondary	55	21.0			
high school and above	19	18.1			
Occupation			1	0.741	0.000
Farming	88	22.6			
Other occupations	39	16.5			
Distance to township					
Near village	43	18.7	3	0.237	0.053
Far village	84	21.8			

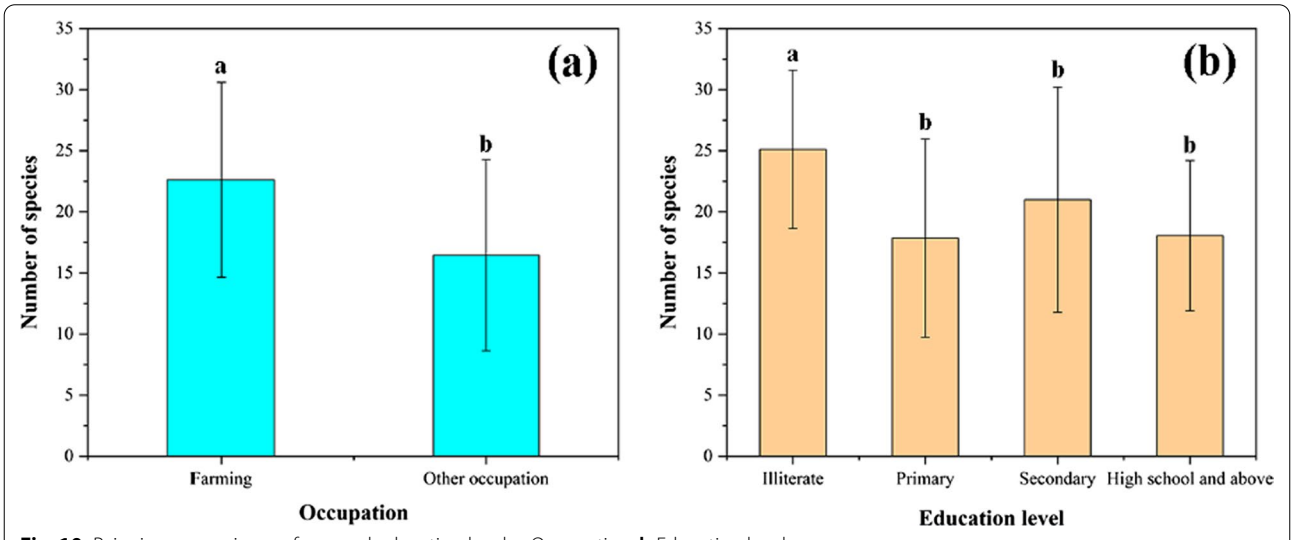

Fig. 10 Pairwise comparisons of age and education level. **a** Occupation; **b** Education level

Recently, with the improvement of living standards, the requirements for dietary balance and variety of foods have gradually increased, and wild food plants have created unprecedented opportunities, especially in the domestication of WEPs, the selection of excellent varieties, the development of WEPs with economic potential and WEPs for both medicine and food. Some similarities exist between medicine and food, and many plants are both edible and medicinal. Plants in local food cultures are inseparable from traditional therapeutic systems [29]. These medicinal dietary plants play an important role in ensuring food and medical safety. Therefore, these plants serve as an established source of income for Dulong people [35].

At the same time, WEPs also face many challenges with economic development and improvements in

transportation. Many studies from various regions have found that sociocultural factors are the main drivers of reduced consumption of WEPs [73, 74]. Other studies pointed out that the main drivers of decreased abundance are perceived to be land-use change and direct exploitation of WEPs. These changes have potential negative implications on food systems from local to global scales [75]. The resources of WEPs are constantly threatened by various natural factors and human activities. Furthermore, global climate change leads to various extreme weather events, for example, thunderstorms, mudslides, and flash floods, which significantly contribute to large-scale plant deaths. In addition, various human activities (single-crop cultivation, habitat destruction, excessive harvesting, overgrazing, etc.) also pose a considerable threat to wild plant resources. For example, planting large amounts of *Amomum tsaoko* in the Dulongjiang region to increase income and promote economic development significantly impacts the local understory vegetation. Moreover, not only are plant resources threatened, but traditional knowledge related to these resources is also gradually being lost (Additional file 1).

It seems to have happened within one overnight that Dulong people completed the transition from traditional livelihoods of gathering, fishing, and hunting to the poverty alleviation of entire tribes, and the traditional knowledge of WEPs is bound to be impacted. With local residents' incomes rising, many people are reluctant to collect WEPs, and the younger generation is not very interested in them, which is the main reason for the loss of traditional knowledge of WEPs.

Conclusion

In summary, 148 WEPs and associated traditional knowledge used by Dulong people were recorded. Multiple uses of these WEPs were analyzed and the most culturally significant WEPs of the Dulong people were identified by quantitative methods. In the future, wild vegetables and fruits with economic potential can be developed to be a source of income for residents. The excellent traits of WEPs can be preserved and exploited by cross-breeding new varieties. More detailed analysis of the nutritional value, chemical composition, and biological activities of WEPs is expected to be performed. The needs of Dulong people and the development of the local community can be realized under the premise of protecting WEPs and related traditional knowledge.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s13002-022-00501-3.

Additional file 1. Appendix A: Table 1 CFSI data. **Appendix B:** Table 2 One-way ANOVA data.

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Authors' contributions

LCL conceived and designed the study. CZ and LXP collected the data. LCL and CZ identified the plants. CZ interpreted and analyzed data. CZ and LXP wrote the manuscript. LXP, AN, LFK, and LCL modified the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials

All data generated or analyzed during this study was included in this published article (along with the supplementary files).

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Author details

[1]Key Laboratory of Ecology and Environment in Minority Areas (Minzu University of China), National Ethnic Affairs Commission of China, Beijing 100081, China. [2]College of Life and Environmental Sciences, Minzu University of China, Beijing 100081, China. [3]Key Laboratory of Ethnomedicine (Minzu University of China), Ministry of Education, Beijing 100081, China. [4]Key Laboratory of Modern Preparation of Traditional Chinese Medicine, Ministry of Education, Jiangxi University of Traditional Chinese Medicine, Nanchang 330006, China. [5]Kunming Institute of Botany, Chinese Academy of Sciences, Kunming 650201, China.

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