Ethnobotanical study on wild edible plants used by three trans-boundary ethnic groups in Jiangcheng County, Pu'er, Southwest China

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Abstract

Background: Dai, Hani and Yao people in the trans-boundary region between China, Laos and Vietnam, have gathered plentiful traditional knowledge about wild edible plants during the long history of understanding and using natural resources. The ecologically rich environment and the multi-ethnic integration provide a valuable foundation and driving force for high biodiversity and cultural diversity in this region. However, little study has uncovered the mystical veil of this unique and attractive culture.

Methods: Ethnobotanical fieldwork, market and village survey have been conducted in 20 villages of Jiangcheng County during the period from 2016 to 2019. Altogether 109 local Dai, Hani and Yao people were interviewed, and their traditional knowledge of wild edible plants was recorded. Voucher specimens were identified by the authors and deposited in the herbarium of Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences (HITBC). The statistical analysis was performed using R Studio software.

Results: 211 wild edible plants, belonging to 73 families and 152 genera, were recorded. These plants were consumed as wild edible vegetables, seasonal fruits, salads, spices, sour condiments, tonic soups, tea substitutes, liquor brewing or dyeing materials. The use value (UV), current cultivation, market availability, as well as the quantitative traditional knowledge inheritance situation of these wild edible plants among different generations were analyzed. Based on the data from threatened species list of China's higher plants and the IUCN red list, the food plant list for

Asia Elephant, the subject database of China plant and the calculated UV score, the top 30 most important wild edible plants were selected for further cultivation in the local village

Conclusion: Traditional knowledge of wild edible plants, owned by Dai, Hani and Yao people in Jiangcheng County, is rich but at risk of losing among the young generation. Diversified cultivation of wild edible plants by the local communities could be a solution for sustainable use of natural resources, and conserve the endangered species in this trans-boundary region.

Key words： wild edible plants; trans-boundary ethnic groups; traditional knowledge; conservation and sustainable use; Jiangcheng County

Background

Southwest China and Southeast Asia region is one of the 34 biodiversity hotspots for conservation priorities in the world [1]. The international borders are essential habitat for the survival of many endangered species. Asia contained approximately 82% of global border hotspots (the richest 5% of border segments) for threatened trans-boundary species and the distribution of threatened species with trans-boundary ranges was concentrated primarily in South-East Asia [2]. China shared 1852 kilometers border with Laos and Vietnam, and there are around 15 cross-border ethnic groups living in this trans-boundary region, with Dai, Hani and Yao people as 3 main indigenous groups [3, 4]. Known as a “green pearl” on the Tropic of Cancer in Yunnan, China, Pu’er city is selected as a key conservation area because of its important biodiversity status in Yunnan and

even in China [5]. Jiangcheng county, belonging to Pu' er city and located in Southwest China, is the only one trans-boundary county bordered by 3 countries (China, Laos and Vietnam). Jiangcheng county was named after its surrounded three rivers and it was part of ancient Ailao Kingdom about 2100 years ago [6]. Geographically, it is situated in the Hengduan Mountain range by lying at the end of Wuliang Mountain with elevation ranging from 317 to 2207 meters. It is also a multi-ethnically inhabited region with 25 residential nationalities [7]. All of these make Jiangcheng county a microcosm of the rich bio-cultural kingdom in the trans-boundary regions among China, Laos, and Vietnam.

Wild edible plants, such as vegetable and fruits, play an important role in our daily life. Wild vegetables are favored by more and more people because they have fresh and aromatic taste, rich mineral nutrients, pollution-free growing environment, strong vitality and high medicinal and human health benefits [8, 9]. Wild edible plants are significant important in almost every part of life for indigenous communities. They could provide supplement food, nutrients, medicines, building materials, firewood, dyes, staple, as well as cash income to native ethnic groups [10-12]. Settled in the low mountain land and faraway from big city, the local people in Jiangcheng county rely a lot on the natural products from wild field. In the past, wild edible plants are mostly self-sufficient and they are mostly consumed as main food substitutions for the local people. Nowadays, wild edible plants are more likely to be sold in the markets for citizens and tourists. Thus, the locals gathered abundant traditional knowledge from these long-term practices. Previous studies of the wild edible plants in Southwest China focused on providing a list of species [13-14]. While the traditional knowledge associated with the listed species as well as their quantitative inheritance information

among different generations were always absent from these studies.

The global climatic shift is having a huge threat on diverse biota [15], and results in global biodiversity loss through drought and warming [16]. There are an estimated 500,000 species of land plants and a third of all land plants are perhaps at risk of extinction due to the habitat loss, fragmentation, and degradation, overexploitation, invasive species, pollution, and anthropogenic climate change [17]. Current species extinction rates are higher than would be expected and the sixth mass extinction may be under way [18]. Besides, most of the residential ethnic groups in this region depend on the local forest for a living. In addition to the poor economy and excessive collection of wild plants, large-scale rubber and other economic plantation, fragmentation and progressively decreased connectivity of forest aggravate the crisis on the sustainable use of the natural resources and the situation of biodiversity conservation in this region is worsening [19-22].

The traditional knowledge, gathered by the aborigines in the long interaction with nature, is an important part of human cultural treasure. While, most traditional knowledge is under threat and at the merge of disappear due to environmental changes, livelihood diversification and the influence of cultural conflicts [23-26]. Meanwhile, the ethnic groups in this region do not have or not use their own written language, and their traditional knowledge could only be inherited to next generation by oral communication. One lost could turn out to be a permanent lost. Thus, the exploration and documentation of the local traditional knowledge of the wild edible plants in this region is of the utmost importance.

The aim of this study was to catalogue the traditional knowledge on the wild edible plants used by three trans-boundary ethnic groups in Jiangcheng County, to quantify the inheritance of traditional knowledge, as well as to provide primary scientific practices for future sustainable utilization and conservation of wild edible plants.

Methods

Study area

Jiangcheng county is closely bordered with Laos and Vietnam, and its geographical coordinates are between longitudes 101°14'-102° 19' east and latitude 22°20'-22°36' north with a subtropical humid climate. Its spring and autumn periods are longer than summer and winter with the average annual rainfall at 2189.3 mm and a comfortable average temperature around 19.4° [7]. During 2016-2019, ethnobotanical studies on wild edible plants utilized by local people were carried out in 20 villages and nearby markets, which distributed at all 6 townships of Jiangcheng county (Fig. 1). Zhengdong, one of township in Jiangcheng, has been awarded as the fourth batch of national beautiful and livable township by the ministry of housing and urban-rural development, China and as ecological civilization township by Yunnan province. Zhengdong town is also an important habitat for around 44 Asia elephants [27]. Nine different villages of Zhengdong township, which are famous for multi-ethnic traditional culture and well-preserved natural forest, were chosen for a detailed study. There is no frost and snow in the whole year, rich in heat resources and fertile land with corn, rice, rubber, tea, coffee, passion flower, nuts, bananas and mangoes as the main economic crops [7]. Hani, Dai and Yao people are the three major ethnic minorities that living at China, Laos and Vietnam trans-boundary regions and had a long tradition and abundant practices of eating wild plants.

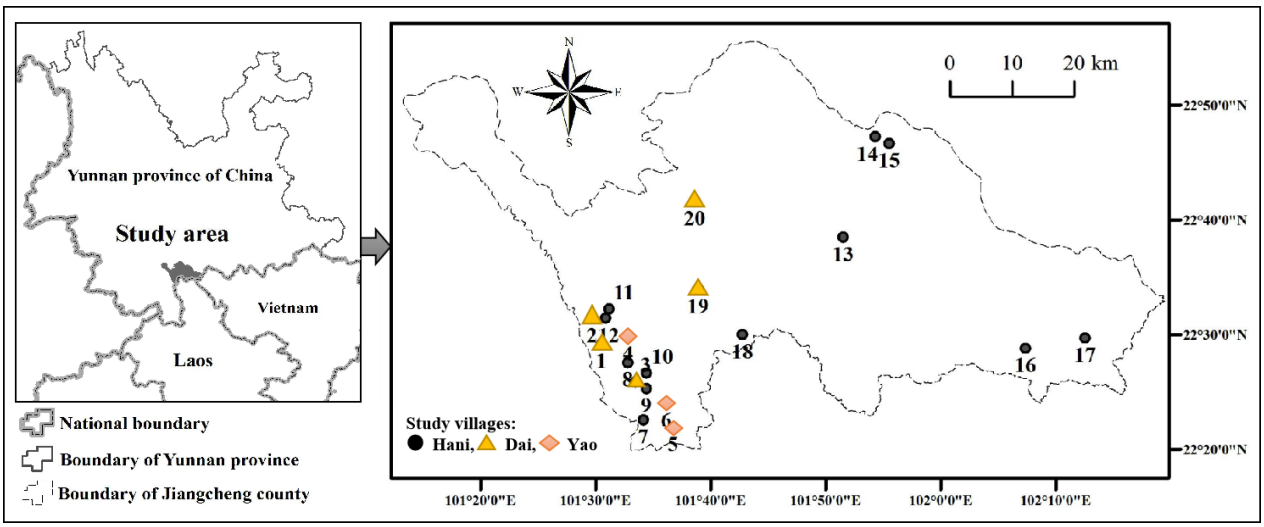

Fig. 1 Location of study sites in Jiangcheng Couty, Pu'er City, Southwest, China. Different shape and color represented different ethnic villages. Village No. 1-3 and 19-20 are Dai people's village named Chengzisanzha, Mankuan, Mantan, Zhongping and Shuicheng respectively. Village No. 4-6 are Yao people's village named Xiamanjing, Xicaotang and Xiaomangong respectively. Village No. 7-18 are Hani people's village named Huibaohe, Malijing, Shibajia, Xijiang, Luoqiya, Nabanhe, Medeng, Gejie, Baga, Bashan, Nuna and Mengkang respectively.

Ethnobotanical survey, data collection and analysis

Multiple interdisciplinary methods were applied to collect traditional knowledge data on wild edible plants consumed by three trans-boundary ethnic groups. Field and markets surveys were carried out in 20 ethnic village (13 Hani, 4 Dai, 3 Yao) during different season of 2016 to 2019 (Figure 2). Detailed ethnobotany studies, including semi-structure interview and specimen's collection, were conducted in 9 villages of 3 ethnic groups (Fig. 3). The main informants were introduced by the local village head firstly, then recruited randomly during house-to-house questioning. A total of 109 informants, including 50 male and 59 female who are aging from 21 to 78, were interviewed during this study. The"5W + H" questions (i.e., questions concerning what, when, where, who/whom, why, and how the subjects utilize wild edible plants) [28, 29] were used to collect the local name, used parts, usage, preparation methods, function, richness or availability information of the wild edible plants.

Fig. 2 Investigated Dai (a), Hani (b), Yao (c) village and local market (d)

Fig. 3 Interviewing the local people (a,b); *Mangifera siamensis* Warbg. ex Craib (c) and *Dendrobium nobile* Lindl. sold at the market (d)

All the interviews were carried out in mandarin mainly, ethnic languages were also used with assistance from local village heads or guides in the studied sites. The local names of wild edible plants were recorded by Chinese Pinyin. The collected voucher specimens were identified by the authors with referring to flora of China and were deposited in the Herbarium of Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences (HITBC). The conservation status was recorded by referring the data from IUCN red list [30], threatened species list of China's higher plants [31], as well as the subject database of China plant [32].

The use values (UV) of each wild edible plant were calculated to evaluate the relative importance of each plant based on the number of times cited and the number of informants [29, 33]. The formula for UV is UV = $(\sum U_i)$ / N. U_i is the times cited by each informant for a certain wild edible plants, while N is the total number of informants. The similarity or dissimilarity of plant species used in both communities was analyzed through the Jaccard index, JI = a / (a + b + c), where a is the number of species in common; b the number of species used only by one specified community and c the number of species used only in another community [34] Microsoft Excel (Microsoft Corporation, http://www.microsoft.com/) was used to make the catalogue and analysis about the ethnobotanical information of wild edible plants. A unitary linear regression analysis was undertaken using R Studio (version 1.3.959). Significant difference was accepted at $P < 0.05$.

Results and discussion

Diversity of wild edible plants, life forms and edible parts in Jiangcheng County

A total of 211 wild edible plants belonging to 73 families and 152 genera, along with ethnobotanical catalogue information such as scientific names, family names, local names, life forms, edible parts, usage and preparations, voucher numbers, cultivation and market status, were recorded (Table 1). The 211 species account for about 20.74%, 9.0%, 3.77% of the total families, genera and species of high plants in Pu'er City. The most frequently used plants are mainly from the family of Poaceae (14 species), Fabaceae (12 species), Euphorbiaceae (8 species), Lamiaceae (8 species), Zingiberaceae (8 species), Araliaceae (7 species) and Moraceae (7 species). At genus level, *Dendrocalamus*, *Dioscorea*, *Solanum*, *Amaranthus*, *Amomum*, *Colocasia*, *Dendrobium*, *Ficus*, *Musa*, and *Zanthoxylum* contain 4 to 6 species. There are 31 families and 121 genera include only one species.

Among the 211 species, there are 95 herb species (45.02 %), 54 trees (25.59 %), 38 vines (18.01 %), 13 shrubs (6.16 %) and 11 bamboos (5.21 %) (Table 3). All wild edible plants were also classified by their edible parts (Table 2). The majority consumed edible parts were tender stem and leaf (91 species, 43.13 %), fruit (50 species, 23.70 %), flower (29 species, 13.74 %), rhizome (15 species, 7.11 %), followed by root, bamboo, young leaf, tender stem heart, stem, young shoot, seed, bark, petiole, and inflorescence (Table 3). The rich variation of edible parts collected from different life form species demonstrated that local communities have gathered a lot of traditional knowledge from their daily consumption of wild edible plants. They could figure out which plant part is safe to

eat and get rid of the poisonous part. For example, the tuber of *Colocasia* (Araceae) plants, such as *Colocasia esculenta* (L.) Schott and *Colocasia fallax* Schott, are mostly edible as coarse grains, vegetables or pig feed [35], while the tuber of *Colocasia gigantea* (Blume) Hook. f. is extremely poison not only to insects but also to people. Once ingestion of this tuber by accident could cause severe pain in the esophagus and digestive system and thus the edible part of this plant is mainly petiole but not tuber [36]. Moreover, many species provide more than two edible parts for the local people, this information could interpret their preference to some specific species, and could also be useful for the further economic exploration of these wild edible plants.

Table 2 Life forms of wild edible plants in Jiangcheng County

Life forms	Records	Percent (%)
Herb	95	45.02
Tree	54	25.59
Herbaceous vine	23	10.90
Woody vine	15	7.11
Shrub	13	6.16
Bamboo	11	5.21

Table 3 Edible parts of wild edible plants in Jiangcheng County

Parts used	Records	Percent (%)
Tender stem and leaf	91	43.13
Fruit	50	23.70
Flower	29	13.74
Rhizome	15	7.11
Root	13	6.16
Bamboo	11	5.21
Young leaf	9	4.27
Tender stem heart	9	4.27
Stem	9	4.27
Young shoot	5	2.37
Seed	4	1.90
Bark	2	0.95
Petiole	2	1.90
Inflorescence	2	0.95

Diversity of usage and preparation methods

As for the usage and preparation methods (Table 4), more than two third of the plants were consumed as potherb (wild vegetables, 67.77%). Potherbs are normally fried or boiled to make a mixed wild vegetable soup. Twenty-four species were used to make salad freshly or after boiling. Besides, 25 wild fruits were consumed as seasonal fruits with 3 of them also used for liquor brewing. The following usages are tonic soup, spice ingredient, sour condiment, liquor brewing, tea substitute, dye material and nut. During our investigation, we find that local people have some special taste preference for choosing the wild edible plants. For instance, there are 18 species, such as *Litsea cubeba* (Lour.) Pers., *Zanthoxylum armatum* DC., *Zanthoxylum myriacanthum* var. *pubescens* (C.C. Huang) C.C. Huang, *Alpinia galanga* (L.) Willd., *Amomum coriandriodorum* S. Q. Tong & Y. M. Xia, are used as spice ingredients to cook beef or mutton, and 11 species, such as *Spondias pinnata* (L. F.) Kurz, *Begonia augustinei* Hemsl. and *Urceola rosea* (Hooker & Arnott) D. J. Middleton, are used as sour condiments to make fish or cook pork soup. Besides the spicy or sour tastes, several species form Solanaceae and Bignoniaceae families are consumed for their bitter taste. *Acacia pennata* (L.) Willd., having strong bad egg smell, is also used to cook fish soup, mixed wild vegetable soup or fried egg.

Table 4 Usage and preparation methods of wild edible plants in Jiangcheng County

Preparation and use	Records	Percent (%)
Potherb	143	67.77
Salad	24	11.37
Seasonal fruit	25	11.85
Spice ingredient	18	8.53
Tonic soup	21	9.95
Sour condiment	10	4.74
Liquor brewing	9	4.27
Tea substitute	7	3.32
Dye material	3	1.42
Nut	3	1.42

On one hand, wild edible plants provide essential source of food for local people, on the other hand, some of these plants are believed to be health beneficial and utilized as medicine and beverage by the local people in Jiangcheng County. In this study, there are 21 plants used to make tonic soup with chicken or pork. The indigenous villagers used 9 plants to make traditional liquor, which are also frequently consumed to treat stomach or inflammatory disease or to help them to have a healthy and strong body. In Pu'er City, there has a long traditional culture of harvesting and cooking herbal medicines with different meat to make some functional soup. More than 100 species of medicinal plants were sold on the herb market in Pu'er City during the Dragon Boat Festival (Chinese Duan Wu festival) [37].

The diverse use and preparation methods of wild edible plants in Jiangcheng County indicated the indigenous people have learned a lot of traditional knowledge about how to adapt well to natural environment. Their strong connections with the nature benefit them not only to avoid harmful materials, but also to own better taste experiences and to absorb more nutrition. These traditional usage and preparation practice raised a wonderfully diversified cooking culture. With the increase demand for a better and healthy daily life, the consumption of wild edible plants has been increasing and many of them have been collected from the field to serve at local restaurants. The practice of making edible medicinal soup meets the requirement of food nutrition and body health at the same time for the modern world, and attracts more tourists to have a stomach feast in Pu'er City. The traditional knowledges is also valuable for future application of wild edible and medicinal plants in the food industry.

The use value and traditional knowledge distribution among different generations and ethnic groups

The use values (UV) of each species were calculated to determine their relative importance to local communities (Table 1). Sixty-five species with the highest UV (0.90-1.00) have remarked as the most consumed wild edible plants in Jiangcheng County. The interviewed ethnic people (50 male informants and 59 female informants), were divided into five different age groups, and consumed 90 to 155 wild edible species (Fig. 4). Generally, male and female villagers eat similarly for the same age groups and the elder generation owns much more traditional knowledge than the younger generation. Based on the T-test and unitary linear regressive analysis by R Studio, there is extremely significant relationship between the age and wild edible plants (Fig. 5). The number of wild edible plants increased along with the age. The traditional knowledge is under serious threats due to environmental degradation and acculturation, as well as biodiversity loss and it showed signs of being forgotten and abandoned by the younger generation [12, 29]. This situation is also occurring in Jiangcheng County. The traditional knowledge is handed down through successive generations. With the pass away of elder people, the increase deforestation of natural forest and monoculture of economic plants, and the decrease availability of wild edible plants, the traditional knowledge has high risk of loss among the younger generation in this trans-boundary region. Our study could also be a referable example for quantitative study of the loss of traditional knowledge among different generations.

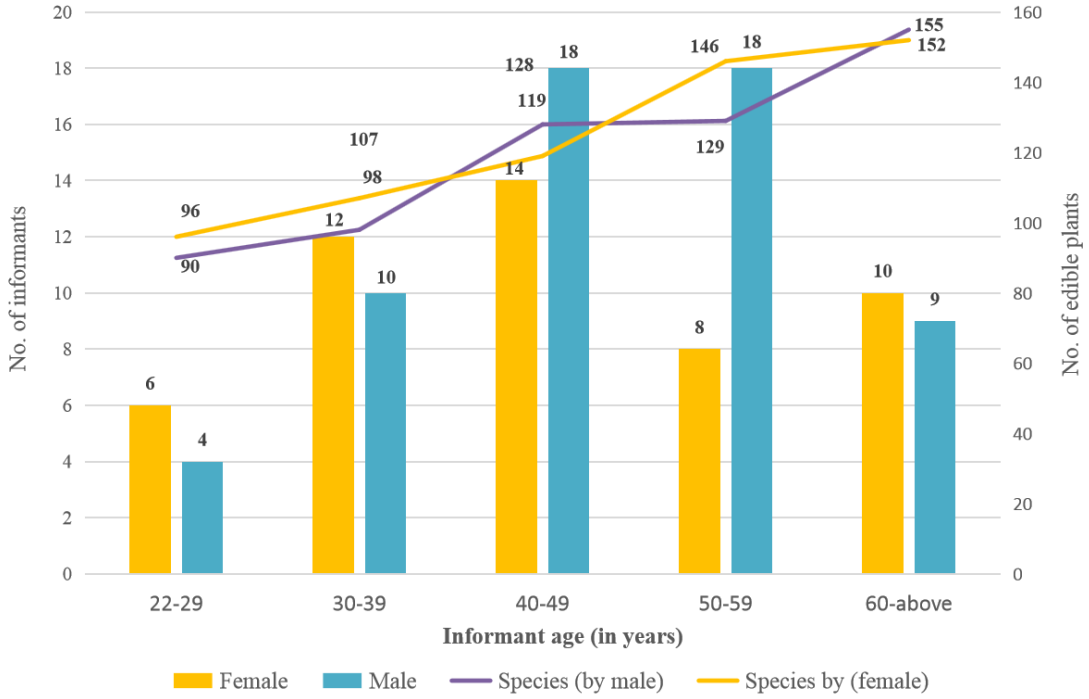

Fig. 4 Characteristics of informants and the average number of edible plants consumed by 5 different age groups

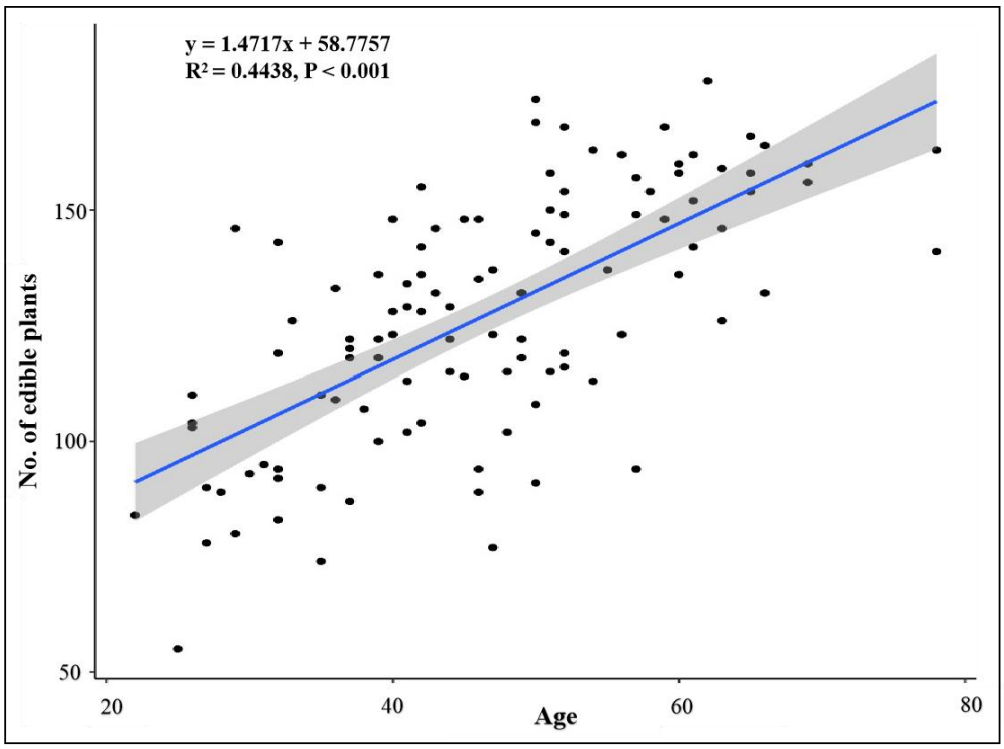

Fig. 5 The relationship of informant age and used edible plants

For different ethnic groups, local Dai, Hani and Yao people shared 211 wild edible species in

total. Among the 3 ethnic groups, the consumed wild edible species number are closely ranging from 183 to 185 (Fig. 6). There are 149 species, accounting for 70.62% of the total wild edible species, used by all 3 ethnic groups. The comparative analysis by Jaccard index (JI) showed that local Dai, Yao and Hani communities shared very similar wild edible plants traditional knowledge, with the JI value as 89.83%, 92.66% and 94.86% for Dai and Yao, Dai and Hani, Yao and Hani respectively. This likeness might due to long terms of interaction and communication at similar geographic environment. The high JI value indicates that local people in this trans-boundary region are tightly connected with each other.

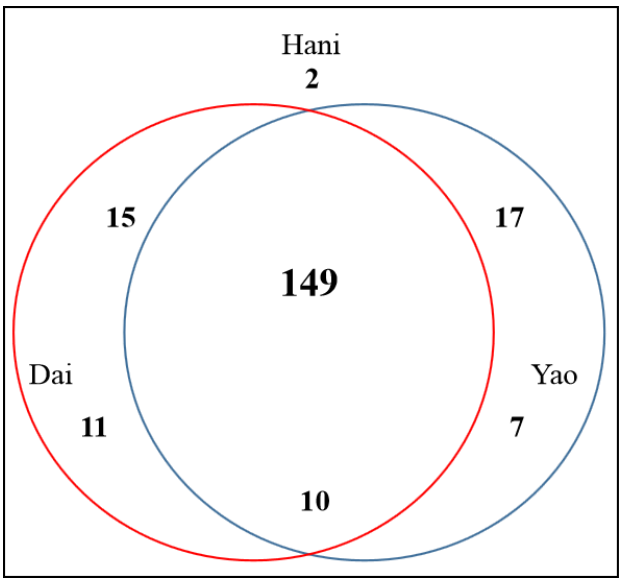

Fig. 6 Composition of wild edible plants among three ethnic groups. Red, green and purple color represent Dai, Hani and Yao people respectively.

Searching around the neighboring areas, there were 284 wild edible species used by Dai, Hani and Jinuo people in Xishuangbanna Dai Autonomous Prefecture [38] and 224 wild edible plants consumed by Hani people in Honghe Prefecture [29]. When contrasted with these neighboring areas, the wild edible species are quite different, with only 87 overlapping species between Jiangcheng

County and Xishuangbanna, and 53 overlapping species for Jiangcheng County and Honghe Prefecture respectively. This result shows local people could always make a living from the limited circumstances and the traditional knowledge of wild edible plants is tightly associated with the local environment. The Jaccard index (JI) value were calculated ranging from 13.87% to 21.32%, suggesting that there has high diversity of wild edible plants among these biodiversity hotspot areas.

Cultivation, market and conservation status in the studied trans-boundary region.

Besides their abundant experiences about harvesting wild edible plants from forest, local Dai, Hani and Yao people also have a very rich traditional knowledge of introduction and cultivation of wild plants. There are 68 plants cultivated by the local people in Jiangcheng County (Table 1). In the neighboring Xishuangbannan, Dai people have cultivated 315 plants in their villages, with 69 species used as medicines, fruits, vegetables, spices, horticultural flowers and construction woods [39]. Seventy-nine kinds of folk utilizable plants of swidden agroecosystem that belong to 38 families and 64 genera were cultivated by Hani people, and used as firewood, food, fruit, fodder, beverage, condiment and textile [40].

Wild edible plants not only supply the daily materials need, but also play an important role in ethnic groups' cash income. There are 117 wild edible plants sold at the local markets by the local people in Jiangcheng County (Table 1), and 146 wild vegetable species were found to be sold on the local markets and restaurants in Xishuangbanna [38]. On one hand, the huge market demands for wild edible plants contribute to thickening the wallet for the local people. On the other hand, it has been stimulating the increase pressure of wild collection to the environment and biodiversity

conservation. For instance, *Panax zingiberensis* C.Y. Wu & K.M. Feng, which was cooked by the local people with chicken to produce healthy soup, and mixed with traditional wine to make tonic liquor, has already been listed as endangered species, and may need more conservation efforts to resolve this potential over-harvesting pressure.

Habit loss is another main threat to conserve the endangered or rare wild edible plants. During our investigation, the shift cultivation land and nearby forest have now almost transformed into rubber plantation. We found the rice field was rented by the businessman to grow banana, chili, watermelon, kidney bean and some other economic crops almost during the whole year. The original rice field, which is normally full of water and an important wetland for many creatures, now has become relatively dried farming land. The decrease areas of rice paddy caused serve loss of wetland habits, biodiversity as well as cultural diversity in Jiangcheng County. For example, *Brasenia schreberi* J.F. Gmel. could be very easily found at the rice field and other wetland area and had some semi-cultivation practice [38], while it is almost disappeared because of the loss of rice field and change of land use for cash crops. Moreover, among the interviewed 109 villagers, there are only 27 ethnic people still know how to eat this species and they were all elder people with the average age at 57.5. This result suggests the younger generation have already lost the traditional knowledge about this edible species, due to the rapid decrease and shrink of wetland habit. Thus, we highlight that more conservation concern and efforts should also be paid to the tropical wetland areas.

Although, the decrease of wild edible plants still happens because of environmental change and human negative effects, there are also several increase of edible species due to human cultural

exchange. *Dendrobium* species are usually consumed as medicine and crushed freshly to treat scald disease by local Dai people [41]. While, *Dendrobium* species are famous and expensive traditional tonic medicine to rescue lives by Han people in the middle and east part of China. In 1990s, there have a huge increase demand of wild *Dendrobium* plants, and the related cultivation industry boomed in Southwest China for its suitable climate and lower investments. Local people learned that *Dendrobium* species not only have external and medicinal use, but also could be cooked and eat for health benefit during their communication with the outside businessman. There were 107 orchid species sold at Xishuangbanna market with *Dendrobium* plants as the main traded species [42]. The culture exchange enriched the dish list of the local people, while it also contributed the increase harvesting and conservation pressure of endangered *Dendrobium* species because of the preference of wild products by the locals. Our results thus indicate that culture exchange could increase the culture diversity but might have more conservation pressure on endangered species, and ethnobotanical data about the use frequency and consume demands of the endangered edible species should be included and considered when we evaluate the conservation status of the threatened species.

Important role of traditional knowledge to local communities and forest ecosystem services

The forest plays an important role in local communities. Local Dai people have a well know proverb believing that only where there is fine forest, there is water, farming land, food and survived people. This classic ecological belief ranked the forest an extremely high position, also gradually effected other local minority groups, and made positive contribution to the biodiversity conservation in this region [43, 44]. Based on the guidelines from specifications for assessment of forest

ecosystem services in China [45], the estimated total value of forest ecosystem services in Pu'er City was 247,785 billion yuan per year, with the per unit area value of forest ecological service at 85,500 yuan per hectare per year [46]. While these assessments were necessarily very simplified, usually focusing on a few, easily quantified services, failed to include the services which are of most importance to local people and could therefore lead to incorrect policy decisions [47]. Regionally speaking, the forest coverage rate of Jiangcheng County increased rapidly from 43% to 68% during 1997 to 2018, according to the public data form the local government [7]. While, the wild edible plants obtained from the forest are relatively decreased according to our result and the description by the elder informants. Globally speaking, Aichi Biodiversity Target 11 (to protect at least 17 percent of terrestrial area by 2020) has been exceeded for forest ecosystems, but deforestation and forest degradation continue to take place at alarming rates and contribute significantly to the ongoing loss of biodiversity [48].

Therefore, on one hand, we suggested that we should equally evaluated the quantity and quality of the forest coverage rate, and pay more attention to the negative effect of mono-cultivated economic forest, such as rubber plantation, on the traditional knowledge conservation and inheritance. On the other hand, ethnobotanical data on the value of the forest for providing the wild edible plants and other non-timber forest products to the local communities as well as the feedback effect from traditional knowledge and cultural diversity to forest conservation should be added into the specifications for assessment of forest ecosystem services.

Traditional cultivated plant genetic resources and diversified agriculture

Local ethnic groups have a long history of tradition to introduce the preferred wild plants into their farming land or homegardens. The cultivated wild species are very important plant genetic resources (PGR) for the development of cash crops. Local Dai communities, cultivated 204 species for edible, medicinal, ornamental and religious purpose, have a very close relationship with the formation and development of PGRs and play an important role in the conservation and utilization of PGRs [49].The UN's intergovernmental panel on climate change (IPCC) in Geneva issued a special report on climate change and land, pointed out that human activities and climate change is to make land resources under huge pressure, while sustainable land and forest management, could prevent and reduce land degradation, maintain land productivity, mitigate the adverse effects of climate change to some extent, and conserve the precious land and ecosystems at the same time [50]. Recently discovery revealed that altering the cropping pattern from intensive monoculture to diversified agriculture, could help to withstand the climate change, protect vital wildlife and alleviate the long-term loss of biodiversity outside natural protected area in the future [51]. Besides, increasing plant species diversity could promote beneficial trophic interactions between insects and plants, ultimately contributing to increased ecosystem services [52]

Thus, we suggested that more wild edible plants could be introduced and cultivated in the nearby protected areas, farming land, rubber forest, tea plantation field and village owned forest, homegardens as well as any suitable sites to build corridors or ex situ reserve areas for some important, rare, medicinal and edible plants, conserve more plant genetic resources and establish a diversified agriculture. Moreover, modern plantation technology should also be updated, and the cultivation and domestication of some preferred wild edible plants should be strengthened by

cooperating with some food industries to reduce field collection, increase economic income and contribute to the sustainable development of local communities.

Fig. 7 Wild Asia elphants feasting local villager cultivated corns in Jiangcheng County

Top 30 wild edible plants for better conservation, understanding and sustainable utilization in China, Laos and Vietnam trans-boundary region

Besides the threats from climate change, plantation and livelihood transformation, over-harvesting and alarming loss of traditional knowledge, the local people also have to face human-elephant conflict for there have around 44 Wild Asia elephant residents in Jiangcheng County (Fig. 7). With the increasing of elephant's population and expansion of its distribution, human-elephant conflict would be more serious due to continuous insufficient food, habitat loss and fragmentation [27, 53, 54]. The wild plants were important and reliable food sources both for human and elephant. Among the reported 240 forage plants for wild Asia elephant in Southwest China [55], there are 44 overlapping wild edible plants both for human and elephant in Jiangcheng County. Thus, local ethnic

413 people might have higher accident risk with wild Asia elephant when they are both trying to harvest
414 the same or similar wild edible plants at the same time. Nevertheless, establishing a food source
415 base with fast-growing, and high biomass indigenous plants has proved to be one of the effective
416 ways to solve this problem [56]. However, how to choose more suitable plants to introduce and
417 cultivate in the elephant food source base is still lack of practice and research data.
418
419 With limited land and investments, it is difficult to overcome all these mentioned problems,
420 while we could use a multiple way to solve or minimize these issues. Based on our ethnobotanical
421 survey, the data from threatened species list of China's higher Plants and the IUCN Red List, the
422 published food plant list for Asia Elephant and the calculated UV score, the top 30 most important
423 wild edible plants (Table 5) were identified and recommended to be further cultivated and expanded
424 in local village for sustainable use and better conservation. These highlighted plants include 15
425 threatened or endangered species, 17 species with UV value over 0.9 and 19 human and elephant
426 both consumed species. The environmental cultural as well as religious benefits of the forest were
427 generally recognized by the local people [57]. By learning the ethnobotanical knowledge from the
428 ethnic groups and encouraging them to cultivate more plants, especially the endangered species, in
429 the community land and individual households retained forest , as well as their homegardens could
430 open a new channel for connecting the fragmented forest as a whole, then contribute to conservation
431 and sustainable use of natural resources.
432
433 Furthermore, from better protection of wild edible plants view, there is urgent need from
434 policymakers to enhance the government coordination in this trans-boundary region [58, 59], and

435 reinforce the monitoring and management of rare or endangered plants trade in local markets, to
436 popularize the biodiversity conservation laws and to promote the awareness of the value of
437 traditional knowledge. From the sustainable utilization and development of wild edible plants view,
438 local government could continue to make their tree times per month's traditional market-day (every
439 1st, 11th, 21st of each month) more famous of typical ethnic culture characters by encouraging local
440 ethnic groups to sell more cultivated wild plants there. The trans-boundary good trade fair would be
441 another platform for local communities to demonstrate their unique culture and to increase the
442 nationalities' self-identification, then contribute to the conservation and inheritance of traditional
443 knowledge for the trans-boundary ethnic groups.

444 **Table 5.** The top 30 most important wild edible plants recommended for cultivation, conservation
445 and sustainable use

Family name	Scientific name	TSLCHP[a]	NPLC[b]	IUCN[c]	Elephant[d]	UV[e]
Anacardiaceae	*Mangifera siamensis* Warbg. ex Craib	EN	-	-	-	1.00
Anacardiaceae	*Mangifera sylvatica* Roxb.	EN	2	EN	Y	0.94
Anacardiaceae	Spondias pinnata (L. F.) Kurz	-	-	-	Y	0.94
Apocynaceae	*Amalocalyx microlobus* Pierre	-	-	-	Y	0.98
Araliaceae	*Panax zingiberensis* C.Y. Wu & K.M. Feng	EN	1	EN	-	0.14
Arecaceae	*Caryota obtusa* Griffith	VU	2	-	Y	0.49
Bignoniaceae	*Mayodendron igneum* (Kurz) Kurz	-	-	-	Y	0.99
Bignoniaceae	*Oroxylum indicum* (L.) Bentham ex Kurz	-	-	-	Y	0.97
Cabombaceae	*Brasenia schreberi* J.F. Gmel.	CR	1	CR	-	0.25
Cycadaceae	*Cycas pectinata* Buchanan-Hamilton	VU	1	VU	Y	0.12
Dilleniaceae	*Dillenia indica* L.	EN	-	-	Y	0.83

Family name	Scientific name	TSLCHP[a]	NPLC[b]	IUCN[c]	Elephant[d]	UV[e]
Elaeocarpaceae	*Elaeocarpus austroyunnanensis* Hu	VU	-	-	-	0.45
Euphorbiaceae	*Baccaurea ramiflora* Loureiro	-	-	-	Y	0.99
Fabaceae	*Acacia pennata* (L.) Willd.	-	-	-	Y	0.99
Fabaceae	*Bauhinia variegata* var. *candida* (Roxb.) Voigt	-	-	-	Y	0.99
Menispermaceae	*Parabaena sagittata* Miers	-	-	-	Y	1.00
Moraceae	*Ficus auriculata* Lour.	-	-	-	Y	0.93
Moraceae	*Ficus virens* Aiton	-	-	-	Y	0.93
Moraceae	*Morus alba* L.	-	-	-	Y	0.93
Orchidaceae	*Dendrobium chrysanthum* Wall. ex Lindl.	VU	1	VU	-	0.52
Orchidaceae	*Dendrobium crepidatum* Lindl. ex Paxton	EN	1	EN	-	0.51
Orchidaceae	*Dendrobium cucullatum* R. Br. ex Lindl.	VU	-	-	-	0.52
Orchidaceae	*Dendrobium devonianum* Paxton	EN	1	EN	-	0.51
Poaceae	*Dendrocalamus hamiltonii* Nees & Arn. ex Munro	-	-	-	Y	1.00
Poaceae	*Pleioblastus amarus* (Keng) Keng f.	-	-	-	Y	1.00
Polygonaceae	*Fagopyrum dibotrys* (D. Don) Hara	-	-	-	Y	0.98
Rutaceae	*Zanthoxylum myriacanthum* var. *pubescens* (C.C. Huang) C.C. Huang	VU	-	-	-	0.19
Solanaceae	*Solanum torvum* Swartz	-	-	-	Y	0.96
Verbenaceae	*Gmelina arborea* Roxb.	VU	-	-	-	0.36
Zingiberaceae	*Etlingera yunnanensis* (T. L. Wu & S. J. Chen) R. M. Smith	VU	2	-	-	0.20

446 [a] TSLCHP is the Threated Species List of China's Higher Plants; EN means endangered; VU is vulnerable; CR is
447 critically endangered; "-" means not included or data deficiency
448 [b] NPLC is National Protection level in China
449 [c] IUCN is the IUCN Red List of Threatened Species
450 [d] Asia elephant forage plants; Y means yes
451 [e] UV means use value

Conclusion

An ethnobotanical study on wild edible plants used by three trans-boundary ethnic groups was conducted in Jiangcheng County, Pu'er City, Southwest China. A total of 211 wild edible plants and their traditional knowledge were documented in this study. Our results show that three trans-boundary Dai, Hani and Yao people have plentiful traditional knowledge on the utilization of wild edible plants with diversified eating parts, preparation methods and use purposes. Local people not only collect the edible plant from wild, but also cultivated it and sold it to the market. However, many of these wild edible plants were only frequently mentioned by the elder informants and there has an alarming losing risk of the traditional knowledge among younger generations. Endangered plants distributed at the wetland or sold at the market, such as *Brasenia schreberi* J.F. Gmel., *Panax zingiberensis* C.Y. Wu & K.M. Feng, *Dedrobium* species, should be paid with more conservation efforts. Based our results, the top 30 most important wild edible plants were highlighted to be further cultivated and expanded in local village.

In conclusion, wild edible plants play an important role in local people's daily life, and the ethnobotanical information of the wild edible plants collected from ethnic groups could provide key scientific data to promote the traditional cultural value among the young generation and relief the stress of human-environment conflict. By referring the traditional knowledge from the ethnic groups and encouraging them to make a diversified cultivation of wild edible plants in the community land and individual households retained forest, as well as their homegardens could launch a new bridge for wild plants to be more profitable cash crops, then contribute to the sustainable use of natural resources, and conserving the endangered species in this trans-boundary region.

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Authors' contributions

RL and HBH conceived and designed the study. LS and RCQ provide financial and academic instructions. YLC, SSZ and RL conducted data collection and analysis. SSZ identified wild edible plants. RL, YLC and HBH interpreted and wrote the draft manuscript. All authors read and approved the final manuscript.

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Competing interests

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