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WeiH and CL designed this study; WeiH, PL, YL, WenH, YJ, JW, CBN, and CL conducted the field work; WeiH analyzed the data and drafted the first version of the manuscript, which was later revised by CL and approved by all authors

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**Competing interests**
No competing interests have been declared.

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ORIGINAL RESEARCH PAPER

# Ethnobotanical study on medicinal plants used by Li people in Ledong, Hainan Island, China

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## Abstract
The paper documents on the uses of traditional medicinal plants used for treating human ailments in three villages of Ledong, a county inhabited by Li ethnic group in the southwest of Hainan Province, China. Semi-structured interviews, key informant interviews and participatory observations were used to collect ethnobotanical data from February to March 2012 and in July 2013. The data collected was analyzed using descriptive statistics. Thirty native knowledgeable people were interviewed. The Li community uses 50 plant species in 36 families for medicinal purposes. The most common medicinal plant families were Leguminosae (14%), Compositae (6%), and Euphorbiaceae (6%), and the most common preparations methods were decoction (84%), crushing (38%), and poultice (34%). The traditional medicinal plants were mainly used for hemostasis (12.9%), body pains (11.4%), gastrointestinal disorders (11.4%), and trauma (10%). Twenty-four species of medicinal plants (48%) have never been reported in the literature of Li medicines. In addition, 22 species (44%) have already been studied by researchers and their extracts or compounds were good bio-actives. However, the rapid socio-economic development in the county is the main threat to the conservation of Li medicine and has resulted in the decrease in the abundance and use of medicinal plants and associated traditional knowledge. Other factors accounting for a decrease in the use of Li medicinal plants like loss of plant diversity, change of land use, and threatened traditional knowledge were equally discussed.

## Keywords
ethnobotany; traditional knowledge; ethnomedicine; Li ethnic group; medicinal plants

## Introduction

Throughout history, medicinal plants have been used traditionally to treat various ailments by folk societies or ethnic groups [1]. Some traditional medical systems like Chinese, Ayurvedic, and Unani contribute to the rapid development of traditional medicines. Practitioners of ethnomedicine employ methods based on the ecological environmental, sociocultural and religious background to provide health care for local people [2,3]. These long-term traditionally used plants have shown to be relatively safer than those herbs which have no history of ethnomedical use [4]. Given that in other areas, evidence of the ethnomedicinal importance of plants for local people has been documented [5–7], a similar study was therefore necessary.

In China, 55 ethnic minorities were officially recognized in the country. Each ethnic group accumulated lots of medicinal experiences and documents as well as medical theories and applications while struggling with diseases. Ethnomedicine has a special theoretical basis as it forms the roots of ethnic cultures. To date, some ethnomedicines have been exploited and have made great contributions to the health of human beings based on their traditional knowledge [1]. For example, the famous medicine called *pseudo-ginseng* (*Panax notoginseng*, or *San-qi* in Chinese), used widely for the prevention and treatment of cardiovascular diseases [8], was firstly discovered and applied by Zhuang ethnic group. *Terminalia chebula* (*He-zi* in Chinese) is not only used often in traditional Chinese medicine (TCM), but also very popular in Tibetan medicine and has been entitled "the king of all medicines" [9]. *Paris polyphylla* (*Chong-lou* in Chinese), a traditional heat clearing and detoxifying ethnomedicine, has the effects of anti-tumor, anti-diabetic, anti-inflammatory, and inhibitory activity against platelet aggregation [10]. It has a wide distribution and is used by many ethnic groups such as Yi, Bai, Miao, Lisu, Naxi, and others [11]. Furthermore, it has been developed into the principal material of many celebrated Chinese patent medicines, such as Yunnan Baiyao, and Gongxuening capsule. However, there are still many valuable ethnomedicines to be explored and studied.

Hainan Island, located in the southern part of China, was considered the remotest place in ancient times. It belongs to the semi-arid tropical monsoon climate and has a well-defined dry season and wet season. The terrain in the east is higher than that of the west [12]. It has favorable natural and geographical conditions, and encloses numerous medicinal plant resources [13], which provides livelihood substances for many ethnic groups. The Li ethnic group was one of the first groups to reside in the area and has developed many cultural practices and customs. The Li's population is estimated at about 1.27 million, accounting for 14.65% of all populations in Hainan Province [14]. Li medicine and its related traditional knowledge were generated along with the interaction between Li people and their environment. As early as the period of Song and Yuan dynasties (960–1368), Li people had a comprehensive understanding of herbals about their forms, functions, properties, collections, processes and categories [15]. They accumulated many experiences in the treatment of bruises, snakebites, rheumatism, malaria, miasma, etc.

However, rapid socioeconomic development is currently leading to loss of indigenous knowledge on the uses of medicinal plants in this area [16]. The Li people do not have written literatures, consequently, traditional knowledge is transferred orally from one generation to the next thereby increasing deformation and the risk of extinction [15]. Moreover, there is little information in the literature on Li medicines and its relationship with the traditional culture of the Li people. Therefore, it is imperative to document and study Li medicines in order to conserve traditional herbal knowledge. The objective of this paper is to document traditional knowledge on the use of medicinal plants by the Li people and to discuss relevant factors accounting for a decrease in the use of Li medicinal plants.

## Material and methods

### Study sites

We conducted field work in three villages (Zha-zao, Fu-bao, and Jia-xi), which are located in Ledong Li Autonomous County, southwest of Hainan Province between N 18°24′–18°58′ and E 108°39′–109°24′ (Fig. 1). Ledong County covers an area of 2747 km$^2$ and occupies about 8.3% of Hainan's total territory. The study area is characterized by abundant rainfalls (1500–2000 mm yearly) and mild temperature (23–25°C per year) [17]. It is also rich in plant products, such as areca nut (*Areca catechu*), litchi (*Litchi chinensis*), longan (*Dimocarpus longan*), mango (*Mangifera indica*), cassava (*Manihot esculenta*), and passion fruit (*Passiflora edulis*). Ledong County has a population of about 500 000 inhabitants and Li ethnic group accounts for nearly 37% of the total population. In the three studied villages, the population is estimated at less than 3000 inhabitants, including 90% of Li people.

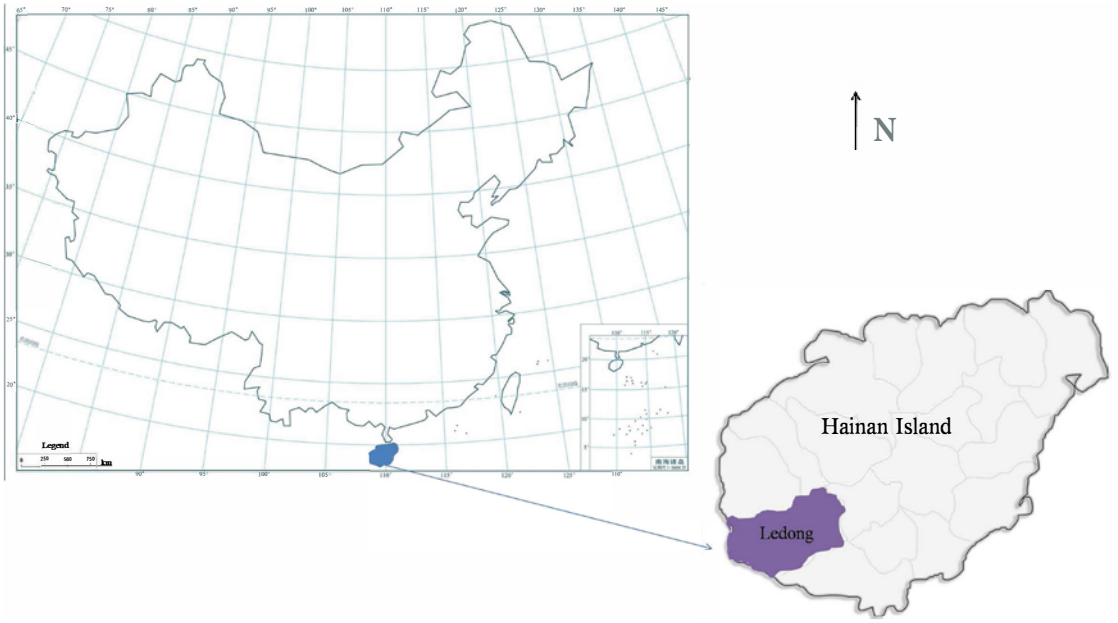


**Fig. 1** The study area on the Hainan Island.

### Data collection

The field works were carried out in three villages of Ledong Li Autonomous County from February to March 2012 and in July 2013. Data on medicinal plants used by the Li people were collected using the semi-structured interview approach [18], key informant interviews, participatory observations, and market surveys. Thirty knowledgeable people (elders or native herbal doctors) were chosen as key informants, with their ages ranging from 25 to 75 years. About 70% of the informants were more than 50 years old. To each respondent, questions were asked to assess their awareness about wild plants used in their area, local names of plants, parts used, mode of use, place of harvest, and habitats of each plant [19]. Voucher specimens of plants were collected in the field with the assistance of local residents. Plant species were identified by referring to Flora of China online and the Scientific Database of China Plant Species. The voucher specimens were deposited in the herbarium of Ethnobotany, Minzu University of China.

The mean proportion of commonly treated ailments, the parts of plants used and the methods of preparation of medicinal plants were evaluated using the cross-table analysis tool in Excel software. Recent existing literature on Li medicines were obtained by searching on SCI-Expanded (SCIE) and China National Knowledge Internet (CNKI) databases. Relevant data that could facilitate an analyses and comprehension of changes in the use of plants for Li medicines were collected by consulting literatures from the National Bureau of Statistics and processed in Excel software.

## Results

### Medicinal plants and their uses

A total of 50 medicinal plant species in 48 genera and 36 families were reported by Li people from the study area (Tab. 1). The three most represented families were that of Leguminosae (seven species accounting for 14%), Compositae, and Euphorbiaceae (comprised both of three species and accounting for 6% respectively). The most frequently used plant species were *Fordia cauliflora*, *Equisetum ramosissimum*, *Zanthoxylum nitidum*, and *Alpinia oxyphylla*. *Hedyotis ampliflora*, *Syzygium hainanense*, and *Libanotis seseloides* were equally used as wild fruits and wild vegetables, respectively.

**Tab. 1** Plants species for medicinal purposes in Ledong County of Hainan Island.

| Scientific name | Family | Local name | Ailments | Methods of preparation | Part used | Modern pharmacological activities | Voucher No. |
|---|---|---|---|---|---|---|---|
| *Adiantum capillus-veneris* L. | Adiantaceae | | Oliguria, hepatitis | Decoction | Whole plant | Anti-inflammatory [46] | HN1201 |
| *Alpinia japonica* (Thunb.) Miq. | Zingiberaceae | Duo giu | Pain, dyspepsia | Decoction, crushing | Root, fruit | | HN1202 |
| *Alpinia oxyphylla* Miq | Zingiberaceae | Zi yen | Kidney ailments, common cold | Decoction | Fruit | Anti-angiogenic [47] | HN1203 |
| *Amorpha fruticosa* L. | Leguminosae | | Bleeding wounds, overheating, endogenetic toxins | Decoction, macerated in alcohol, poultice | Flower | | HN1204 |
| *Andrographis paniculata* (Burm.f.) Nees | Acanthaceae | Me sai hao | Overheating, endogenetic toxins, bronchitis | Decoction, crushing, poultice | Aerial part | Upper respiratory tract infectious diseases [48] | HN1205 |
| *Antidesma bunius* (L.) Spreng. | Euphorbiaceae | Pa ban nong | Diarrhea | Decoction, crushing, poultice | Leaf, root | | HN1206 |
| *Antidesma montanum* BI. | Euphorbiaceae | | Pain | Decoction | Root, leaf, stem | | HN1207 |
| *Ardisia crenata* Sims | Myrsinaceae | | Pain, rheumatism, lymphnoditis | Crushing, poultice | Root | | HN1208 |
| *Asparagus cochinchinensis* (Lour.) Merr. | Asparagaceae | Ze men len | Constipation, lungs diseases | Decoction, poultice | Root | Immune-related cutaneous diseases [49] | HN1209 |
| *Bryophyllum pinnatum* (L. f.) Oken | Crassulaceae | | Pain, edema, mammitis | Decoction, crushing, poultice | Whole plant | Anti-inflammatory [50] | HN1210 |
| *Caesalpinia pulcherrima* (L.) Sw. | Leguminosae | | Blood problems | Crushing, poultice | Seed | Antiulcer [51] | HN1211 |
| *Celosia argentea* L. | Amaranthaceae | Gan ba lan | Dizziness | Boiled in soup | Seed | Preventing urolithiasis [52] | HN1213 |
| *Crotalaria pallida* Ait. | Leguminosae | | Kidney deficiency, dizziness | Decoction | Seed | | HN1214 |
| *Datura stramonium* L. | Solanaceae | | Convulsion | Decoction, macerated in alcohol | Leaf, flower, seed | | HN1215 |
| *Dianella ensifolia* (L.) DC. | Liliaceae | Gen wi ting | Abscess, tinea | Decoction | Rhizome | | HN1216 |
| *Dracaena angustifolia* (Medik.) Roxb. | Agavaceae | Pong hi | Gastroenteric disorder | Decoction | Young stem | Anti-inflammatory [53] | HN1217 |

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**Tab. 1** Continued

| Scientific name | Family | Local name | Ailments | Methods of preparation | Part used | Modern pharmacological activities | Voucher No. |
|---|---|---|---|---|---|---|---|
| *Eclipta prostrata* (L.) L. | Compositae | | Hepatitis | Decoction, macerated in alcohol | Aerial part | Anti-inflammatory [54] | HN1218 |
| *Equisetum ramosissimum* Desf. | Equisetaceae | Zu nang | Fractures | Decoction | Aerial part | Antioxidant [55] | HN1219 |
| *Erigeron acer* L. | Compositae | | Pain | Decoction, crushing, poultice | Whole plant | | HN1220 |
| *Eryngium foetidum* L. | Umbelliferae | | Cough, dyspepsia, snakebite | Decoction, poultice | Whole plant | Antimicrobial [56] | HN1221 |
| *Exbucklandia tonkinensis* (Lec.) H. T. Chang | Hamamelidaceae | | Timber | Decoction, macerated in alcohol, poultice | Stem | | HN1222 |
| *Flemingia philippinensis* Merr. & Rolfe | Leguminosae | | Mosquito bites, inflammation | Decoction | Seed | High bacterial inhibitory [57] | HN1223 |
| *Fordia cauliflora* Hemsl. | Leguminosae | Zhi hlou van | Stomatitis | Poultice | Leaf | | HN1224 |
| *Hedyotis ampliflora* Hance | Rubiaceae | Mian la wa | Bleeding wounds, trauma | Decoction | Whole plant | | HN1225 |
| *Hedyotis costata* (Roxb.) Kurz | Rubiaceae | Tha wong | Trauma | Decoction, poultice | Leaf | | HN1226 |
| *Helicteres angustifolia* L. | Sterculiaceae | Pa bian | Snakebite | Decoction, crushing, poultice | Whole plant | | HN1227 |
| *Jasminum nervosum* Lour. | Oleaceae | Ra ri | Hypofunction | Decoction, crushing, poultice | Whole plant | Antioxidant [58] | HN1228 |
| *Lantana camara* L. | Verbenaceae | | Overheating, endogenetic toxins, rheumatism | Boiled in soup, crushing, poultice | Whole plant | Antiulcer [59] | HN1229 |
| *Libanotis seseloides* (Fisch. & C.A. Mey. ex Turcz.) Turcz. | Umbelliferae | Gan hai kao | Overheating, endogenetic toxins | Crushing | Leaf | | HN1230 |
| *Lycopodium japonicum* Thunb. | Lycopodiaceae | | Blood diseases, irregular menstruation | Decoction, crushing, poultice | Whole plant | | HN1231 |
| *Melastoma candidum* D. Don | Melastomataceae | | Edema, pain, bleeding wounds | Decoction | Root, leaf | | HN1232 |
| *Osbeckia opipara* C.Y. Wu & C. Chen | Melastomataceae | | Woman diseases | Decoction | Root, fruit | | HN1233 |

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**Tab. 1** Continued

| Scientific name | Family | Local name | Ailments | Methods of preparation | Part used | Modern pharmacological activities | Voucher No. |
|---|---|---|---|---|---|---|---|
| *Ottelia acuminate* (Gagnep.) Dandy | Hydrocharitaceae | | Overheating | Decoction | Root, leaf | | HN1234 |
| *Petrocosmea duclouxii* Craib | Gesneriaceae | | Bleeding wounds, snakebite | Decoction, crushing | Whole plant | | HN1235 |
| *Piper sarmentosum* Roxb. | Piperaceae | Be fiang | Rheumatism, gastritis | Decoction, crushing | Root | Anti-inflammatory [60] | HN1236 |
| *Plumbago zeylanica* L. | Plumbaginaceae | Hong ken | Rheumatism, sprains, pyogenic infections | Decoction, macerated in alcohol, poultice | Whole plant | Tumor cell suppressed [61] | HN1237 |
| *Polygonum perfoliatum* L. | Polygonaceae | Gang fi fa | Cough | Decoction | Leaf | | HN1238 |
| *Polyalthia suberosa* (Roxb.) Thwaites | Annonaceae | | Sprains, snakebite, overheating | Decoction, macerated in alcohol, crushing | Fruit, leaf, root, bark | | HN1239 |
| *Pothos chinensis* (Raf.) Merr. | Araceae | | Extravasated blood | Crushing | Whole plant | | HN1240 |
| *Pteris cretica* L. var. *nervosa* (Thunb.) Ching & S.H. Wu | Pteridaceae | Lonly | Abdominal pain | Decoction | Whole plant | | HN1241 |
| *Rauvolfia verticillata* (Lour.) Baill. | Apocynaceae | | Pain, hypertension | Decoction | Root | | HN1242 |
| *Salvia plebeia* R. Br. | Labiatae | | Sprains, flu, lymphadenitis | Decoction, poultice | Whole plant | Anti-inflammatory [62] | HN1243 |
| *Sapium baccatum* Roxb. | Euphorbiaceae | | Edema, insecticide | Decoction | Bark | Antimicrobial [63] | HN1244 |
| *Senna tora* (L.) Roxb. | Leguminosae | | Inflammation, constipation, dizziness | Decoction, macerated in alcohol, poultice | Seed | Anthelmintic [64] | HN1212 |
| *Streblus asper* Lour. | Moraceae | | Snakebite, constipation | Decoction | Root, bark | Anti-diabetic [65] | HN1245 |
| *Syzygium hainanense* Chang et Miau | Myrtaceae | Zi pu | Burn | Decoction, crushing | Fruits, bark | | HN1246 |
| *Tadehagi triquetrum* (L.) H. Ohashi | Leguminosae | Ko gai | Oliguria, sore-throat | Decoction, crushing | Whole plant | | HN1247 |
| *Tilia tuan* Szyszyl. | Tiliaceae | | Rheumatism, pain, sprains | Decoction, macerated in alcohol | Root | | HN1248 |
| *Viscum coloratum* (Kom.) Nakai | Loranthaceae | | Rheumatism, lumbago | Decoction | Aerial part | Inhibitory effects on the formation of osteoclast-like multinuclear cells [66] | HN1249 |

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**Tab. 1** Continued

| Scientific name | Family | Local name | Ailments | Methods of preparation | Part used | Modern pharmacological activities | Voucher No. |
|---|---|---|---|---|---|---|---|
| *Zanthoxylum nitidum* (Roxb.) DC. | Rutaceae | Wu za wu mao | Inflammation, bleeding wounds | Crushing | Leaf | Antiulcer [67] | HN1250 |

We recorded about 18 human ailments that were treated using medicinal plants. These plants were primarily used to heal bleeding wounds (12.9%), to treat body pains (11.4%), gastrointestinal disorders (11.4%) and trauma (10%; Fig. 2). The most common bleeding wounds in the Li area were caused by scratches, chops, and snakebites. On the other hand, the most common gastrointestinal disorders were stomachache and constipation, meanwhile the forms of trauma recorded were sprains and fractures or contusions. Women diseases mainly included menstrual disorder, amenorrhea, and metrorrhagia. With respect to trauma, it could be linked to the surrounding mountainous and inconvenient traffic living environment. In addition, Li people do not sell herbs or collect them for other sellers, but rather use them to heal household, family and friend diseases.

### Parts of plants used and mode of preparation

The main parts of plants which are widely used for medicinal purposes include the entire plant (32%), roots (26%), leaves (18%), and aerial parts (6%) according to Fig. 3. The entire plant was mostly used for the treatment of snakebite, rheumatism, and sprains, while the roots were mostly used for analgesia and detoxification.

In the present study, plants remedies were mainly prepared by decoction (84%), then by crushing (38%), poultice (34%) and maceration in alcohol (16%; Fig. 4). Decoction is a common way for local people to prepare medicines. It enables the main chemical compounds to dissolve easily after heating and makes it readily available to the body [20]. Most medicinal plant preparations were taken orally (88%), while 38% were administered for diseases such as wounds or skin infections. Dosages were given differently depending on the age of the patient and severity of the condition being treated.

### Life form and origin of herbal species

The life forms of the identified species included trees, shrubs, herbs, and climbers. Shrubs and herbs accounted for 80% of all the plant species recorded. About 86% of all the species were widely distributed in China and easy to harvest. Only *Hedyotis ampliflora* was endemic to Hainan Island while *Ottelia acuminata* was endemic to China. Six species (10%) were cultivated species including *Andrographis paniculata*, *Bryophyllum pinnatum*, *Amorpha fruticosa*, *Caesalpinia pulcherrima*, *Celosia argentea*, and *Crotalaria pallida*. Cultivation of medicinal plants cannot only conserve the plant resources, but also make them available for harvesting and use.

Li people used to practice swidden agriculture, resulting in their lands being vulnerable to alien invasive plants [21]. Six medicinal plants used by Li people were alien species originating from different parts of the world, including *Celosia argentea*, *Bryophyllum pinnatum*, *Equisetum ramosissimum*, *Senna tora*, *Datura stramonium*, and *Lantana camara*.

## Discussion

### Comparative study of Li medicinal plants with previous reports

Among the 50 plant species used by Li people, 24 species (48%) were found to have never been documented in the ethnobotanical investigation of Li ethnic group of Hainan Island [22–24]. On the other hand, the 26 remaining species (52%) like *Andrographis paniculata*, *Dracaena angustifoli*, *Celosia argentea*, *Rauvolfia verticillata*, *Bryophyllum pinnatum*, *Equisetum ramosissimum*, *Antidesma montanum*, *Tadehagi triquetrum*, *Asparagus cochinchinensis*, and *Melastoma candidum* have been previously documented in the literature. Among the 26 documented species, the medicinal application methods of 17 species were similar meanwhile nine new application methods were recorded. According to previous studies [22–24], herbaceous species

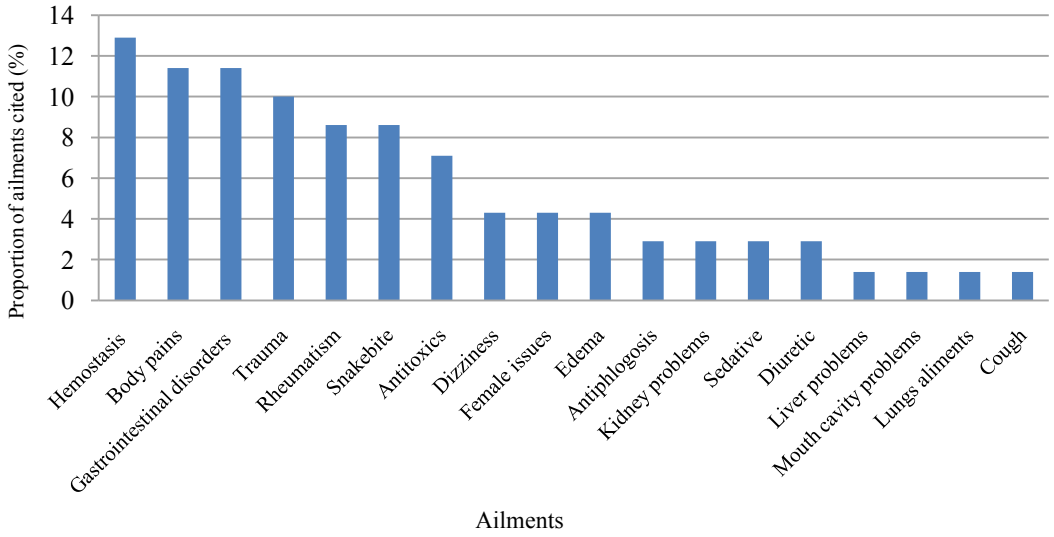


**Fig. 2** Proportion of ailments treated with Li medicinal plants.

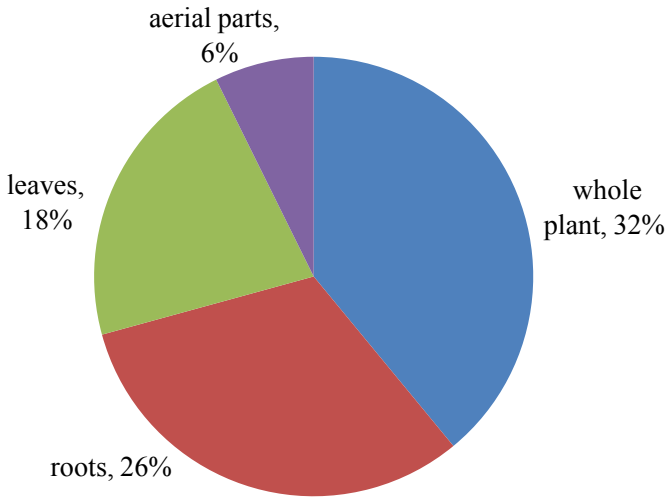


**Fig. 3** Plant parts used for medicinal purposes and proportion of total medicinal species.

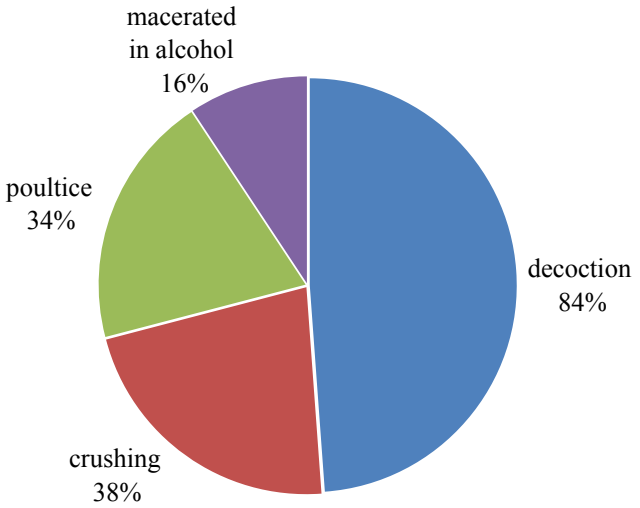


**Fig. 4** Medicinal plants preparation methods.

were the most used among all plants recorded. Similarly, the most common utilized mode of treatment was by oral ingestion, and medicinal plants were primarily used to treat injuries, rheumatism, and infections. The characteristic diseases recorded in the study area were directly related to the mountainous, hot and humid environmental conditions of the area inhabited by the Li ethnic group.

Twenty-two species (44%) have been previously studied using modern research methods. These include *Bryophyllum pinnatum*, *Adiantum capillus-veneris*, *Piper sarmentosum*, *Caesalpinia pulcherrima*, *Streblus asper*, *Jasminum nervosum*, *Eryngium foetidum*, *Plumbago zeylanica*, *Senna tora*, and *Alpinia oxyphylla* (Tab. 1). The chemical compounds extracted from these plants were proven to be efficient bio-actives. They are important antioxidants, anti-inflammatory, antiulcer and anti-diabetic products. Among these 22 medicinal plants, the traditional medicinal functions of 10 species have been tested and confirmed by modern methods. These are *Andrographis paniculata*, *Adiantum capillus-veneris*, *Bryophyllum pinnatum*, *Sapium baccatum*, *Salvia plebeian*, *Senna tora*, *Piper sarmentosum*, *Plumbago zeylanica*, *Zanthoxylum nitidum*, and *Lantana camara*. Further pharmacological investigations will help to evaluate the traditional uses of local medicinal plants.

## Possible factors accounting for a decrease in the use of Li medicinal plants

**Loss of plant diversity.** In the present study, only 50 traditional medicinal plant species were recorded in Ledong, the largest county of Hainan Province. This appears to be less than other ethnobotanical investigations conducted in the Li ethnic group [22–24]. Plant diversity in Ledong was compared with that of

**Tab. 2** Comparison of medicinal plants between Ledong and other counties.

| County | Acreage ($km^2$) | Population ($10^4$) | Ethnic minorities | Climate | Family | Genus | Species |
|---|---|---|---|---|---|---|---|
| Ledong, Hainan | 2763 | 50.0 | Li | Tropical monsoons | 36 | 48 | 50 |
| Wuzhishan, Hainan | 1128 | 46.5 | Li | Tropical mountain | 125 | 360 | 515 |
| Jingxi, Guangxi | 3322 | 65.0 | Zhuang | Southern subtropical monsoon | 67 | 104 | 116 |
| Jinping, Yunnan | 3677 | 35.6 | Miao, Yao, Dai | Tropical monsoons | 64 | 101 | 116 |
| Wenshan, Yunnan | 2977 | 48.9 | Zhuang, Miao | Southern subtropical monsoon | 92 | ** | 220 |

** The data were not available.

some similar counties including Wuzhishan, Jingxi, Jinping and Wenshan (Tab. 2). The counties are located in the tropical areas of south China and have diverse ethnic minorities with small populations. They have a similar land area, climate, vegetation type, and population density [25]. Tab. 2 reveals that the number of medicinal plants recorded in Ledong is much less than that in the other four administrative zones. Despite its small surface area, Wuzhishan has the most abundant plant diversity of the province.

**Change of land use.** The decline in the use of medicinal plants by the Li ethnic group appears to be caused by the mode of land use. Referring to the *Hainan Statistical Yearbook* between the year 2008 and 2012 [26–31], we found that tropical crops planted per unit area in Ledong increased by about 8% against 4% in Wuzhishan (Fig. 5). The proportion of tropical crops on the total area of Ledong was much lower than that in Wuzhishan's before 2011. Afterwards, the former grew rapidly and was almost close

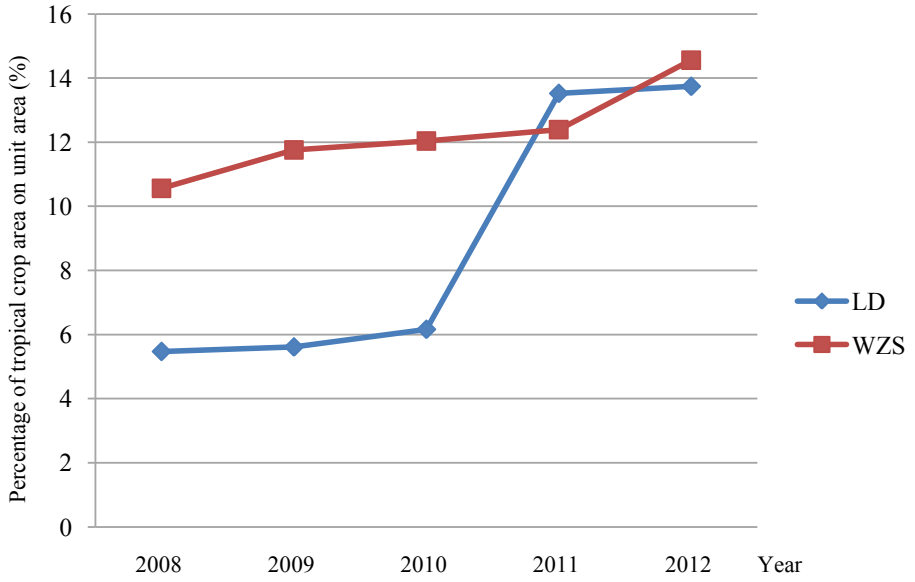


**Fig. 5** Comparison of the proportion of tropical crops per unit area between Ledong (LD) and Wuzhishan (WZS) between the year 2008 and 2012.

to the latter. Despite that the Ledong County is more than twice as larger in size than the Wuzhishan County (Tab. 2), they possess almost the same proportion of tropical cropped area. However, the abundance in medicinal plants have become fewer in Lendong than in the Wuzhishan County. As a result of further comparative analysis of the two counties, the decrease in medicinal plants of Ledong appears to be caused not only by the expansion in surface areas planted with tropical crops but also because of the specific kinds of tropical crops cultivated (Fig. 6).

Among the tropical crops cultivated, there is increased cultivation of rubber trees, fruit trees, and vegetables. Comparisons between the three types of tropical crops in Ledong, Wuzhishan, and Jinping using the *Statistical Yearbook* from 2007 to 2012 (Fig. 6) [26–35], reveals that the output of each tropical crop in Ledong was much larger than that in the other two counties. Between 2007 and 2010, the dry rubber yield of Ledong was basically steady. However, there was a sudden increase between 2010 and 2011 in rubber production as well as for fruits and vegetables. With the rapid expansion of tropical crops, land available for medicinal plants is much reduced nowadays.

The intensive cultivation of tropical cash crop has resulted in a huge change of land use in most areas of Hainan Island. The tropical cash crops, such as rubber, cassava, eucalyptus, sugarcane, anti-season vegetables, and tropical fruits (coconut, banana, areca, pineapple, and papaya), have been cultivated widely nowadays. For example, there are about 491 000 km$^2$ rubber estate on Hainan Island [36], making Hainan the second largest natural rubber plantation base of China. The large-scale rubber estate was implanted at the cost of deforestation, which has lead to the loss of natural habitat and traditional agricultural ecosystems. This large-scale destruction has accounted for the reduced abundance of local medicinal plants.

**Threatened traditional knowledge.** As the nomenclature and classification of medicinal plants is closely related to the Li's cultural diversity [37], it represents the wisdom and experience of medicinal plant resources used by the Li people. The traditional knowledge of Li medicines is orally transferred from generation to generation. More and more young people prefer to work in urban areas and offer less time to learn traditional medicinal knowledge. This is seriously affecting the transfer of cultural and traditional practices between generations and is a driving factor of acculturation.

From this study, it was observed that the old generation was more willing to use medicinal plants as primary health care. However, with the rapid expansion of tropical cash crops, local medicinal plants have decreased significantly. The elders cannot find herbs in the mountains as before. To this effect, there is limited use of herbs by the elders to treat their common diseases and consequently, they have to rely on modern health care [38]. The gradual reduction in Li medicinal plants, it is inevitably

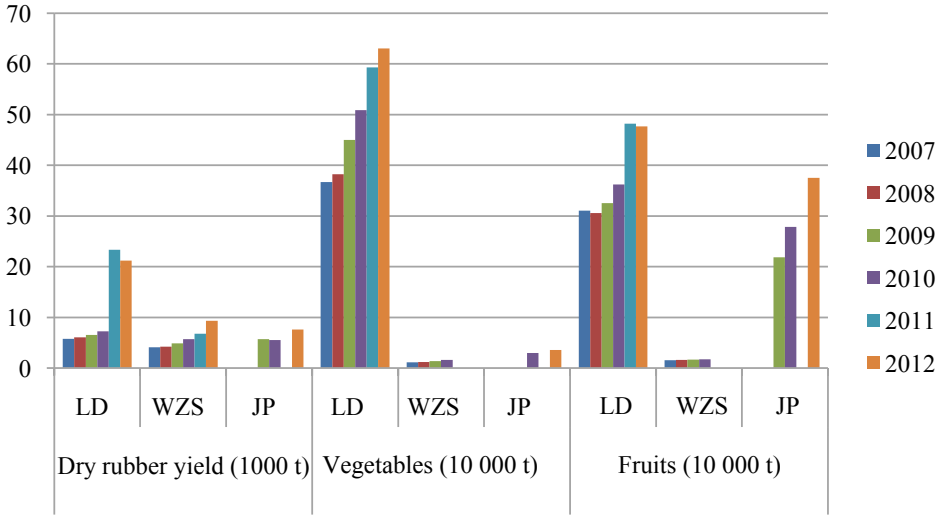


**Fig. 6** The dynamic change of some main tropical crops in Ledong (LD), Wuzhishan (WZS), and Jinping (JP) from 2007 to 2012.

threatening their relevant traditional knowledge. For the young people living in urban areas which are far from the elders, the possibility to find or harvest medicinal plants is much difficult. Similarly, the vernacular names and culture of local plants will be forgotten, together with their uses and preparations methods. The impact of large-scale monospecific agro-industrialization is an important threat to traditional plants diversity and to the related traditional medicinal knowledge and culture.

To date, there are many uncertainties about the efficiency and importance of Li medicinal plants thereby making it difficult to be developed. Once its economic benefits and cultural values get accepted, its use and conservation will be greatly promoted [39]. According to traditional medical systems of Li ethnic group, the traditional uses can provide references for the development of modern therapies to some extent. For instance, some Li medicines have been studied and have shown good clinical efficacy, such as *Cephalotaxus hainanensis*, a good medicine for the treatment of leukemia; and *Calophyllum inophyllum* with anti-HIV ingredients [40]. To date, the drugs and products made from Li medicinal plants are still quite few [41]. Some species like *Alpinia oxyphylla*, known as one of the top four southern medicines (the other three are *Areca catechu*, *Amomum villosum*, *Morinda officinalis*), is now widely cultivated by farmers. Similarly, efficient medicinal plants such as *Fordia cauliflora* [42] and *Helicteres angustifolia* [43] can be taken into consideration for potential development of medicines. With the increased demand of herbal products in the international market [44], there is a possibility that the Li medicine will attract more interests.

In addition, the local government could take measures to conserve the culture and traditional medicines of the Li people by defining relevant policies for biodiversity conservation, promoting the consideration of the conservation of important biodiversity and community values by large-scale agro-industrialization projects, building cooperation with research institutions and corporations, encouraging young people to learn and cultivate medicinal plants, conducting training courses or workshops about the potential value of local medicinal plants [45], and facilitating propagandas about the culture of medicinal plants used by Li ethnic group.

## Conclusion

Hainan is rich in biodiversity thanks to its favorable geographical conditions, which endows the Li medicine with distinct characteristics and compositions. However, only 50 medicinal plant species in 36 families were recorded in Ledong County. Compared to other regions, the number of medicinal plant species is lesser in Ledong County. Similarly, the plants are less abundant and available than in the past. The transfer of traditional knowledge between generations is disrupted. The increased plantation of cash crops especially rubber trees, vegetables and tropical fruits in Ledong is a driving factor for this trend meanwhile in other regions like Wuzhishan and Jinping, plantation of cash crops are stable and areas of rich plant resources are nearly untouched. This accounts for the low abundance of medicinal plants in Ledong. Therefore, it is clear that the monospecific cultivation of cash crops on a large-scale level may affect the local ecosystem structure. If the situation continuous, the related traditional knowledge of Li medicine will be further threatened. This case study addresses on a broader view, a scenario of the impact of rapid economic development in tropical China on the reduction of biodiversity and the associated traditional knowledge.

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