



Assessing sustainable use of wild medicinal plants: a case study in the Naban River Watershed National Nature Reserve (NRWNNR), Yunnan/China

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Research

Abstract

Background: Commercially harvested wild medicinal plants are often subject to overharvesting. This study aims to examine the ecological requirements, collection status, harvest practices, sustainability of harvest and trade chain of five medicinal plant species and assesses the socio-economic importance of these medicinal plants for local households.

Method: We studied the abundance of five selected medicinal plant species in the surrounding areas of five selected villages. Harvest and trade related information was recorded by interviewing plant collectors and middlemen as well as pharmacies in Germany. For the ecological analyses concerning the occurrence of plants we performed ANOVA followed by LSD Post-Hoc tests. Correlations between profit from collection of medicinal plants and income per household in the five villages were calculated with the Pearson Correlation Coefficient.

Results: The results showed that (1) harvest practices are destructive for individual plants, (2) economic contribution of plant harvest varies between villages and species and (3) the amount of cash earned is negatively related to average per capita income in the village.

Conclusion: A management plan for sustainable harvest or cultivation is recommended to ensure the future existence of the plant species as well as the sustainability of market supply.

Keywords: Non-Timber Forest Products (NTFPs), wild collection, household economics, Traditional Chinese Medicine, sustainable harvest

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Background

Traditional and herbal medicine is getting more important and popular all over the world (Lee *et al.* 2008). According to the World Healthcare Organization (WHO), more than 80% of the world's population rely on the use of traditional medicinal products for their primary health care (Hamilton *et al.* 2003; Sun *et al.* 2007). In China for example, 30-50% of all health care delivered is in the form of Traditional Chinese Medicine (TCM; Lee *et al.* 2008; Li *et al.* 2008b). Globally, the use of plants as medicines represents by far the biggest use of biodiversity in terms of species numbers (Schippmann *et al.* 2003). The World Bank expects the trade of medicinal plants to grow up to a trading value of five trillion USD by 2050 (Bopana & Saxena 2007).

China is the world's biggest exporter of medicinal and aromatic plants (MAPs) and likewise an important importer (Cunningham *et al.* 2008). In 2013, China (without Hong Kong) exported 201,788 tons of MAPs equivalent to 1196.6 million USD, conversely it imported 99,175 tons of MAPs during the same period with a total value of about 212 million USD (UN COMTRADE; <http://comtrade.un.org/db/default.aspx>). Over the last ten years, the quantity of medicinal plants obtained from just one province in China (Yunnan) has increased tenfold (Hamilton 2004).

However, increase in the demand and consumption of medicinal plants puts more pressure on wild populations as large numbers of medicinal plants traded are collected from the wild (Hamilton 2004; Leaman 2006). For instance, of more than 11,000 medicinal plant species used in China, only 492 species (approximately 4%) are under cultivation (Hamilton 2004; Ji *et al.* 2004; Leaman 2006).

Medicinal plants are the main source of income for many people in rural areas. In some communities, 40-63% of household income originates from the trade of so-called Non-Timber Forest Products (NTFP) often encompassing medicinal plants (Boesi 2014; Rodríguez *et al.* 2006; Schippmann *et al.* 2003). Since prices for medicinal plants paid to the collectors are generally low, people tend to "mine" plant resources to generate more income in the short-term instead of managing their resources to achieve sustainable collection (Bopana & Saxena 2007). Today, many species already show a decline in availability in natural habitats (Boesi 2014; Botha *et al.* 2004; Cunningham 1994; Delgado-Lemus *et al.* 2014). The vulnerability of a plant population under harvesting pressure depends on the plant parts being harvested and the quantity, intensity and frequency of harvest (Schippmann *et al.* 2006). When whole roots of herbaceous plants are reaped

the harvest is entirely destructive and may put the population itself at risk of overharvesting (Cunningham 1994; Cunningham 2001). It is important to conserve and properly manage medicinal plant resources, not only to maintain biodiversity but also in order to improve rural economy and welfare of the local people, who depend on these plants for income and subsistence (Boesi 2014; Cunningham *et al.* 2008; Hall & Bawa 1993; Lee *et al.* 2008; Martin 1992; Shanley & Stockdale 2008; Sher *et al.* 2014).

The present study aimed to assess the ecological requirements, harvest practices, processing and trade chain of five commercially harvested medicinal plant species. Furthermore, the sustainability of current collection practices is tested in the Naban River Watershed National Nature Reserve in Yunnan province, P.R. China as well as the impact of collection on local livelihoods and its socioeconomic role in the area.

Materials and Methods

Study area

The study was conducted in the Naban River Watershed National Nature Reserve (NRWNNR), which is part of the Xishuangbanna Dai Autonomous Prefecture, Yunnan province, located within the Southeast Yunnan- Western Guangxi Centre of endemism (Ji *et al.* 2004; Yang *et al.* 2004). The climate of Xishuangbanna represents a transition between the subtropics and the tropics. Geographically it belongs to the East Asian Monsoon Region (Cao *et al.* 2006; Guo *et al.* 2002). Consequently, it is characterized by a rainy season from May to October and a dry season from November until April (Cao *et al.* 2006).

The tropical rain forests of Xishuangbanna are presently undergoing drastic changes. By the year 2003, the tropical seasonal rain forests lost 67% of its former size and nowadays only covers 4% of Xishuangbanna (Guo *et al.* 2002; Li *et al.* 2008a). More than 5280 plant species are documented in Xishuangbanna which equals 34.8% of total plant species in Yunnan and 14.9% of the Chinese flora (Fu *et al.* 2006). Almost 1000 of these species, mostly those growing in fallow land and forests are used by people (Liu *et al.* 2006).

The NRWNNR is located north of Jinghong township, covering an area of 267 km² (see Fig. 1). The Nature Reserve was established in 1991 and became a "National Nature Reserve" in 2000. The Reserve is managed according to the "Man and the Biosphere" program of the UNESCO (Dyer & Holland 1988). This study was conducted in five villages in the NRWNNR, namely Bengganhani, Danuoyou,

Manxinglongdai, Shijiazhai and Xiaonuoyoushangzhai. These villages were selected based on a previous study in which extensive

collection of medicinal plants has been shown (Ghorbani *et al.* 2011).

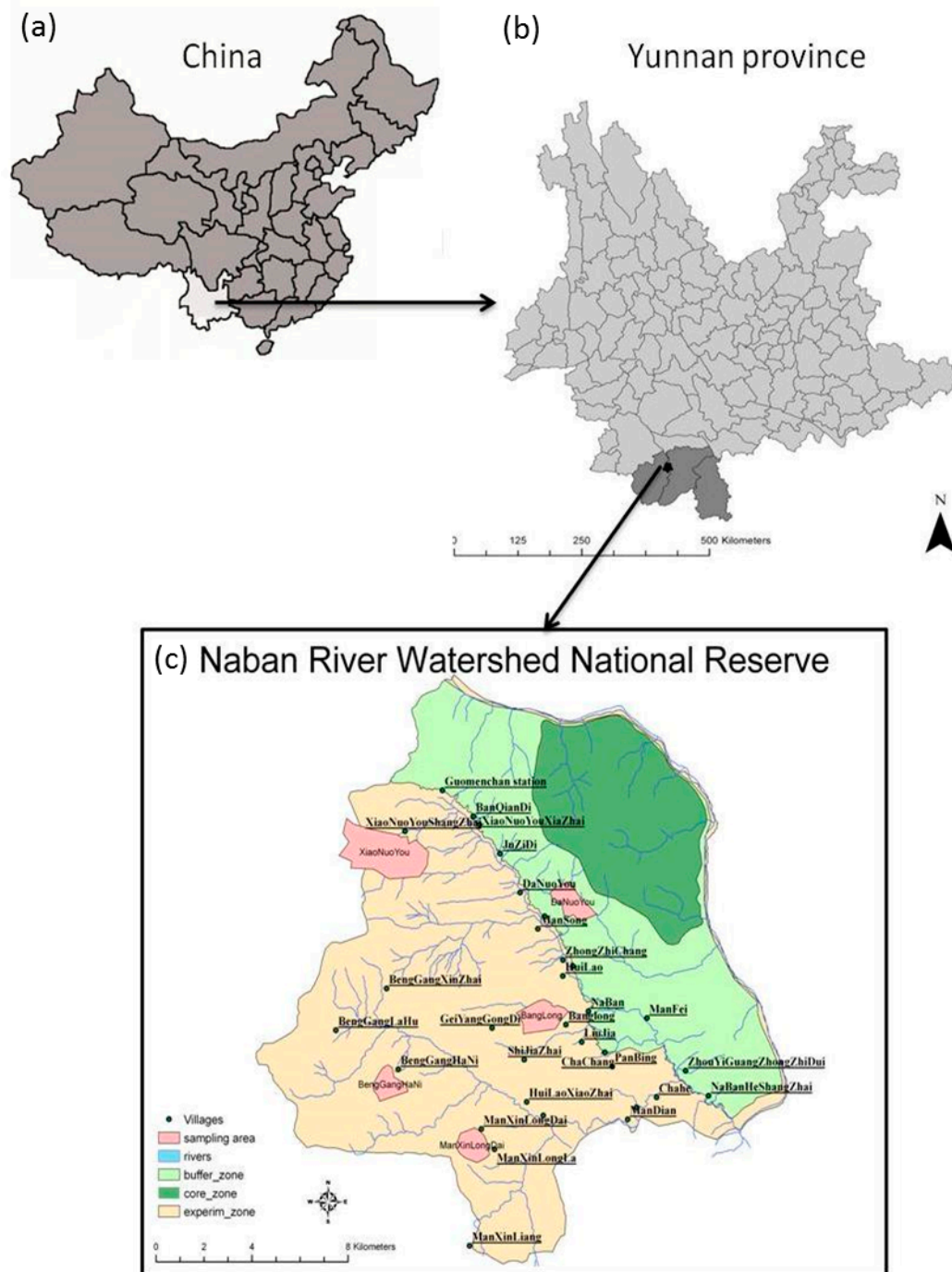


Figure 1. Location of the Research Area within China. Yunnan province is located in the south-west of China (a) and the Xishuangbanna Dai Autonomous Prefecture is located in the south of Yunnan (b). The selected villages within the Naban River Watershed National Nature Reserve are highlighted within the area (c).

Selected plant species

We selected five medicinal species for assessment based on their intensive collection and their economic importance in the region (Ghorbani *et al.* 2011; Ghorbani *et al.* 2012a; Fig. 2). These species

are *Asparagus filicinus* Buch-Ham. ex D. Don, *Asparagus subscandens* F. T. Wang & S. C. Chen, (both Asparagaceae), *Paris polyphylla* Sm., (Melanthiaceae), *Stemona tuberosa* Lour., (Stemonaceae) and *Tacca chantrieri* André,

(Taccaceae), the nomenclature follows the International Plant Names Index (2012). All plants are part of the Traditional Chinese Medicine (TCM) system and local folk medicines.

A. filicinus and *A. subscandens* (Fig. 2) are used as one ethno species in TCM, meaning they are not separated into two species and both are traded as “Tiandong” or “Asparagi Radix” (Bucher *et al.* 2011). *A. filicinus* is distributed in the Himalayan region whereas *A. subscandens* is endemic to Yunnan and listed as threatened in the Red List book of China (Wang & Xie 2004). The roots of both species are

tuberous. *A. filicinus* is used medicinally in India, Nepal, China and Vietnam (Joshi & Joshi 2000; Rajbhandari *et al.* 2009; Sharma & Thakur 1994).

P. polyphylla (Fig. 2) is one of the most potent and valuable plants in TCM and is traded as “Rhizoma Paradisi” (Long *et al.* 2003; Madhav *et al.* 2010). It is a perennial herb with annulate rhizomes which are used medicinally. It is listed as vulnerable in the IUCN Red List (Baillie *et al.* 2004). It is found in Bhutan, India, Laos, Myanmar, Nepal, Thailand, Vietnam, Taiwan and China. It grows at elevations between 100 and 3500 m a.s.l. mostly in moist, shaded habitats and forests (Long *et al.* 2003).



Paris polyphylla Sm., flowering



Tacca chantrieri André., flowering



Asparagus subscandens F. T. Wang & S. C. Chen



Asparagus filicinus Buch- Ham. ex D. Don



Stemona tuberosa Lour., leaves

Figure 2. Pictures of the aboveground parts of the selected plant species. *P. polyphylla*, *T. chantrieri* and *A. filicinus* show erect growth form whereas *A. subscandens* and *S. tuberosa* are climbers. Although *Asparagus* spp. are regarded as an ethnospecies their leaflets display different width and are easily distinguishable in the field. All photos taken by S.F. Bucher.

S. tuberosa (Fig. 2) is a perennial herb growing as a vine and has tuberous roots which are used in TCM as “*Stemonae Radix*” (Greger 2006). *S. tuberosa* is distributed in Bangladesh, Cambodia, India, Laos, Myanmar, Philippines, Thailand, Vietnam and China. It grows in forest margins, thickets, mountain slopes and besides trails at elevations between 300-2500 m a.s.l. (www.efloras.org).

T. chantrieri (Fig. 2) is a perennial plant with rhizomes. It is also used in Vietnamese and Thai traditional medicine (Huai & Pei 2004; Lemmens & Bunyaphatsara 2003) and is listed as vulnerable in the Red List book of China (Wang & Xie 2004). It is distributed in the subtropical regions of South East Asia and occurs especially in humid areas between 200 and 1300 m a.s.l., mainly in forests, valleys and along rivers (www.efloras.org).

Data collection and analysis

To record abundance and ecological requirements of selected species (elevation and canopy cover) we conducted transects in the forest areas surrounding the target villages and along riverbeds within the forest. Each transect was 500 m long and 4 m wide (a central line and two m distance to each side). All transects ran in parallel within a forest area being 100 m far from each other. A total of 29 transects at five study sites in the area were conducted (Fig. 1c). Directions were selected prior to fieldwork with the help of satellite images to cover as much of the forest area as possible. In each transect, the occurrence of individuals of selected plant species, their height, the distance from the starting point of the transect and its central line as well as forest canopy cover and elevation was recorded using a measuring tape, GPS devices and visual estimations.

Interviews were conducted in Chinese with 29 villagers from the selected villages who are active in medicinal plant collection and trading. The average household income differed between villages from RMB 1474 year⁻¹ in Shijiazhai to 1681 in Manxinglongdai and Danuoyou. Bengganhani had an average income of RMB 1537 year⁻¹ and in Xiaunuoyoushangzhai the average income per household was 1667 year⁻¹ (Wehner 2011). Before conducting interviews, permission was asked from informants. Information about the current harvest methods, annual harvest volume, places and time of collection, processing of harvested plant parts, sale prices, trade routes and annual income generated from collection of medicinal plants and local uses of the selected plant species were recorded following a standardized questionnaire (see supplement 1). In addition to that, a wholesaler in Menghai, five pharmacies in Jinghong town, a market for medicinal plants in Kunming (the capital of the province) as well

as three pharmacies in Germany (the “end” of the trade chain) were visited and information regarding trade of target medicinal plants, further processing and prices were recorded. Income generated from medicinal plant collection was compared to annual per capita income for each village to determine the contribution of medicinal plant harvest to the household cash income. Plants are traded as dried plant parts, therefore all information about weight is displayed as kilograms of sun-dried plant matter. Prices are given in Chinese Currency RMB (1 RMB equals USD 0.161 or EUR 0.144 on 11.05.2015).

To assess the amount of plant individuals needed for 1 kg of dried plant material, ten individuals of *A. subscandens* and *A. filicinus* were excavated, tubers were processed as described by collectors (boiled, peeled and sun-dried) and dry weight was recorded. Based on this information and the information on plant population size around the selected villages, we calculated how long the current populations would last in the different villages, if the harvest amounts would remain constant and 25% of all households are engaged in the harvest as it is currently the case. Since no information on regeneration and dispersal of these species was available, it could not be included in our calculations.

Ecological analyses concerning the occurrence of plants (elevation, forest or river transect and canopy cover) we performed ANOVA followed by LSD Post-Hoc tests. For mean values the standard errors are indicated. Correlations between profit from collection of medicinal plants and income per household in the five villages were calculated with the Pearson Correlation Coefficient. For all statistical analyses SPSS 13.0 was used.

Results

Plant population sizes and ecological requirements

The occurrence of plants in the forest depended strongly on elevation and canopy cover at specific sites and varied largely between forest areas surrounding the selected villages (Table 1). *S. tuberosa* was scarce in the region as were *P. polyphylla* and *T. chantrieri*. The latter ones were restricted to rather moist areas within the forest whereas *A. subscandens* was quite frequent and tolerant concerning the species-specific ecological requirements studied. The average elevation of the species was significantly different ($p < 0.001$; Table 1). *Asparagus filicinus* occurred at two sample sites only and seemed to be restricted to higher elevations, growing in areas above 1700 m a.s.l. *A. subscandens* was not limited to certain light conditions and occurred in areas ranging from 0-100% canopy cover with a mean of $69 \pm 19\%$.

Table 1. Average elevation |distribution of species studied

| Species | Elevation (m a.s.l.) | Canopy cover (%) | Beng Gang Ha Ni 1800 m | Da Nuo You 1200 m | Man Xing Long Dai 1700 m | Shi Jia Zhai 1400 m | Xiao Nuo You Shang Zhai 1500 m |
|-----------------------|-------------------------|------------------------|------------------------------|----------------------|--------------------------------|---------------------------|-----------------------------------------|
| <i>A. filicinus</i> | 1819 ± 24 | 77 ± 10 | 106 ± 43 | 0 | 2 ± 2 | 0 | 0 |
| <i>A. subscandens</i> | 1502 ± 231 | 69 ± 19 | 9 ± 4 | 40 ± 21 | 6 ± 3 | 77 ± 12 | 37 ± 9 |
| <i>P. polyphylla</i> | 1759 ± 122 | 80 ± 11 | 32 ± 14 | 0 | 39 ± 21 | 3 ± 3 | 5 ± 4 |
| <i>S. tuberosa</i> | 1622 ± 170 | 71 ± 13 | 5 ± 2 | 4 ± 3 | 0 | 1 ± 1 | 0 |
| <i>T. chantrieri</i> | 1092 ± 196 | 76 ± 15 | 0 | 23 ± 18 | 0 | 17 ± 12 | 0 |

Harvest volume and economical importance

Underground parts are used medicinally for all species selected. The collection is mainly carried out between November and March. Fresh roots or rhizomes are boiled, peeled (in the case of *S. tuberosa* and *Asparagus* spp.) and sun-dried before being traded.

Harvest volumes of plants (here expressed as dry matter), collected during one year, varied depending on plant species and site (Fig. 3). On average 24.0 ± 9.9 kg year⁻¹ of *Asparagus* spp., 12.3 ± 9.4 kg year⁻¹ of *P. polyphylla*, 33.1 ± 14.9 kg year⁻¹ of *S. tuberosa* and 0.2 kg year⁻¹ of *T. chantrieri* were harvested per collector. *Asparagus* spp., *P. polyphylla* and *S. tuberosa* were mainly collected in winter, which is the dry season (November-March) whereas *T. chantrieri* was collected all year round and was mainly used for subsistence rather than sale. In general, harvest volumes were highest in Shijiazhai and lowest in Danuoyou and Manxinglongdai (Fig. 3). Most of the villagers reported decreasing plant availability.

Villagers collect plants mainly on the way to and from fields. The collection was intensified in winter during the dry season when labour in the fields is reduced and thus income is low. About 83% of collectors interviewed reported the collection of *Asparagus* spp. for sale, whereas almost no one had collected *T. chantrieri* during the previous year. *P. polyphylla* was also collected sparsely due to scarce availability. Surprisingly, only nine villagers could name a medicinal use for *Asparagus* spp. whereas all villagers could name at least one medicinal use for *P. polyphylla* indicating that especially for the *Asparagus* species, the traditional ethnobotanical knowledge is absent.

The numbers of individuals necessary to obtain such yield volumes (Fig. 3) also varied depending on species. Up to 30 kg dried root can be obtained from one individual of *S. tuberosa* (pers. comm. from villager), whereas for one kg of dried plant root of *Asparagus* spp. on average 71 individual plants have

to be collected [54 (45-68) individuals of *A. subscandens* and 88 (57-185) of *A. filicinus*, respectively]. Based on this information, we found that assuming collection practices remain unchanged, the amount of *Asparagus* spp. will suffice for another 0.31 to 0.86 years of collection in Bengganhani, 0.82 to 1.43 years in Danuoyou, 0.069 to 0.562 years in Manxinglongdai, 0.27 to 0.64 in Shijiazhai and 4.97 and 38.08 years in Xiaonuoyoushangzhai. Due to the fact that we had to exclude regeneration, which will happen, these numbers are no reliable estimations but serve to indicate future trends and the current collection pressure on natural populations and are rather to be interpreted as a comparison between villages.

Prices for one kg of dried plant material varied vastly along the trade chain (see Fig. 4). In villages, one kg of *Asparagus* spp. was traded for RMB 22.26 (USD 3.58) in average, one kg of *P. polyphylla* for RMB 96 (USD 15.46), *S. tuberosa* for RMB 7.18 (USD 1.16) and *T. chantrieri* for RMB 6 (USD 0.97; Fig. 4). In between villages and markets there was no further processing of the plant parts that could justify the increase of prices. In pharmacies specialized in TCM in Germany, one kg of *Asparagus* spp. was 45 times of its price at the villages in China. The price difference for *P. polyphylla* was 21 times and for *S. tuberosa* it was 117 times of the price in the villages in China. *T. chantrieri* was not available in Germany.

The contribution of medicinal plants to the total household income varied between villages (1.14 % of household income in Danuoyou and 25.44 % in Shijiazhai). The harvest amount (kg year⁻¹) of *S. tuberosa* was significantly negatively correlated to average income per capita in each village ($r = -.611$, $p < 0.05$). Similarly, the amount of *P. polyphylla* collected was highly significantly related to the average income per capita ($r = -.995$, $p < 0.005$) as was the collection of *Asparagus* spp. ($r = -.653$, $p < 0.005$), that is poorer villages collected more intensively.

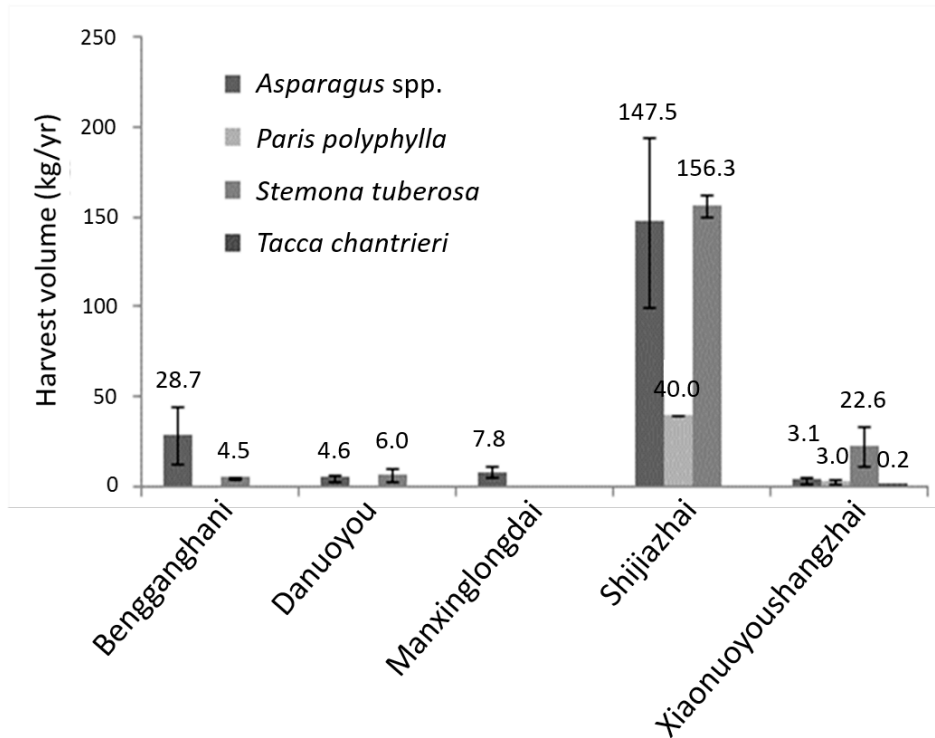


Figure 3. Harvest volume in kg per year and household in the selected villages. Grey shades are giving species identity; whiskers indicate the standard error. *Asparagus* spp. n= 24, *P. polyphylla* n= 4, *S. tuberosa* n= 10, *T. chantrieri* n= 1.

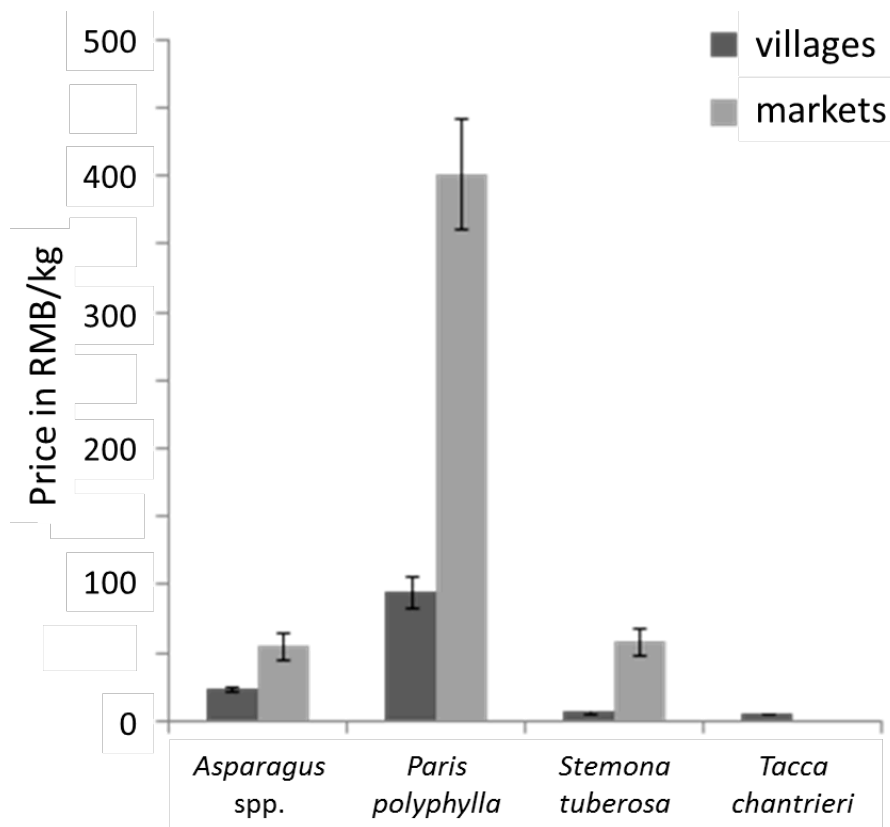


Figure 4. Prices per kg dried plant matter in RMB. Grey shades indicate location (dark= village, light= markets), whiskers give the standard error

Discussion

During the interviews, most of the villagers reported a decrease in plant availability, which seems to be a global issue (Boesi 2014; Botha *et al.* 2004; Cunningham 1994; Delgado-Lemus *et al.* 2014). Households with less assets and poorer families tend to collect more medicinal plants for cash generation than others which is also true for bamboo shoots (*Dendrocalamus* sp.) which are collected as food in the area (Ghorbani *et al.* 2012a). In Shijiazhai collection was highest and income lowest (RMB 1474 year⁻¹) of the selected villages. An explanation for this might be in the accessibility of plant sites that is good at Shijiazhai besides the fact that there is less agricultural land available compared to other villages. Although plant abundance was also high in Bengganghani, overall collection was much lower and the household income was higher (RMB 1575 year⁻¹). In Danuoyou and Manxinglongdai, the household income was highest (RMB 1681 year⁻¹), whereas collection was lowest. Paumgarten and Shackleton (2009) documented a similar pattern between NTFP collection and household economic status. Evidence from Boesi (2014) shows that gathering and especially trading of NTFPs has become more important and a crucial activity for the economy of whole villages or even towns during recent years. Our finding that collection of medicinal plants occurred mainly in winter supports this hypothesis. In our area, the collection of NTFPs generated up to 25.4% of the households' income, which underlines their economic significance for the region. The plant with highest economic value in our study (*P. polyphylla*) showed the strongest correlation of harvest volume (kg year⁻¹) to average per capita income. *Asparagus* spp. was second and *S. tuberosa* showed the weakest yet still significant correlation to the per capita income of the household. The lack of traditional knowledge regarding uses of medicinal plants - especially for *Asparagus* spp. - points to the fact that collection practices were brought to the area by outsiders. It illustrates that these medicinal plants are not the main components of local folk medicine, which exists in parallel to TCM, but instead are important in TCM. For *Asparagus* spp. we also found that if current collection practices remain unchanged, the populations are at high risk of going extinct at least in most of the villages. The use frequency of 0.017 (based on citation of species in free-listing interviews divided by the number of informants, varying between 0 and 1) has been reported for *A. filicinus* and 0.014 for *A. subscandens* in the study area (Ghorbani *et al.* 2012a). However, there was no difference in collection between the two *Asparagus* species (Bucher *et al.* 2011; Ghorbani *et al.* 2012a). The former species was proven to contain medicinally active compounds; however, no study has been

conducted to test the medicinal effectiveness of the latter species (Bucher *et al.* 2011; Joshi & Joshi 2000; Rajbhandari *et al.* 2009; Sharma & Thakur 1994). *A. filicinus* is distributed in the whole Himalayan region and is therefore much less susceptible to overharvesting than *A. subscandens* with limited distribution to Yunnan. This makes *A. subscandens* a priority species for conservation and further research on its medicinal properties and effectiveness is needed (Bucher *et al.* 2011). The use frequency reported for *P. polyphylla* is 0.05 and 0.09 for *T. chantrieri* (Ghorbani *et al.* 2012a). Considering the low harvest volume of *T. chantrieri* but high use frequency, it seems that the plant is only used locally by villagers and it is not collected commercially. Local people did not use *S. tuberosa* at all albeit the highest volume of dried plant matter harvest per household were recorded for this plant. According to a rapid vulnerability assessment (RVA, based on literature data, indigenous knowledge and field observations), all species (except *T. chantrieri* on which no data was available) are moderately vulnerable to overexploitation in the area (Ghorbani *et al.* 2012a).

Ecological and biological information on these plants are needed to fully understand harvest impacts on the population demographics (like regeneration, seed dispersal or propagation). However, this kind of data is scarce - not only for the species selected in this study but also for most medicinal plant species harvested from the wild (Cunningham *et al.* 2008). In our study we tried to reduce this gap of knowledge by collecting information on ecological requirements of the species. For *P. polyphylla* and *T. chantrieri* a sustainable collection is more likely to be realized since these species possess rhizomes instead of tuberous roots. Regeneration from rhizomes is possible and therefore modified collection practices in which only some parts of the rhizomes are harvested are recommended. However, this still needs to be tested scientifically and a way of transferring this knowledge to local people needs to be established.

In our study we detected exceptionally large increments in prices for plant material along the trading chain. For example, for *Asparagus racemosus* a 100% increase of price was recorded (Bopana & Saxena 2007) a number which is easily outstripped by our target species. Other studies showed that the collectors' urgent needs of cash are one of the reasons why prices are especially low at the villages (Sher *et al.* 2014). Since no further processing of plant material is required for these species, this increase in value is only generated by costs of transportation, storage and especially profit-making by the middlemen along the trade chain and

not via additional labour costs as proposed by Sher *et al.* (2014). Unfortunately, it is generally difficult to trace back medicinal plants to their original collection sites for there are many retailers and wholesalers involved in the trade chain. One option for rating plant collection is the FairWild Standard (Meinshausen 2006) which assesses sustainability not only based on ecological aspects as well as social and economic aspects. Knowing the origin of medicinal plants is therefore one of the basic demands expressed by the FairWild Standard in order to be able to achieve and certify sustainable collection from wild stands (Meinshausen 2006). Current collection is usually carried out without regulations- apart from laws which are not being enforced- and a proper management plan which also needs to be developed (Bucher *et al.* 2011). Village based cooperatives which, on the one hand monitor plant harvests and on the other hand take care of the marketing of the harvested plants could be a step to fulfil requirements of the FairWild standard and improve local livelihood. Since it is extremely difficult to monitor wild plant populations and control appropriate harvest, the potential cultivation of these plants by locals needs to be studied. This has already been successfully done for *P. polyphylla* in the north of the province (Yang *et al.* 2004) and for other plant species such as *Agave potatorum* in Mexico, where also ecological research has been conducted and awareness in the local people could be raised (Delgado-Lemus *et al.* 2014). There is a big potential for cultivation and marketing of the selected species in the area as has been demonstrated by Ghorbani *et al.* (2012b). Cultivation could prevent over-exploitation which arises either from more intensive or extensive harvesting. Other studies from Pakistan also emphasized the high value of training villagers in processing the plant material, since value-added activities are only conducted to the extent needed to meet the minimum quality standard required by the local market (Sher *et al.* 2014).

It has been shown that knowledge about wild food plants depends on the age of people (Ghorbani *et al.* 2012b); especially young generations from towns and wealthier communities lost traditional botanical knowledge (Boesi 2014; Pilgrim *et al.* 2008). Therefore, traditional knowledge on medicinal plants should be strengthened, and awareness to conservation should be raised especially among younger generations, to prevent future overexploitation of natural resources.

Conclusions

In summary, medicinal plants represent a commodity of economic importance in the area especially important for villagers with low income. Conservation of natural plant populations is important to sustain

household economics and livelihoods of people in the area. In the long term, mainly poor people are affected by unsustainable harvest of NTFP practice, as medicinal plants are one of their important income sources.

Declarations

List of abbreviations: medicinal and aromatic plants (MAPs), Non-Timber Forest Products (NTFP), Traditional Chinese Medicine (TCM).

Ethics approval and consent to participate: The study did not involve animals or the export of plant material. The benefit was shared by translating and publishing Bucher *et al.* 2011 in Chinese.

Consent for publication: The pictures were taken by SFB.

Availability of data and materials: The data is made public with this manuscript.

Competing interests: There are no competing interests.

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Authors' contributions: The research was designed by all authors. Data collection was carried out by SFB and AG. The analysis was done by SFB with the help of all co-authors who also critically discussed the manuscript. All co-authors agreed on this version.

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Annex 1. Questionnaire

Village:

Researchers:

Date:

Number:

Name:

Age:

Sex:

Occupation:

Education:

Ethnic group:

Household number:

Name of plant:

How does the plant look like?

What are the needs of the plants/ where is it growing?

Where do you collect the plants/ how many plants are there?

How are the plants collected and how are they selected?

Are there fewer plants than in former times?

Are the plants grown in home gardens?

Which parts are used:

In which way they are used:

Who is collecting the plants:

How much is collected:

How often are the plants collected:

When the plant is collected, how does it grow for the next year?

Is there a processing of the plant material and who is processing them?

Is it sold?

If yes, to whom and for how much?

How much is sold?

is it possible to ask for more money, if the quality is better?