Ethnomedicinal Analysis of Toxic Plants from Five Ethnic Groups in China

Huyin Huai, Qinqin Dong and Aizhong Liu

Research

Abstract

Toxic plants are important elements of ethnomedicine. Ethnomedicinal knowledge on toxic plants recorded from five indigenous people, Dai, Lahu, Miao, Tujia, and Wa in south and southwestern China, was summarized and analyzed based on available literature. A formula has been developed to evaluate toxic plants in the ethnomedicine of different ethnic groups using the Average Use Values (AUVs) of them. In total, 118 toxic plants often used as ethnomedicines were found from the five ethnic groups. These toxic plants were mainly distributed in 21 families, i.e., 75.4% of species and 68.1% of genera were concentrated in the 21 families. Araceae, Asteraceae, Euphorbiaceae, and Fabaceae are 4 important families which contain rich toxic plants. Eleven toxic plants were thought to be deadly toxic. These toxic plants were often used medicinally to treat injuries from falls, broken bones, and skin problems. Most toxic plants were medicinally used for multiple purposes in the five ethnic groups. The medicinal role of toxic plants was ascertained by comparing the AUVs or UVs in these ethnomedicines. The culture and the resources available were two main factors affecting ethnic healers selecting and using toxic plants.

Introduction

Poisonous plants are considered as detrimental to or adversely affecting human bodies and animals (Eddouks *et al.* 2002, Huai & Xu 2000, Levetin & McMahon 2008). However, toxins from plants are closely related to health aspects of humans and animals (Habermehl 2004, Levetin & McMahon 2008, Rates 2001) with "toxic" constituents from them often applied as effective treatments of some refractory symptoms of human disease (Harvey *et al.* 1998). The taxine alkaloid, for example, is a poisonous compound from yews (*Taxus* spp.) but has been found to have positive pharmacological functions in the treatment of cancer (Wang *et al*. 2005, Wilson *et al*. 2001). Toxic plants are very useful sources of compounds identified through screens to develop new drugs (Heinrich 2000, Rates 2001, Vetter 2000).

Indigenous knowledge is a very important and inexhaustible "information bank" for toxin research (Huai & Xu 2000). Plants that generally cause human beings or animals to have symptoms such as vomiting, stomach cramps, or difficulty breathing, are considered as "toxic plants" in traditional communities. Indigenous people all over the world are usually good at using toxic plants for different aims, such as hunting, wars, and treating diseases (Al-Qura'n 2005, Levetin & McMahon 2008, Neuwinger 2004). Some "toxic" plants are also nutritious (Bhattarai *et al.* 2009, Stinson 1992).

In traditional Chinese medicine (including ethnomedicine and folk medicine), "toxic" plants are commonly used to treat different health problems. This phenomenon is similar in other folk medicinal systems elsewhere

Correspondence

Huyin Huai, College of Bioscience and Biotechnology, Yangzhou University, Yangzhou 225009, P.R. CHINA.

Qinqin Dong, College of Bioscience and Biotechnology, Yangzhou University, Yangzhou 225009, P.R. CHINA.

Aizhong Liu, Xishuangbanna tropical Botanical Garden, Chinese Academy of Sciences, Kunming 650223, P.R. CHINA.
liuaizhong@xtbg.ac.cn

Ethnobotany Research & Applications 8:169-179 (2010)

Published: June 30, 2010

www.ethnobotanyjournal.org/vol8/i1547-3465-08-169.pdf

in the world (Al-Qura'n 2005, Arias 2000). Much Chinese ethnobotanical knowledge on toxic plants has been recorded in recent years (Guo *et al.* 1990, Guo *et al.* 1991, Qiu *et al.* 2006, Zhang 1996, Zhu *et al.* 2006). Previous studies on toxic plants focused on their chemical compositions and pharmacological effects (e.g., Farnsworth 1966, Rios & Waterman 1998, Vetter 2000). However, little is known about the relationships between the uses of toxic plants and their taxonomic and cultural contexts in different ethnic groups. Different ethnic groups may have their own knowledge and experiences of using plant resources even if they inhabit the same environments. In this paper, we focused on the toxic plants as reported in ethnomedicine sources on five ethic groups in south and southwest China and tried to answer the following questions: What health problems do ethnic healers usually use toxic plants to treat? Is there any difference in use of the same toxic plant by healers with different cultural backgrounds? Are there any correlations between toxic plants and use? All of the answers to these questions are important guidelines for the exploration of toxic bioresources.

Methods and materials

The Dai, Lahu, Miao, Tujia, and Wa ethnic groups live in mountainous areas of south and southwest China. Ethnobotanical investigations on their traditional medicine have been conducted and published in recent years (e.g., Dai (Lin *et al.* 2003b), Lahu (Zhang 1996), Lahu (Simao Institute of Ethnomedicine 1987), Miao (Qiu *et al*. 2006), Tujia (Zhu *et al.* 2006), and Wa (Guo *et al.* 1990, Guo *et al.* 1991). Toxic plants are commonly used in these ethnomedicinal systems. As our basic method, we have conducted a metadata analysis through harvesting of results from the above published materials. The information includes species name, family name, part used, use, preparation, toxicity, and special use.

Thus far, there are not standardized quantitative methods for evaluating the toxicity of a plant in ethnomedicine. Indigenous people often evaluate the toxicity of a plant based on their experiences. Here, we classified the toxicity of poisonous plants into three groups, i.e., low, medium, and high, based on the records of toxicity reported in the published sources. A "high" level means that this plant contains deadly toxins and leads a person or animal to quick death, even if only a small amount is taken. "Low" means that the plant can cause somebody poisoning when a great amount is used or it is used incorrectly. A "medium" plant is intermediary between "low" and "high."

The formula suggested by Phillips and Gentry (1993a & b) was used to evaluate the medicinal use value (*UVs*) of each species *s*:

$$UVs = \frac{\sum_{i=1}^{n} U_{is}}{n_s}$$

where U_{is} was the number of medicinal uses of species *s* mentioned by informant *i*, and *ns* was the number of informants who mentioned species *s*. Here, since this is a meta-data analysis of published texts (that could represent few too many interviews but are published as a single summary), *i* and *ns* have been treated as one for each ethnomedicinal system, while the number of ethnomedicines which was recorded for species *s* fluxuates. Based on this formula, when only one use of species *s* was recorded in only one ethnomedicine, its *UVs* was 1; if one use of another species was recorded by 4 ethnomedicinal systems respectively, its *UVs* was 1 as well. Because we were not tracking differences in the number of users but only in the uses per species with *UVs* it was very difficult to identify differences. In order to avoid this problem we developed a concept of average *UVs* (*AUVs*). *AUVs* can be calculated by the following formula:

$$AUV_s = UV_s \times \%P_s$$

where *UVs* was calculated based on the formula suggested by Phillips and Gentry (1993a & b). $\%P_s$ was the percentage of the ethnomedicinal systems examined that mentioned species *s*.

The relationships among the five ethnomedicinal systems and their use of toxic plants were analyzed by SPSS 16.0 (SPSS 2008) applying a Pearson's product-moment correlation.

Results and discussion

The diversity of toxic plants in the five ethnomedicine

In total, 118 species of ethnomedicinally toxic plants from the five ethnic groups were inventoried (Table 1), covering 51 families and 92 genera. The average ratio of number of species to family was 2.31. Twenty families (39.2%) contained at least two species of toxic plants (Table 2).

Table 1. Inventory of toxic medicinal plants recorded in Dai, Lahu, Miao, Tujia, and Wa ethnic groups in south and southwest China.

Plant Family/Species	Part Used	Toxicity	Reference
Apocynaceae			
Alstonia scholaris (L.) R.Br.	Bark, leaf	low	Guo *et al*. 1990
Kopsia officinalis Tsiang & P.T. Li	Fruit	low	Lin *et al*. 2003

Plant Family/Species	Part Used	Toxicity	Reference
Nerium oleander L.	Leaf, bark	high	Zhu *et al*. 2006
Periploca forrestii Schltr.	Root, whole plant	low	Qiu *et al*. 2006
Rauvolfia verticillata (Lour.) Baill.	Root	low	Lin *et al*. 2003
Araceae			
Alocasia macrorrhizos (L.) G. Don	Stem	medium	Guo *et al*. 1991
Amorphophallus rivieri Durieu ex Carrière	Tuber	medium	Zhu *et al*. 2006
Amydrium sinense (Engl.) H. Li	Whole plant	medium	Zhu *et al*. 2006
Arisaema consanguineum Schott	Corm	high	Zhu *et al*. 2006
Arisaema erubescens (Wall.) Schott	Tuber	medium	Guo *et al*. 1991, Qiu *et al*. 2006
Arisaema fargesi Buchet	Tuber	low	Zhu *et al*. 2006
Arisaema rhizomatum C.E.C. Fisch.	Tuber	medium	Zhu *et al*. 2006
Colocasia esculenta (L.) Schott	Rhizome	low	Zhang, 1996
Epipremnum pinnatum (L.) Engl.	Whole plant	low	Lin *et al*. 2003
Pinellia ternata (Thunb.) Breitenb.	Tuber	medium	Zhu *et al*. 2006, Qiu *et al*. 2006
Remusatia vivipara (Roxb.) Schott	Whole plant, tuber	high	Guo *et al*. 1991, Zhang, 1996
Typhonium roxburghii Schott	Whole plant, tuber	medium	Guo *et al*. 1991
Typhonium trilobatum (L.) Schott	Tuber, leaf	medium	Lin *et al*. 2003
Aristolochiaceae			
Aristolochia debilis Siebold & Zucc.	root	low	Qiu *et al*. 2006
Aristolochia griffithii Hook. f. & Thomson ex Duch.	root	low	Anonymous 1987
Aristolochia tubiflora Dunn	Root, whole plant	low	Qiu *et al*. 2006
Asarum sieboldii Miq.	Root, whole plant	low	Zhu *et al*. 2006
Asarum wulingense C.F. Liang	Whole plant	low	Qiu *et al*. 2006
Saruma henryi Oliv.	Root, rhizome	low	Zhu *et al*. 2006
Asparagaceae			
Hosta plantaginea (Lam.) Asch.	Flower	medium	Zhu *et al*. 2006
Asteraceae			
Achillea wilsoniana Heimerl	Whole plant	medium	Qiu *et al*. 2006
Carpesium abrotanoides L.	Whole plant	low	Zhu *et al*. 2006
Eupatorium chinense L.	Whole plant	medium	Qiu *et al*. 2006
Gynura procumbens (Lour.) Merr.	Whole plant	low	Lin *et al*. 2003
Siegesbeckia pubescens (Makino) Makino	Whole plant	low	Qiu *et al*. 2006
Solidago decurrens Lour.	Whole plant	low	Zhu *et al*. 2006
Spilanthes callimorpha A.H. Moore	Whole plant	low	Guo *et al*. 1990, Lin *et al*. 2003
Spilanthes paniculata Wall. ex DC.	Whole plant	medium	Guo *et al*. 1990
Balsaminaceae			
Impatiens uliginosa Franch.	Whole plant	low	Qiu *et al*. 2006
Berberidaceae			
Dysosma difformis (Hemsl. & E.H. Wilson) T.H. Wang	Root, rhizome	medium	Zhu *et al*. 2006, Qiu *et al*. 2006
Dysosma majorensis (Gagnep.) T.S. Ying			

Plant Family/Species	Part Used	Toxicity	Reference
Dysosma veitchii (Hemsl. & E.H. Wilson) Fu ex Ying	Root, rhizome	medium	Zhu *et al*. 2006, Qiu *et al*. 2006
Dysosma versipellis (Hance) M. Cheng ex T.S. Ying			
Nandina domestica Thunb.	Fruit, root	medium	Qiu *et al*. 2006
Cactaceae			
Opuntia stricta (Haw.) Haw.	Root, stem	low	Qiu *et al*. 2006
Campanulaceae			
Lobelia clavata E. Wimm.	Root, leaf	high	Guo *et al*. 1991
Lobelia colorata subsp. *taliensis* (Diels) T.J. Zhang & D.Y. Hong	Root	low	Guo *et al*. 1991
Caryophyllaceae			
Psammosilene tunicoides W.C. Wu & C.Y. Wu	Root	low	Qiu *et al*. 2006
Chloranthaceae			
Chloranthus erectus (Buch.-Ham.) Verdc.	Whole plant	low	Guo *et al*. 1990
Chloranthus henryi Hemsl.	Root	low	Zhu *et al*. 2006
Chloranthus holostegius (Hand.-Mazz.) S.J. Pei & Shan	Root, leaf	low	Guo *et al*. 1991
Colchiaceae			
Gloriosa superba L.	Rhizome	high	Lin *et al*. 2003
Combretaceae			
Quisqualis indica L.	Fruit	low	Guo *et al*. 1991
Convolvulaceae			
Pharbitis purpurea (L.) Voigt	Seed	medium	Qiu *et al*. 2006
Coriariaceae			
Coriaria sinica Maxim.	Root, leaf	medium	Zhu *et al*. 2006, Qiu *et al*. 2006
Cornaceae			
Alangium chinense (Lour.) Harms	Root, root bark	medium	Zhu *et al*. 2006, Qiu *et al*. 2006
Costaceae			
Costus speciosus (J. König) Sm.	Rhizome	low	Lin *et al*. 2003
Cucurbitaceae			
Trichosanthes cucumeroides (Ser.) Maxim.	Fruit	medium	Zhu *et al*. 2006
Dioscoreaceae			
Dioscorea bulbifera L.	Tuber, leaf	low	Guo *et al*. 1991, Zhu *et al*. 2006
Dioscorea cirrhosa Lour.	Tuber	low	Qiu *et al*. 2006
Dioscorea hispida Dennst.	Tuber	medium	Anonymous 1987, Guo *et al*. 1990
Dipterocarpaceae			
Dipterocarpus turbinatus Gaertn.	Leaf	medium	Lin *et al*. 2003
Ericaceae			
Gaultheria leucocarpa Bl. var. *crenulata* (Kurz) T.Z. Hsu	Whole plant, root	low	Qiu *et al*. 2006

Plant Family/Species	Part Used	Toxicity	Reference
Euphorbiaceae			
Croton caudatus Geiseler	Whole plant	low	Lin *et al*. 2003
Croton tiglium L.	Seed, leaf	high	Guo *et al*. 1991, Lin *et al*. 2003
Euphorbia antiquorum L.	Stem, leaf	medium	Guo *et al*. 1991, Lin *et al*. 2003
Euphorbia lathyris L.	Whole plant, seed	medium	Zhu *et al*. 2006, Qiu *et al*. 2006
Glochidion puberum (L.) Hutch.	Root, fruit	low	Qiu *et al*. 2006
Jatropha curcas L.	Bark, leaf	medium	Guo *et al*. 1991
Ricinus communis L.	Leaf, root, fruit, seed	low	Guo *et al*. 1990, Lin *et al*. 2003, Qiu *et al*. 2006, Zhu *et al*. 2006
Fabaceae			
Adenanthera microsperma Teijsm. & Binn.	Seed, root, bark, leaf	low	Lin *et al*. 2003
Caesalpinia minax Hance	Seed	low	Lin *et al*. 2003
Erythrina arborescens Roxb.	Bark	low	Guo *et al*. 1990
Millettia pachycarpa Benth.	Root, leaf, seed	high	Guo *et al*. 1991, Zhang 1996
Ormosia hosiei Hemsl. & E.H. Wilson	Seed	low	Qiu *et al*. 2006
Ormosia nuda (F.C. How) R.H. Chang & Q.W. Yao	Fruit	low	Qiu *et al*. 2006
Pachyrhizus erosus (L.) Urb.	Seed, root tuber	medium	Qiu *et al*. 2006, Lin *et al*. 2003
Gelsemiaceae			
Gelsemium elegans (Gardner & Champ.) Benth.	Whole plant, root	high	Guo *et al*. 1991, Zhang, 1996
Ginkgoaceae			
Ginkgo biloba L.	Leaf, seed	medium	Zhu *et al*. 2006
Hypoxidaceae			
Curculigo orchioides Gaertn.	Rhizome	medium	Guo *et al*. 1991, Zhu *et al*. 2006
Iridaceae			
Iris tectorum Maxim.	Rhizome	low	Qiu *et al*. 2006
Lauraceae			
Cassytha filiformis L.	Whole plant	low	Guo *et al*. 1990, Lin *et al*. 2003
Litsea glutinosa (Lour.) C.B. Rob.	Root bark, bark, leaf	medium	Lin *et al*. 2003
Liliaceae			
Rohdea japonica (Thunb.) Roth	Root, rhizome	medium	Zhu *et al*. 2006, Qiu *et al*. 2006
Sansevieria trifasciata Prain	Leaf	medium	Lin *et al*. 2003
Lycopodiaceae			
Huperzia serrata (Thunb.) Trevis.	Whole plant	low	Zhu *et al*. 2006
Melanthiaceae			
Paris polyphylla Sm.	Rhizome	low	Guo *et al*. 1990, Lin *et al*. 2003, Qiu *et al*. 2006
Veratrum mengtzeanum Loes.	Root	medium	Zhang, 1996
Meliaceae			
Melia azedarach L.	Fruit, bark	medium	Zhu *et al*. 2006, Qiu *et al*. 2006
Menispermaceae			
Stephania cephalantha Hayata	Root tuber	low	Qiu *et al*. 2006

Plant Family/Species	Part Used	Toxicity	Reference
Stephania epigaea H.S. Lo	Root tuber	low	Lin *et al*. 2003
Moraceae			
Antiaris toxicaria Lesch.	Bark, leaf	high	Lin *et al*. 2003
Orchidaceae			
Cremastra appendiculata (D. Don) Makino	Bulb	low	Qiu *et al*. 2006
Papaveraceae			
Chelidonium majus L.	Whole plant	medium	Zhu *et al*. 2006
Eomecon chionantha Hance	Whole plant	low	Qiu *et al*. 2006
Macleaya cordata (Willd.) R. Br.	Whole plant	high	Qiu *et al*. 2006
Phytolaccaceae			
Phytolacca acinosa Roxb.	Root	medium	Zhu *et al*. 2006
Plumbaginaceae			
Plumbago indica L.	Whole plant	medium	Anonymous, 1987
Plumbago zeylanica L.	Root, leaf, whole plant	medium	Guo *et al*. 1990, Lin *et al*. 2003, Qiu *et al*. 2006
Polygonaceae			
Polygonum hydropiper L.	Whole plant	medium	Zhu *et al*. 2006
Ranunculaceae			
Aconitum carmichaeli Debeaux	Root tuber	high	Qiu *et al*. 2006, Zhu *et al*. 2006
Aconitum sinomontanum Nakai	Root	medium	Qiu *et al*. 2006
Anemone hupehensis (Lemoine) Lemoine	Whole plant, root	medium	Zhu *et al*. 2006
Anemone rivularis Buch.-Ham. ex DC.	Whole plant, root	low	Anonymous, 1987, Guo *et al*. 1990, Qiu *et al*. 2006
Ranunculus grandis Honda	Whole plant	medium	Zhu *et al*. 2006
Rhamnaceae			
Gouania leptostachya DC.	Stem, leaf, root	medium	Lin *et al*. 2003
Rosaceae			
Duchesnea indica (Andrews) Focke	Whole plant	low	Qiu *et al*. 2006, Zhu *et al*. 2006
Spiraea japonica L.f.	Root	low	Qiu *et al*. 2006
Rutaceae			
Toddalia asiatica (L.) Lam.	Root, bark	low	Lin *et al*. 2003, Qiu *et al*. 2006, Zhu *et al*. 2006
Zanthoxylum nitidum (Roxb.) DC.	Root, stem, leaf	low	Lin *et al*. 2003
Zanthoxylum planispinum Siebold & Zucc.	Root, fruit	low	Qiu *et al*. 2006
Saxifragaceae			
Saxifraga stolonifera Curtis	Whole plant	low	Qiu *et al*. 2006, Zhu *et al*. 2006
Solanaceae			
Datura stramonium L.	Root, leaf, fruit	low	Lin *et al*. 2003
Nicotiana tabacum L.	Leaf	medium	Guo *et al*. 1991, Qiu *et al*. 2006
Solanum americanum Mill.	Whole plant	medium	Lin *et al*. 2003, Qiu *et al*. 2006
Solanum hazenii Britton	Root, leaf, fruit	low	Lin *et al*. 2003
Solanum torvum Sw.	Root	low	Guo *et al*. 1991

Plant Family/Species	Part Used	Toxicity	Reference
Stenonaceae			
Stemona tuberosa Lour.	Root tuber	low	Guo *et al*. 1990
Theaceae			
Camellia oleifera Abel	Seed	low	Qiu *et al*. 2006
Urticaceae			
Urtica fissa E. Pritz.	Whole plant	low	Zhu *et al*. 2006
Valerianaceae			
Valeriana jatamansi Jones	Root, rhizome	low	Zhu *et al*. 2006
Verbenaceae			
Rotheca serrata (L.) Steane & Mabb.	Whole plant	low	Lin *et al*. 2003
Vitaceae			
Ampelopsis japonica (Thunb.) Makino	Root tuber	low	Zhu *et al*. 2006

Table 2. Plant families with at least two toxic species out of 118 reported from Dai, Lahu, Miao, Tujia, and Wa ethnic groups in south and southwest China. Number of genera and species in each family and percent of the total genera and species reported. Overall diversity ranked by combined specific and generic diversity.

Rank	Families	Genera	Species
1	Araceae	9 (10.0%)	13 (11.0%)
2	Asteraceae	7 (7.7%)	8 (6.8%)
3	Fabaceae	6 (6.6%)	7 (5.9%)
4	Euphorbiaceae	5 (5.5%)	7 (5.9%)
5	Aristolochiaceae	3 (3.3%)	6 (5.1%)
6	Apocynaceae	5 (5.5%)	5 (4.2%)
7	Ranunculaceae	3 (3.3%)	5 (4.2%)
	Solanaceae	3 (3.3%)	5 (4.2%)
8	Berberidaceae	2 (2.2%)	5 (4.2%)
9	Papaveraceae	3 (3.3%)	3 (2.5%)
10	Rutaceae	2 (2.2%)	3 (2.5%)
11	Chloranthaceae	1 (1.1%)	3 (2.5%)
	Dioscoreaceae	1 (1.1%)	3 (2.5%)
12	Lauraceae	2 (2.2%)	2 (1.7%)
	Liliaceae	2 (2.2%)	2 (1.7%)
	Melanthiaceae	2 (2.2%)	2 (1.7%)
	Rosaceae	2 (2.2%)	2 (1.7%)
13	Campanulaceae	1 (1.1%)	2 (1.7%)
	Menispermaceae	1 (1.1%)	2 (1.7%)
	Plumbaginaceae	1 (1.1%)	2 (1.7%)
	Total	**62 (68.1%)**	**89 (75.4)**

At the generic level, 19.6% of toxic genera had more than one species. Genera with more than one species are listed in Table 3.

Table 3. Families and genera of toxic plants with multiple species reported as used medicinally by Dai, Lahu, Miao, Tujia, and Wa ethnic groups in south and southwest China.

Families	Genera	Species
Araceae	*Arisaema*	4
	Typhonium	2
Berberidaceae	*Dysosma*	4
Aristolochiaceae	*Aristolochia*	3
	Asarum	2
Euphorbiaceae	*Croton*	2
	Euphorbia	2
Chloranthaceae	*Chloranthus*	3
Dioscoreaceae	*Dioscorea*	3
Solanaceae	*Solanum*	3
Asteraceae	*Spilanthes*	2
Campanulaceae	*Lobelia*	2
Fabaceae	*Ormosia*	2
Menispermaceae	*Stephania*	2
Plumbaginaceae	*Plumbago*	2
Ranunculaceae	*Aconitum*	2
	Anemone	2
Rutaceae	*Zanthoxylum*	2

The parts of toxic plants used as ethnomedicines included roots, whole plant and leaf, flowers, fruit, and seeds. Roots were most frequently used. In some cases, parts of toxic plants used as medicines were not the main parts containing toxins. For example, the Dai people used the bark and leaf of *Antiaris toxicaria* Lesch. as medicine, while its gum contained deadly toxins. As another example, the leafs of *Plumbago indica* L. were considered to be very toxic by

Lahu people, its whole plant, however, was often used as medicines.

Family is an important taxonomic classification level for determining the usefulness of plant species to local people (Thomas *et al.* 2009). This is also true for the toxicity of plants. In the 5 ethnomedicine systems, many toxic plants belong to just a few families (Araceae, Asteraceae, Fabaceae, Euphorbiaceae, Aristolochiaceae, and Apocynaceae). These are among the main families containing toxic plants (Levetin & McMahon 2008). Although some families, such as Lobeliaceae, Loganiaceae and Moraceae, have only a few species with toxicity, the toxins from them are deadly poisonous. Huai *et al.* (2003) reported that *Lobelia clavata* E. Wimm. and *Gelsemium elegans* (Gardner & Champ.) Benth. were considered as two of the most poisonous plants in the Autonomous County by Jinping Miao, Yao and Dai in Yunnan Province in China. They were also used medicinally by the Lahu, Hani, Yao people (Huai *et al*. 2003).

Toxic plants used the most frequently in the five ethnic groups

In spite of living in the same environments, different ethnic groups have their own knowledge and experiences of using toxic plants as medicines. We compared the plants used by the five groups, and found that some toxic plants were used as medicines by two or more ethnic groups, and some were used only by single ethnic group. For instance, castor (*Ricinus communis* L.) was used by four ethnic groups (Wa, Dai, Tujia and Miao) (Table 4). *Ricinus communis* is cultivated commonly in south and southwest China. This fact might be the main reason why it was used frequently. *Plumbago zeylanica* L., *Anemone rivularis* Buch.-Ham. ex DC., *Toddalia asiatica* (L.) Lam., and *Paris polyphylla* Sm. were used in three of the five ethnomedicinal systems (Table 4).

UVs and AUVs showed that toxic plants used as medicines by the five ethnic groups had high medicinal use values (Table 5). This result indicated that toxic plants used as medicines were an important content of the five ethnomedicinal systems. Each toxic plant used had at least two different medicinal usages (Table 4). Of them, *Anemone rivularis* had the highest UVs value, and *Croton tiglium L.* had the lowest UVs value. This indicates that *A. rivularis* had the most multiple usages in different ethnomedicinal systems. Although *C. tiglium* was used by two ethnic groups, it was used only for two health problems. The UVs of toxic plants were not correlated closely with the number of ethnic groups who used them. The use number of a plant contributed greatly to the UVs. Compared with UVs, AUVs were better at reflecting the relative use values of toxic plants in ethnomedicine. For example, the plants *R. communis*, *Alangium chinense* (Lour.) Harms, *Coriaria sinica* Maxim., *Dioscorea hispida* Dennst., *Euphorbia lathyria* L., and *Curculigo orchioides* Gaertn. shared the same UVs, 4.00, but had different AUVs. The AUV of *R. communis* was higher than that of the other species. Obviously, some toxic plants were used only by a single ethnic group, and others were commonly used by two or more ethnic groups. This meant that different ethnic groups had their own ethnobotanical knowledge reflected by their different choices and preferred using different toxic plants.

Table 4. The most frequent cited toxic plants used by Dai, Lahu, Miao, Tujia, and Wa ethnic groups in south and southwest China. UV (Use Value); AUV (Average Use Value)

Species	Number of ethnic groups using plant (%)	*UV*	*AUV*
Ricinus communis	4 (80%)	4.00	3.20
Anemone rivularis	3 (60%)	9.00	5.40
Paris polyphylla		6.33	3.79
Plumbago zeylanica			
Toddalia asiatica		5.00	3.00
Duchesnea indica	2 (40%)	7.50	3.00
Aconitum carmichaeli		6.50	2.60
Arisaema erubescens		6.00	2.40
Melia azedarach		5.50	2.20
Nicotiana tabacum			
Rohdea japonica			
Saxifraga stolonifera			
Spilanthes callimorpha			
Cassytha filiformis		4.50	1.80
Dysosma veitchii			
Euphorbia antiquorum			
Gelsemium elegans			
Alangium chinense		4.00	1.60
Coriaria sinica			
Curculigo orchioides			
Dioscorea hispida			
Euphorbia lathyria			
Solanum nigrum		3.50	1.40
Dioscorea bulbifera		3.00	1.20
Pachyrhizus erosus			
Pinellia ternat			
Remusatia vivipara			
Millettia pachycarpa		2.50	1.00
Croton tiglium		2.00	0.80

Table 5. Plants with the "highest" toxicity used medicinally by Dai, Lahu, Miao, Tujia, and Wa ethnic groups in south and southwest China and their Use Values (UV) and Averge Use Values (AUV).

Species	Ethnic groups using plants	UV	AUV
Aconitum carmichaeli	Tujia, Miao	6.50	2.60
Gelsemium elegan	Wa, Lahu	4.50	1.80
Remusatia vivipara	Wa, Lahu	3.00	1.20
Macleaya cordata	Miao	6.00	1.20
Millettia pachycarpa	Wa, Lahu	2.50	1.00
Arisaema consanguineum	Tujia	4.00	0.80
Croton tiglium	Tujia, Dai	2.00	0.80
Gloriosa superba	Dai	3.00	0.60
Antiaris toxicaria	Dai	3.00	0.60
Nerium indicum	Tujia	3.00	0.60
Lobelia clavata	Wa	3.00	0.60

The high toxic plants and their usages among ethnic groups

Eleven species were believed to be extraordinarily toxic by the five ethnic groups (Table 5). Due to their extreme toxicity, these toxic plants often were used only by local specialists to treat special health problems. Five of these species (Table 5), were only shared as medicines by two ethnic groups. The Miao specialist used only two high toxic plants *Aconitum carmichaeli* Debeaux and *Macleaya cordata* (Willd.) R. Br. while *Gloriosa superb* L. and *A. toxicaria* were used as medicines only by Dai healers. Previously, Huai *et al*. (2003) reported *L. clavata* and *G. elegans* as being highly toxic plants used in the Miao, Yao and Dai society in Yunnan of China. This survey confirmed their medicinal use in these ethnic groups.

These 11 plants also had high UVs. They were all above or equal to 2.00 with the UV and AUV of *A. carmicharli* being the highest. Although *M. cordata* had a high UV, 6.00, its AUV was only 1.20, lower than *G. elegan*. *Croton tiglium* had the lowest UV in these 11 plants, 2.00, but its AUV was not the lowest. These results indicated that the plants with "highest" toxicity also played a very important role in some ethnomedicinal systems, although many of them were not commonly used by all ethnic groups concerned.

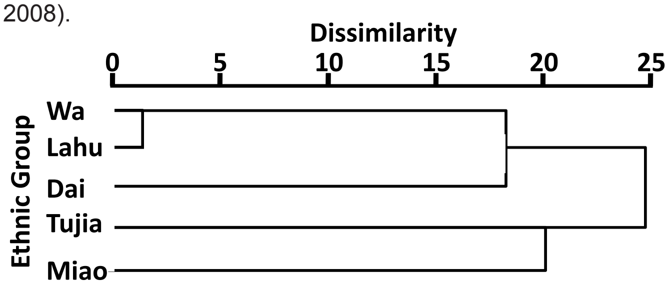
The use of highly toxic plants may mean some special beneficial toxin exists in these plants. The high AUVs and UVs indicated that these medicinal plants might have a potential to develop new drugs. Thus these highly toxic plants used as medicines are particularly interesting in further research or new drug development.

Table 6. The top 15 indications treated with toxic plants and the number of concerned plants used by Dai, Lahu, Miao, Tujia, and Wa ethnic groups in south and southwest China.

Usage	Species (%)
Injuries from falls*	94 (78.3)
Skin problems**	84 (70.0)
Snakebite	34 (28.3)
Stomach ache	34 (28.3)
Rheumatoid arthritis	32 (26.7)
Tussis	21 (17.5)
Burn and scald	19 (15.8)
Throat inflammation	16 (13.3)
Lymph inflammation	10 (8.3)
Malaria	9 (7.5)
Parotitis	8 (6.7)
Menoxenia	7 (5.8)
Cold	7 (5.8)
Anesthesia	7 (5.8)
Diarrhea	7 (5.8)

* including injuries from falls, bone broken, and bleeding caused by trauma.
** including various ailments related to skin.

Figure 1. Hierachical cluster dendrogrm of Dai, Lahu, Miao, Tujia, and Wa ethnic groups in south and southwest China. based on their use of toxic plants. Produced using SPSS 16.0 applying a Pearson's product-moment correlation (SPSS 2008).



Health problems and treatment with toxic plants

Toxic plants often were used for different medical purposes among different ethnic groups. Some health problems were treated preferentially with toxic plants across the five ethnic groups. The frequent health problems treated with toxic plants in these ethnic groups and the numbers of toxic plants involved are shown in Table 6. Injuries (including bleeding caused by trauma and broken bones) were the most frequent problems treated, with 94 toxic plants (78.33% of total toxic plants) from the five ethnic groups. Skin problems were the second most frequent illness treated with 84 toxic plants (70%). The toxic plants used for injuries and dermatological medicines were significantly higher than for other health problems ($u=6.465$, $p<0.01$). Although treatment of skin ailments frequently involved toxic plants in the five ethnic groups, these indigenous people had different experiences and uses for toxic plants for treatment of skin ailments. It is usually difficult to define “what is a skin ailment?” and “which skin problems were included within skin ailments?”. When the medicinal specialists from different ethnic groups answer these questions, the answers usually differed from one another. Here, the skin problems defined included various ailments related to skin problems in local areas. In addition, some toxic plants were used for treating snakebite, stomachache, rheumatoid arthritis, tussis, burns, scalds, malaria, colds, throat inflammation, and diarrhea. In another word, the use of toxic plants was usually correlated closely with specific health problems in local communities.

It is common that the same toxic plants were used by different ethnic groups to treat the same health problems. Since a given ethnomedicine system was usually developed and practiced independently with unique cultural backgrounds for ages, the context of the given ethnomedicine formed its own specializations, though their practitioners might live in the same areas. The same species was often used by different ethnic healers to treat the same health problems. This was likely to be a result of experience exchange due to its high medicinal effectiveness. Thus, plants used more often by different ethnic healers to treat the same ailment should be the focus of more attention during the hunt for new drugs.

Toxicity of toxic plants depends on their chemical composition. Alkaloids are one of the main components that can cause poisoning. For example, more than 40 alkaloids were isolated from *G. elegans* (Hua *et al*. 2008), which could cause violent clonic convulsions leading to respiratory failure (Rujjianawate *et al*. 2003); benzofuran lignan glycosides isolated from *G. elegans* showed a potent cytotoxic activity (Hua *et al*. 2008); The diterpenoid alkaloids were thought to be the main toxin in *A. carmichaeli* (Konno *et al.* 1982); dioscorine and sapogenins isolated from *Aconitum* also showed cytotoxic activity (Webster *et al*. 1984); plumbagin isolated from *P. zeylanica*, presented significant cytoxicity (Lin *et al*. 2003). Medicinal activity of toxic plants also depended on its composition. Benzophenanthridine alkaloids, coumarins, cyclohexylamides and terpenoids isolated from *T. asiatica* showed various medicinal activities, including strong anti-platelet aggregation activity (Tsai *et al*. 1998), antibacterial and antifungal activities (Duraipandiyan & Ignacimuthu 2009), and anticancer (Rajkumar *et al.* 2008).

Crude extracts with uncertain composition have also been shown to be biologically active from many toxic plants. *Duchesnea indica* (Andrews) Focke extract showed strong anti-inflammatory activity, in particularly suppressing pro-inflammatory cytokines and mediator by blocking NF-kB activation (Zhao *et al*. 2008). The crude extracts from *P. zeylanica* could increase the activities of serum lactate dehydrogenase, acid phosphatase, liver alkaline phosphatase, and sugar concentrations in the blood in clinic experiments (Beg & Ahamd 2000). Identifying the compounds responsible for the activities in these toxic plants is the premise of better understanding and using toxic plants.

Conclusion

Based on this study, the culture and the resources available were two main factors affecting ethnic healers' selection choices for uses of toxic plants. Although the active composition of toxic plants used medicinally by the five ethnic groups was uncertain, our current survey may provide interesting clues to further understand and apply these toxic plants.

Acknowledgements

This research was supported by the National Natural Science Foundation of China (Grant No. 30770220). The authors are grateful to two anonymous reviewers for their valuable comments on this paper.

Literature Cited

Al-Qura'n, S. 2005. Ethnobotanical survey of folk toxic plants in southern part of Jordan. *Toxicon* 46:119-129.

Arias, A.B.T. 2000. Ichthyotoxic plants used in Spain. *Journal of Ethnopharmacology* 73:505-512.

Beg, A.Z. & I. Ahmad. 2000. Effect of *Plumbago zeylanica* extract and certain curing agents on multidrug resistant bacteria of clinical origin. *World Journal of Microbiology & Biotechnology* 16:841-844.

Bhattarai, S., Chaudhary, R.P. & R.S.L. Taylor. 2009. Wild edible plants used by the people of Manang district, Central Nepal. *Ecology of Food and Nutrition* 48(1):1-20.

Duraipandiyan, V. & S. Ignacimuthu. 2009. Antibacterial and antifungal activity of Flindersine isolated from the traditional medicinal plant, *Toddalia asiatica* (L.) Lam. *Journal of Ethnopharmacology* 123:494-498.

Eddouks, M., M. Maghrani, A. Lemhadri, M.L. Quahidi & H. Joud. 2002. Ethnopharmacological survey of medicinal plants used for the treatment of diabetes mellitus, hypertension and cardiac diseases in the south-eastern region of Morocco (Tafilalet). *Journal of Ethnopharmacology* 82:97-103.

Farnsworth, N.R. 1966. Biological and phytochemical screening of plants. *Journal of Pharmaceutical Sciences* 55:225-276.

Guo, S., H. Duan & D. Guo. 1990. *Si Ndah Ba Raog Joung Gox* (The Ethnomedicines of the Wa in China) (I). Yunnan Nationality Press, Kunming.

Guo, D., S. Guo & H. Duan. 1991. *Si Ndah Ba Raog Joung Gox* (The Ethnomedicines of the Wa in China) (II). Yunnan Nationality Press, Kunming.

Habermehl, G.G. 2004. Highlights on plant toxins in *Toxicon*. *Toxicon* 44(4):341-344.

Harvey, A.L., K.N. Bradley, S.A. Cochran, E.G. Rowan, J.A. Quillfeldt & D.A Jerusalinsky. 1998. What can toxins tell us for drug discovery. *Toxicon* 36:1635-1640.

Heinrich, M. 2000. Plant resources of south-east Asia medicinal and poisonous plants 1. *Phytochemistry* 53:619-620.

Hua, W., Q.C. Zhao, J. Yang, G.B. Shi, L.J. Wu & T. Guo. 2008. Two new benzofuran lignin glycosides from *Gelsemium elegans*. *Chinese Chemical Letters* 19:1327-1329.

Huai, H. & J. Xu. 2000. Indigenous knowledge: an inexhaustible “information bank” for toxin research. *Toxicon* 38(6):745-746.

Huai, H., S. Yang & S. Pei. 2003. Ethnobotany of two “toxic” plants: *Lobelia clavata* and *Gelsemium elegans* in Southeast Yunnan, China. *Ethnobotany* 15:20-22.

Konno, C., M. Shirasaka & H. Hikino. 1982. Structure of senbusine A, B and C, diterpenic alkaloids of *Aconimtu carmichaeli* roots from China. *Journal of Natural Products* 45(2):128-133.

Levetin, E. & K. McMahon. 2008. *Plants & Society.* 5th edition. McGraw-Hill, New York.

Lin L.C., L.L. Yang & C.J. Chou. 2003. Cytotoxicity naphthoquinones and plumbagic acid glucosides from *Plumbago zeylanica*. *Phytochemistry* 62(4):619-622.

Lin, Y., Z. Yi & Y. Zhao. 2003. *Chinese Dai Medicine Colorful Illustrations*. Yunnan Nationality Press, Kunming.

Neuwinger, H.D. 2004. Plants used for poison fishing in tropical Africa. *Toxicon* 44(4):417-430.

Phillips, O. & A.H. Gentry. 1993a. The useful plants of Tambopata, Peru: I. Statistical hypotheses tests with a new quantitative techniques. *Economic Botany* 47:15-32.

Phillips, O. & A.H. Gentry. 1993b. The useful plants of Tambopata, Peru: II. Additional hypotheses testing in quantitative ethobotany. *Economic Botany* 47:33-43.

Qiu, D., J. Du & T. Xia. 2006. *Zhonghua Bencao Miaoyaojuan Caise Tupu* (Chinese Herbals—Colorful Illustrations of the Miao). Publishing House of Ancient Chinese Medical Books, Beijing.

Rajkumar, M., R.H. Chandra, K. Asres & C. Veeresham. 2008. *Toddalia asiatica* (Linn.) Lam. – a comprehensive review. *Pharmacognosy Reviews* 2(4):386-397.

Rates, S., 2001. Plants as source of drugs. *Toxicon* 39 (5):603-613.

Rios, J.L. & P.G. Waterman. 1998. A review of the pharmacology and toxicology of *Astragalus*. *Phytotherapy Research* 11:411-418.

Rujjianawate, C., D. Kanjanapothi & A. Panthong. 2003. Pharmacological effect and toxicity of alkaloids from *Gelsemium elegans* Benth. *Journal of Ethnopharmacology* 89:91-95.

Simao Institute of Ethnomedicine. 1987. *The Commonly Used Medicine of the Lahu*. Yunnan Nationality Press, Kunming.

SPSS. 2008. Statistical Package for Social Sciences. SPSS for Windows, Rel. SPSS 16.0.2. 2008. Chicago: SPSS Inc.

Stinson, S. 1992. Nutritional Adaptation. *Annual Review of Anthropology* 21:143-170.

Thomas E., I. Vandebroek, S. Sanca & P.V. Damme. 2009. Cultural significance of medicinal plant families and species among Quechua framers in Apillampa, Bolivia. *Journal of Ethnophamacology* 122:60-67.

Tsai, I.L., M.F. Wun, C.M. Teng, T. Ishikawa & I.S. Chen. 1998. Anti-platelet aggregation constituents from formosan *Toddalia asiatica*. *Phytochemistry* 48(8):1377-1382.

Vetter, J. 2000. Plant cyanogenic glycosides. *Toxicon* 38:11-36.

Wang, J., F. He, C. Hzang, W. Fong, P. Xiao, R. Han & M. Yang. 2005. Differential gene expression profiles in paclitaxel-induced cell cycle arrest and apoptosis in human breast cancer MCF-7 cells. *Acta Pharmaceutica Sinica* 40 (12):1099-1104.

Webster, J., W. Beck & B. Ternai. 1984. Toxicity and bitterness in Australian *Dioscorea bulbifera* L. and *Dioscorea hispida* Dennst. from Thailand. *Journal of Agricultural and Food Chemistry* 32(5):1087-1090.

Wilson, C.R., J.M. Sauer & S.B. Hooser. 2001. Taxines: A review of the mechanism and toxicity of yew (*Taxus* spp.) alkaloids. *Toxicon* 39 (2-3):175-185.

Zhang, S. 1996. *Cokawr Ladhofnatzhid Lir* (The Ethnomedicines of the Lahu in China). Yunnan Nationality Press, Kunming.

Zhao, L., S.L. Zhang, J.Y. Tao, F. Jin, R. Pang, Y.J. Guo, P. Ye, J.H. Dong & G.H. Zheng. 2008. Anti-imflammatory mechanism of a folk herbal medicine, *Duchesnea indica* (Andr.) Focke at RAW264.7 cell line. *Immunological Investigations* 37:339-357.

Zhu, G., J. Du & J. Zhang. 2006. *The Ethnomedicines of the Tujia*. Publishing House of Ancient Chinese Medical Books, Beijing.