Regular article

Analysis of vascular plant resources and diversity in Liupan Mountains of Ningxia Province, China

Dongdong Wang[a], Minli Ruan[b], Jingming Jia[a]*, Anhua Wang[a]*

[a] *School of Traditional Chinese Materia Medica, Shenyang Pharmaceutical University, Shenyang 110016, China;*
[b] *University of Michigan, Ann Arbor. 930 N University Ave, Ann Arbor, MI 48109, the USA*

Abstract

Liupan Mountains are situated in the south of Ningxia Hui Autonomous Region and east of Gansu Province. This area is rich in forests and vegetation. After field investigation, literature review and specimen identification, the plant resources and diversity of Liupan Mountains were studied by the 4th Shenyang Pharmaceutical University Chinese Medicine Resources Scientific Expedition Team. There were 161 species of vascular plants belonging to 60 families and 119 genera collected from July to August 2010 in this area. Among them, the dominant families are *Campanulaceae*, *Ranunculaceae*, *Orobanchaceae*, *Asparagaceae*, *Fabaceae*, *Rosaceae* and *Asteraceae*, with 6, 7, 8, 8, 10, 10, and 22 species, respectively. Although representing only 11.7% of the total number of families, these families had a species occupancy rate of over 44.1%. At the genus level, *Pedicularis* is the most dominant genus with 6 species, while 92 genera contain only 1 species, accounting for 77.3% of the total number of genera. In a word, our research has updated the plant resources and diversity in Liupan Mountains. Furthermore, by providing practical and meaningful suggestions for strengthening the protection and utilization of plant resources in Liupan Mountains, our research is of great significance for maintaining the diverse ecosystem in this area.

Keywords: plant resources; diversity; Liupan Mountains

1 Introduction

Liupan Mountains cover the southern part of the Ningxia Hui Autonomous Region and the eastern part of Gansu Province. Its geographical coordinates are between 106°09'-106°30' east longitude and 35°15'-35°41' north latitude [1,2]. This area is the transitional area between the warm temperate semi-humid zone and the semi-arid zone, and also the ecological transition area between the warm temperate broadleaf forest zone and the desert steppe zone [3,4]. Liupan Mountains are renowned for the rich forest cover and vegetation, with 836 vascular plant species belonging to 93 families and 359 genera [1]. Among these, more than 500 species are classified as medicinal plants, including *Astragalus membranaceus* (Fisch.) Bunge, *Codonopsis pilosula* (Franch.) Nannf. And *Scutellaria baicalensis* Georgi [5,6]. The study aims to explore plant resources and diversity in Liupan Mountains, with special attento to updating the knowledge about

* Author to whom correspondence should be addressed. Address: School of Traditional Chinese Materia Medica, Shenyang Pharmaceutical University, 103 Wenhua Rd., Shenyang 110016, China; Tel.: +86-24-23986501 (Jingming Jia); +86-24-43520726 (Anhua Wang); E-mail: jiajingming@163.com (Jingming Jia); sywanganhua@163.com (Anhua Wang).

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natural medicinal plants in the area.

The 4th Scientific Expedition Team of Chinese Medicine Resources of Shenyang Pharmaceutical University investigated the plant species in Liupan Mountains in 2010, through field investigation, specimen collection, literature retrieval and specimen checking. A detailed survey was conducted to analyze the resources and biodiversity, aiming to gain insights into the types, distribution and utilization of plant resources in Liupan Mountains. The findings of this study provide a scientific basis for the rational construction and sustainable utilization of precious plant resources there.

2 Research method

In July 2010, the 4th Scientific Expedition Team of Chinese Medicine Resources of Shenyang Pharmaceutical University investigated the plant resources in Liupan Mountains. The survey covered representative areas, taking into account the topography, landform, altitude and plant types in different regions of Liupan Mountains. During the expedition, samples were collected and photos were taken along the way. Information such as the collection location, time and main morphological characteristics of plants were recorded. The latitude and longitude of the collected plants were recorded using a GPS logger. More than 2300 plant specimens were collected and nearly 3800 photos of plants were taken. The vascular plant species were confirmed by consulting references such as the "Flora of China" and "Flora of Ningxia". Subsequently, the diversity of plant resources in Liupan Mountains was comprehensively analyzed and evaluated, which provided valuable reference for the development, utilization and protection of plant resources in Liupan Mountains.

3 Results

3.1 Analysis of vascular plant species composition in Liupan Mountains

We collected 161 vascular plant species in Liupan Mountains in total (Table 4). They belonged to 60 families and 119 genera, including 3 families, 3 genera, and 3 species of pteridophytes; 3 families, 3 genera, and 3 species of gymnosperms; 54 families, 113 genera, and 155 species of angiosperms (with 45 families, 101 genera, and 136 species of dicotyledons; 9 families, 12 genera, and 19 species of monocotyledons). Angiosperms accounted for the most in the three levels of families, genera, and species (89.10%, 95.04% and 96.30%, respectively). Among angiosperms, dicotyledons are the predominant group. There are relatively few species of pteridophytes and gymnosperms.

Table 1 Statistics of vascular plant species in Liupan Mountains

Plant type	No. families	Rate/%	No. genera	Rate/%	No. species	Rate/%
Pteridophytes	3	5.00	3	2.52	3	1.86
Gymnosperms	3	5.00	3	2.52	3	1.86
Angiosperms	54	90.00	113	94.96	155	96.28
Dicotyledons	45	83.33	101	89.38	136	87.74
Monocotyledons	9	16.67	12	10.62	19	12.26
Total	60	100.00	119	100.00	161	100.00

3.2 Analysis of plant family and genera composition in Liupan Mountains

The vascular plants collected from Liupan Mountains were classified into 60 plant families. Most of the families consisted of only a few species. Fifty-three collected plant families had only 1-5 species, accounting for 88.3% of the total number of families. Additionally, 7 families contained more than 6 species, accounting for 11.7% of the total number of families. The 7 families are *Campanulaceae*, *Ranunculaceae*, *Orobanchaceae*, *Asparagaceae*, *Fabaceae*, *Rosaceae* and *Asteraceae*, with 6, 7, 8, 8, 10, 10, and 22 species, respectively. Although accounting for only 11.7% of the total number of families, these 7 families occupied over 44.1% among all these species.

Table 2 Statistics of species in different families of vascular plants in Liupan Mountains

No.species within families	No. families	Rate/%	No. species	Rate/%
1 species	32	53.33	32	19.88
2-5 species	21	35.00	58	36.02
6-10 species	6	10.00	49	30.43
>10 species	1	1.67	22	13.67

The vascular plants were classified into 119 plant genera in total. Among them, 92 genera contained only 1 species, accounting for 77.3% of the total number of genera. Additionally, there was only 1 genus with 6 species, namely the genus *Pedicularis*.

Information of all collected plants is shown in Table 4.

Table 3 Statistics of species in the different genera of vascular plants in Liupan Mountains

No. species within genus	No. genus	Rate/%	No. species	Rate/%
1 species	92	77.31	92	57.14
2 species	17	14.29	34	21.12
3-5 species	9	7.56	29	18.01
6 species	1	0.84	6	3.73

Table 4 Statistics of vascular plant resources in Liupan Mountains

No.	Families	Genera	Species
1	Smilacaceae	*Smilax*	*Smilax menispermoidea* A. DC.
2	Plumbaginaceae	*Limonium*	*Limonium aureum* (L.) Hill.
3	Liliaceae	*Lilium*	*Lilium pumilum* DC.
4	Cupressaceae	*Juniperus*	*Juniperus formosana* Hayata
5	Primulaceae	*Primula*	*Primula maximowiczii* Regel
6	Plantaginaceae	*Pseudolysimachion*	*Pseudolysimachion linariifolium* (Pallas ex Link) Holub
7	Plantaginaceae	*Veronica*	*Veronica szechuanica* Batalin

(to be continued)

Continued Table 4

No.	Families	Genera	Species
8	Lamiaceae	*Dracocephalum*	*Dracocephalum heterophyllum* Benth.
9	Lamiaceae	*Dracocephalum*	*Dracocephalum purdomii* W. W. Smith
10	Lamiaceae	*Nepeta*	*Nepeta sibirica* L.
11	Lamiaceae	*Thymus*	*Thymus mongolicus* Ronn.
12	Lamiaceae	*Scutellaria*	*Scutellaria amoena* C. H. Wright
13	Euphorbiaceae	*Euphorbia*	*Euphorbia helioscopia* L.
14	Fabaceae	*Astragalus*	*Astragalus chrysopterus* Bunge
15	Fabaceae	*Glycyrrhiza*	*Glycyrrhiza uralensis* Fisch.
16	Fabaceae	*Hedysarum*	*Hedysarum petrovii* Yakovl.
17	Fabaceae	*Lathyrus*	*Lathyrus pratensis* L.
18	Fabaceae	*Melilotus*	*Melilotus dentatus* (Waldstein & Kitaibel) Persoon
19	Fabaceae	*Oxytropis*	*Oxytropis latibracteata* Jurtz.
20	Fabaceae	*Oxytropis*	*Oxytropis myriophylla* (Pall.) DC.
21	Fabaceae	*Oxytropis*	*Oxytropis ochrantha* Turcz.
22	Fabaceae	*Thermopsis*	*Thermopsis lanceolata* R. Br.
23	Fabaceae	*Vicia*	*Vicia unijuga* A. Br.
24	Menispermaceae	*Menispermum*	*Menispermum dauricum* DC.
25	Pteridaceae	*Adiantum*	*Adiantum pedatum* L. Sp.
26	Balsaminaceae	*Impatiens*	*Impatiens noli-tangere* L.
27	Poaceae	*Fargesia*	*Fargesia nitida* (Mitford) Keng f. ex Yi
28	Saxifragaceae	*Rodgersia*	*Rodgersia aesculifolia* Batalin
29	Polemoniaceae	*Polemonium*	*Polemonium caeruleum* Linnaeus
30	Betulaceae	*Corylus*	*Corylus mandshurica* Maxim.
31	Betulaceae	*Betula*	*Betula albosinensis* Burkill
32	Hypericaceae	*Hypericum*	*Hypericum ascyron* L.
33	Chloranthaceae	*Chloranthus*	*Chloranthus japonicus* Sieb.
34	Violaceae	*Viola*	*Viola prionantha* Bunge
35	Violaceae	*Viola*	*Viola bulbosa* Maxim.
36	Crassulaceae	*Phedimus*	*Phedimus aizoon* (Linnaeus) ‘t Hart
37	Campanulaceae	*Adenophora*	*Adenophora ningxianica* Hong
38	Campanulaceae	*Adenophora*	*Adenophora potaninii* Korsh.
39	Campanulaceae	*Campanula*	*Campanula punctata* Lamarck
40	Campanulaceae	*Codonopsis*	*Codonopsis pilosula* (Franch.) Nannf.
41	Campanulaceae	*Codonopsis*	*Codonopsis tsinlingensis* Pax & K. Hoffmann

(to be continued)

Continued Table 4

No.	Families	Genera	Species
42	Campanulaceae	*Adenophora*	*Adenophora capillaris* subsp. *paniculata* (Nannfeldt) D. Y. Hong & S. Ge
43	Asteraceae	*Ajania*	*Ajania salicifolia* (Mattf.) Poljak.
44	Asteraceae	*Arctium*	*Arctium lappa* L.
45	Asteraceae	*Parasenecio*	*Parasenecio pilgerianus* (Diels) Y. L. Chen
46	Asteraceae	*Parasenecio*	*Parasenecio roborowskii* (Maxim.) Y. L. Chen
47	Asteraceae	*Carduus*	*Carduus crispus* L.
48	Asteraceae	*Cirsium*	*Cirsium leo* Nakai et Kitag.
49	Asteraceae	*Cirsium*	*Cirsium maackii* Maxim.
50	Asteraceae	*Crepis*	*Crepis rigescens* Diels
51	Asteraceae	*Echinops*	*Echinops przewalskyi* Iljin
52	Asteraceae	*Ligularia*	*Ligularia duciformis* (C. Winkl.) Hand.-Mazz.
53	Asteraceae	*Ligularia*	*Ligularia przewalskii* (Maxim.) Diels
54	Asteraceae	*Parasenecio*	*Parasenecio palmatisectus* (J. F. Jeffrey) Y. L. Chen
55	Asteraceae	*Saussurea*	*Saussurea iodostegia* Hance
56	Asteraceae	*Saussurea*	*Saussurea macrota* Franch.
57	Asteraceae	*Saussurea*	*Saussurea nivea* Turcz.
58	Asteraceae	*Senecio*	*Senecio dubitabilis* C. Jeffrey et Y. L. Chen
59	Asteraceae	*Klasea*	*Klasea centauroides* (L.) Cass.
60	Asteraceae	*Klasea*	*Klasea centauroides* subsp. *strangulata* (Iljin) L. Martins
61	Asteraceae	*Ligularia*	*Ligularia sagitta* (Maxim.) Mattf.
62	Asteraceae	*Aster*	*Aster heterolepis* Hand.-Mazz.
63	Asteraceae	*Leontopodium*	*Leontopodium junpeianum* Kitam.
64	Asteraceae	*Artemisia*	*Artemisia verlotorum* Lamotte
65	Orchidaceae	*Herminium*	*Herminium monorchis* (L.) R. Br.
66	Melanthiaceae	*Paris*	*Paris polyphylla* Smith
67	Melanthiaceae	*Paris*	*Paris verticillata* M.-Bieb.
68	Polygonaceae	*Bistorta*	*Bistorta suffulta* (Maxim.) H. Gross
69	Polygonaceae	*Rheum*	*Rheum racemiferum* Maxim.
70	Polygonaceae	*Bistorta*	*Bistorta vivipara* (L.) Gray
71	Orobanchaceae	*Orobanche*	*Orobanche cernua* Loefling
72	Orobanchaceae	*Euphrasia*	*Euphrasia pectinata* Tenore
73	Orobanchaceae	*Pedicularis*	*Pedicularis curvituba* Maxim.
74	Orobanchaceae	*Pedicularis*	*Pedicularis bella* Hook. f.

(to be continued)

Continued Table 4

No.	Families	Genera	Species
75	Orobanchaceae	*Pedicularis*	*Pedicularis muscicola* Maxim.
76	Orobanchaceae	*Pedicularis*	*Pedicularis spicata* Pall.
77	Orobanchaceae	*Pedicularis*	*Pedicularis chinensis* Maxim.
78	Orobanchaceae	*Pedicularis*	*Pedicularis alaschanica* Maxim.
79	Dryopteridaceae	*Cyrtomium*	*Cyrtomium fortunei* J. Sm.
80	Onagraceae	*Epilobium*	*Epilobium hirsutum* L.
81	Onagraceae	*Chamerion*	*Chamerion angustifolium* (Linnaeus) Holub
82	Gentianaceae	*Halenia*	*Halenia elliptica* D. Don
83	Gentianaceae	*Gentiana*	*Gentiana macrophylla* Pall.
84	Gentianaceae	*Gentiana*	*Gentiana dahurica* Fisch.
85	Ephedraceae	*Ephedra*	*Ephedra sinica* Stapf
86	Aristolochiaceae	*Asarum*	*Asarum himalaicum* Hook. f. et Thoms. ex Klotzsch.
87	Geraniaceae	*Geranium*	*Geranium platyanthum* Duthie
88	Geraniaceae	*Geranium*	*Geranium pratense* L.
89	Ranunculaceae	*Aconitum*	*Aconitum barbatum* var. *hispidum* (DC.) Seringe
90	Ranunculaceae	*Actaea*	*Actaea asiatica* Hara
91	Ranunculaceae	*Anemone*	*Anemone tomentosa* (Maxim.) Pei
92	Ranunculaceae	*Delphinium*	*Delphinium grandiflorum* L.
93	Ranunculaceae	*Delphinium*	*Delphinium mollipilum* W. T. Wang
94	Ranunculaceae	*Thalictrum*	*Thalictrum aquilegiifolium* var. *sibiricum* Linnaeus
95	Ranunculaceae	*Anemone*	*Anemone demissa* Hook. f. et Thoms.
96	Actinidiaceae	*Clematoclethra*	*Clematoclethra scandens* subsp. *actinidioides* (Maximowicz) Y. C. Tang & Q. Y. Xiang
97	Oleaceae	*Syringa*	*Syringa pubescens* subsp. *microphylla* (Diels)M.C.Chang & X.L.Chen
98	Equisetaceae	*Equisetum*	*Equisetum hyemale* L.
99	Rubiaceae	*Galium*	*Galium asperifolium* var. *sikkimense* (Gand.) Cuf.
100	Rubiaceae	*Rubia*	*Rubia membranacea* Diels
101	Rubiaceae	*Galium*	*Galium verum* L.
102	Rosaceae	*Cotoneaster*	*Cotoneaster soongoricus* (Regel et Herd.) Popov
103	Rosaceae	*Geum*	*Geum aleppicum* Jacq.
104	Rosaceae	*Prunus*	*Prunus hypoleuca* (Koehne) J. Wen
105	Rosaceae	*Dasiphora*	*Dasiphora fruticosa* (L.) Rydb.
106	Rosaceae	*Potentilla*	*Potentilla tanacetifolia* Willd. ex Schlecht.
107	Rosaceae	*Rosa*	*Rosa moyesii* Hemsl.

(to be continued)

Continued Table 4

No.	Families	Genera	Species
108	Rosaceae	*Rosa*	*Rosa tsinglingensis* Pax. et Hoffm.
109	Rosaceae	*Rosa*	*Rosa xanthina* Lindl.
110	Rosaceae	*Sorbaria*	*Sorbaria kirilowii* (Regel) Maxim.
111	Rosaceae	*Sorbus*	*Sorbus koehneana* Schneid.
112	Solanaceae	*Hyoscyamus*	*Hyoscyamus niger* L.
113	Caprifoliaceae	*Valeriana*	*Valeriana officinalis* L.
114	Caprifoliaceae	*Lonicera*	*Lonicera chrysantha* Turcz.
115	Caprifoliaceae	*Lonicera*	*Lonicera tangutica* Maxim.
116	Caprifoliaceae	*Lonicera*	*Lonicera tragophylla* Hemsl.
117	Caprifoliaceae	*Triosteum*	*Triosteum pinnatifidum* Maxim.
118	Thymelaeaceae	*Stellera*	*Stellera chamaejasme* L.
119	Apiaceae	*Bupleurum*	*Bupleurum chinense* DC.
120	Apiaceae	*Bupleurum*	*Bupleurum commelynoideum* var. *flaviflorum* Shan et Y.Li
121	Apiaceae	*Osmorhiza*	*Osmorhiza aristata* (Thunb.) Makino et Yabe
122	Apiaceae	*Bupleurum*	*Bupleurum smithii* Wolff
123	Cornaceae	*Cornus*	*Cornus macrophylla* Wallich
124	Paeoniaceae	*Paeonia*	*Paeonia obovata* Maxim.
125	Paeoniaceae	*Paeonia*	*Paeonia anomala* subsp. *veitchii* (Lynch) D. Y. Hong & K. Y. Pan
126	Brassicaceae	*Cardamine*	*Cardamine macrophylla* Willd.
127	Amaryllidaceae	*Allium*	*Allium victorialis* L.
128	Amaryllidaceae	*Allium*	*Allium bidentatum* Fisch. ex Prokh. & Ikonn.-Gal.
129	Caryophyllaceae	*Dianthus*	*Dianthus superbus* L.
130	Caryophyllaceae	*Gymnocarpos*	*Gymnocarpos przewalskii* Bunge ex Maxim.
131	Caryophyllaceae	*Gypsophila*	*Gypsophila capituliflora* Rupr.
132	Caryophyllaceae	*Stellaria*	*Stellaria nemorum* L.
133	Rhamnaceae	*Rhamnus*	*Rhamnus ussuriensis* J. Vass.
134	Dioscoreaceae	*Dioscorea*	*Dioscorea nipponica* Makino
135	Pinaceae	*Picea*	*Picea crassifolia* Kom.
136	Asparagaceae	*Asparagus*	*Asparagus filicinus* D. Don
137	Asparagaceae	*Maianthemum*	*Maianthemum bifolium* (L.) F. W. Schmidt
138	Asparagaceae	*Polygonatum*	*Polygonatum sibiricum* Delar. ex Redoute
139	Asparagaceae	*Polygonatum*	*Polygonatum cirrhifolium* (Wall.) Royle
140	Asparagaceae	*Polygonatum*	*Polygonatum gracile* P. Y. Li
141	Asparagaceae	*Polygonatum*	*Polygonatum zanlanscianense* Pamp.

(to be continued)

Continued Table 4

No.	Families	Genera	Species
142	Asparagaceae	*Maianthemum*	*Maianthemum henryi* (Baker) LaFrankie
143	Asparagaceae	*Polygonatum*	*Polygonatum odoratum* (Mill.) Druce
144	Araceae	*Pinellia*	*Pinellia ternata* (Thunb.) Breit.
145	Araceae	*Arisaema*	*Arisaema wardii* Marq. et Shaw
146	Celastraceae	*Parnassia*	*Parnassia oreophila* Hance
147	Celastraceae	*Euonymus*	*Euonymus phellomanus* Loesener
148	Celastraceae	*Euonymus*	*Euonymus verrucosus* Scop.
149	Sapindaceae	*Acer*	*Acer stachyophyllum* subsp. *betulifolium* (Maximowicz) P. C. de Jong
150	Sapindaceae	*Koelreuteria*	*Koelreuteria paniculata* Laxm.
151	Adoxaceae	*Sambucus*	*Sambucus adnata* Wall. ex DC.
152	Adoxaceae	*Viburnum*	*Viburnum opulus* subsp. *calvescens* (Rehder) Sugim.
153	Araliaceae	*Aralia*	*Aralia chinensis* L.
154	Araliaceae	*Eleutherococcus*	*Eleutherococcus giraldii* (Harms) Nakai
155	Araliaceae	*Panax*	*Panax japonicus* (T. Nees) C. A. Meyer
156	Araliaceae	*Panax*	*Panax bipinnatifidus* Seemann
157	Berberidaceae	*Epimedium*	*Epimedium brevicornu* Maxim.
158	Berberidaceae	*Berberis*	*Berberis kangdingensis* Ying
159	Hydrangeaceae	*Hydrangea*	*Hydrangea xanthoneura* Diels
160	Salicaceae	*Populus*	*Populus davidiana* Dode
161	Boraginaceae	*Eritrichium*	Eritrichium borealisinense Kitag.

4 Discussion

Liupan Mountains are located in the south of Ningxia Hui Autonomous Region and the east of Gansu Province. Through research, 161 species of vascular plants belonging to 60 families and 119 genera were collected. The dominant families are *Campanulaceae*, *Ranunculaceae*, *Orobanchaceae*, *Asparagaceae*, *Fabaceae*, *Rosaceae* and *Asteraceae*, with 6, 7, 8, 8, 10, 10, and 22 species, respectively. Their dominant position may be related to their superior reproductive structure and strong environmental adaptability. Further research is needed.

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