Endemic Wild Ornamental Plants from Northwestern Yunnan, China

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Abstract. Northwestern Yunnan is situated in the southern part of the Hengduan Mountains, which is a complex and varied natural environment. Consequently, this region supports a great diversity of endemic plants. Using field investigation in combination with analysis of relevant literature and available data, this paper presents a regional ethnobotanical study of this area. Results indicated that northwestern Yunnan has an abundance of wild ornamental plants: this study identified 262 endemic species (belonging to 64 genera and 28 families) with potential ornamental value. The distinguishing features of these wild plants, their characteristics and habitats are analyzed; the ornamental potential of most plants stems from their wildflowers, but some species also have ornamental fruits and foliage. Among the endemic genera, Pedicularis and Rhododendron have particularly high numbers of ornamental wild species, while Aconitum, Gentiana, Corydalis, Silene, Delphinium, Cremanthodium, and Saussurea also contain significant numbers of wild ornamental species. It is suggested that cultivation of these species may be beneficial, both commercially and to help conserve endangered endemic plant species.

Northwestern Yunnan, in southwestern China is a diverse region that is internationally recognized as biodiversity hotspot and a center of plant diversity (Davis et al., 1995; Li, 1994; Mittermeier et al., 2004). Bordering the Tibetan Plateau and northern Myanmar, northwestern Yunnan contains a diversity of vegetation zones spanning subtropical to alpine. As a result of these unique habitats and its location, northwestern Yunnan is characterized by exceedingly high levels of species endemism and harbors an exceptionally high number of rare and vulnerable species.

The variety of habitats in northwestern Yunnan stems from unique landscape features: the region is comprised of rugged, parallel mountain ranges (with glaciated peaks exceeding 6,500 m) and deep gorges (down to altitudes of 600 m). The mountain ranges provide dispersal corridors for upland flora from the Tibetan Plateau to the northwest and the Sichuan Highlands to the northeast, while the river valleys are conduits for flora from the Indo-Malayan and east Asian lowlands to the southwest and southeast (Sun, 2002). However, the same mountain ranges and gorges that have allowed adjacent floras to overlap, have also maintained sufficient isolation between valleys to enable significant in situ evolution.

Northwestern Yunnan is part of the Mountains of Southwest China Biodiversity Hotspot, which includes the Hengduan, Gaoligong, and Nu Shan mountains of western Yunnan, and the Tibetan Plateau and northern Myanmar, northwestern Yunnan contains a diversity of vegetation zones spanning subtropical to alpine. As a result of these unique habitats and its location, northwestern Yunnan is characterized by exceedingly high levels of species endemism and harbors an exceptionally high number of rare and vulnerable species.

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Given the rich diversity, it is not surprising that montane plants of northwestern Yunnan extends up to the southeastern edge of the Tibetan Plateau (Mittermeier et al., 2004). Within the Hengduan Mountains more than 7,000 vascular plant species (incorporating 1,467 genera and 985 families) have been recorded. Among these, 5,079 species are endemic to China, 2,988 to the Hengduan Mountains, and 910 are only found in northwestern Yunnan (with 13 genera containing 10 or more endemic species) (Chinese Academy of Science, 1993, 1994; Fang, 1993; Li and Li, 1993; Wu and Ding, 1998).

Given the rich diversity, it is not surprising that montane plants of northwestern Yunnan have played an important role in world horticulture and have been introduced to Western countries where they have been widely cultivated. Some of the best known examples include Rhododendron, Primula, Gentiana, Pedicularis, and Saussurea, which are all important genera in northwestern Yunnan (Chen et al., 1989; Feng, 1983; Guan et al., 1998; Hu, 1990; Shi and Jin, 1999; Yang, 1956). Many of these ornamental species are endemic to small areas of northwestern Yunnan (e.g., Rhododendron russatum), therefore, their cultivation not only provides for potential sources of income generation, but also offers a potential form of conservation management: these plants can be used directly for their ornamental plant value or as genetic resources for plant breeding programs. The aims of current paper are to describe the unique flora of northwestern Yunnan and provide detailed information of those resources, in terms of their potential horticultural value as ornamental species.

General Study Area

Northwestern Yunnan (lat. 25°30’–29°15’S and long. 98°05’–101°15’E) is on the Yunnan-Guizhou Plateau in southwestern China (Fig. 1). To the west the region merges into the Himalayan mountain ranges, to the north onto the Tibetan Plateau, while the south borders the temperate and subtropical lowlands of central and southern Yunnan. This mountainous region forms the upper reaches of three major river systems, the Nu Jiang (Salween River), the Lancang (Mekong), and the Jinsha Jiang (the upper reach of the Yangtze River). A wide range of vegetation types exists including, grassland, cushion-like alpine grasslands, evergreen broadleaf forest, mixed forest, alpine mosaic, deciduous broadleaf forest and

Fig. 1. The study area, northwestern Yunnan of China.

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Dali Prefectures, lat. 25°30’–29°15’N, and long. 16 counties of Diqing, Lijiang, Nujiang, and temperate conifer forest (Wu and Zhu, 1987; Yang, 1990).

The elevations of lower hill areas and valley plains along the Jinsha, Lancang and Nujiang, range between about 700 and 1,100 m. However, the taller mountains, such as Yulong, Haba and Meili snow mountains exceed heights of 5,000 m. The average temperature in this region is 10 to 15 °C, the highest and lowest temperatures in the ranges of 30 to 37 °C and −4 to −12 °C, respectively. The annual average rainfall is between 1,185, and 1,439 mm (Yang, 1990).

Site selection. Northwestern Yunnan covers 16 counties of Diqing, Lijiang, Nujiang, and Dali Prefectures, lat. 25°30’–29°15’N, and long. 98°05’–101°15’E. Its total area is 68,908 km² (17.5% of Yunnan Province).

Sed were selected according to the physiogeographical regionalization parameters outlined by Yang (1990) which are comprehensive contributions about physiogeographical regionalization of Yunnan. We used six areas: Yunlong, Laping alpine-medium hillside area (15,000 km²), Nu Jiangalpine mountains and gorge area (10,000 km²), Dali and Lijiang basin and range area (1,000 km²), Jinsha Jiang river valley area (15,000 km²), Zhongdian and Deqin alpine mountains and plateau area (16,000 km²), and part of the Baoshan and Fengqing medium mountain and basin area. In terms of political boundaries, the study sites covered the northern part of the Dali Bai Autonomous Prefecture, most of the Lijiang Naxi Autonomous Prefecture, the Nujiang Lisu Autonomous Prefecture and Diqing Zang Autonomous Prefecture. 16 counties are included in the study area: Yunlong, Dali, Eryuan, Jianchuan, Heqing, Binchuan, Lijiang, Ninglang, Yongsheng, Zhongdian, Deqin, Weixi, Laping, Lushui, Fugong, and Gongshan (Fig. 1).

Methods

An initial check list was made of the presence and distribution of plants in the study areas, based on the following plant surveys: List of seed plants in Yunnan (Kunming Institute of Botany, 1984), Vegetation of Yunnan (Wu and Zhu, 1987), Vascular Plants in Hengshuan Mountains (Chinese Academy of Science, 1993, 1994), Flora of Yunnan (Wu and Chen, 1986, 2000; Wuet al., 1997), and Flora of China (Chen and Hu, 1989; Hu, 1990; Shi and Jin, 1999; Yang, 1956). Herbarium records from the Kunming Institute of Botany were used to validate field samples. The compiled database included the following information: species, genus and family names, plant attributes including distribution patterns, life form, vegetation types, flower colors, flowering season and ornamental value. Using this database, we identified those endemic species that had ornamental value. Evaluation and reinvestigation of this list of endemic plants from northwestern Yunnan was based on literature, herbarium records, the database and field work.

Definition of ornamental plants. Different botanist have different definitions of ornamental plants. In this study, we consider wild ornamental plants to be those which occur naturally in the field and have highly ornamental features such as ornamental flowers, fruit, or foliage.

Results and Discussion

Wild ornamental plants endemic to northwestern Yunnan. In total, northwestern Yunnan contains 2,206 species, (belonging to 324 genera and 38 families), of which 910 species (41%) are endemic (Li et al., 2003). There are a total of nine endemic families with more than eight endemic species. A considerable number of these endemic species were found to be wild flowers. We identified 262 species, belonging to 64 genera and 28 families endemic to northwestern Yunnan. Among the endemic genera, Pedicularis and Rhododendron are particularly rich in endemic wild ornamental species (Table 1).

Analysis of life-form. The inventory shows that most of the endemic wild flowers are herbs or subshrubs; probably is a result of the harsh geographical environment in the study area (Table 2). Alpine plants are highly adapted to growth in particularly harsh conditions, since they have evolved special characteristics in response to a particular combination of cool climate and mountainous terrain. The cool climate in the study area, particularly in winter, results in generally low temperatures, frequent frosts and strong winds. Snow persists at the highest altitudes, for 1 to 3 months in the subalpine zone and 3 to 4 months in the alpine zone. These factors have major effects on plant growth. Low temperatures, frost and snow restrict plant growth for most of the year, particularly at high altitudes. Northwestern Yunnan alpine and mountain areas are characterized by a sequence of vegetation communities with distinct altitudinal zones. Vegetation communities are groups of plants living together with similar preferences and tolerances for particular environmental conditions. These communities can be described by differences in species, height and growth form, and structure. The most obvious change in communities is the transition, at the altitude known as the treeline, to a treeless vegetation.

Above the treeline is the true alpine zone where the vegetation is primarily dwarfed shrubs and ground hugging herbs, with no trees.

The growth habit also helps in surviving freezing temperatures: cushion and rosette herbs may be 10 °C higher than the surrounding air.

Analysis of ornamental features. Ornamental plants can be divided into three main types: those with ornamental flowers, ornamental fruits, or ornamental foliage. However, many wild plants have several ornamental parts, therefore, these divisions serve to distinguish different groups on their primary ornamental features.

The results show that of the endemic ornamental plants in northwestern Yunnan, 235 species have ornamental flowers, and most of them belong to the families Ericaceae, Compositae, Liliaeaceae, Orchidaceae, Ranunculaceae, Rosaceae, and Gentianaceae. Flower colors vary from red and purple to white and yellow. The red-flowered plants include some species of the genus Pedicularis, such as P. habachanensis, P. praeruptorum; the genus Rhododendron, such as R. cyanocarpum, R. fastigiatum, R. codonanathum; and the genus Androsace, such as A. alchemilloides. Most of the purple-flowered plants belong to the genera Gentiana, Primula, Aconitum, Delphinium, and Corydalis (exemplified by species such as G. bella, P. annulata, A. acutisulcum, D. brevisepalum, and C. petrophila). White-flowered species include Sorbus harrowiana, Spiraea calcicola, Anemone multifloula, prominent yellow-green flowers include Rhododendron dendricola, R. rhombifolium, Pedicularis lomatomi, and P. tomentosa.

Table 3 shows the approximate flowering times of 262 wild ornamental plants endemic to northwestern Yunnan. Flowering times are affected by a variety of factors, including, habitat, elevation and species type. Generally at higher elevations plants will bloom later and for longer periods of time. The number of species blooming in early spring and midsummer is greater than those blooming in fall or mid-winter. Most Pedicularis spp., Rhododendron spp., Primula spp. and Gentiana spp. bloom in early spring and midsummer, whereas, Cremantisimum spp. and Delphinium spp. bloom in fall and winter.

There are only 17 endemic wild species with ornamental fruits in northwestern Yunnan. These plants have fruits with a vivid color or unique shape; most of the species belong to Aceraceae, Rosaceae, Aquifoliaceae and Actinidiaceae. Plants from the Aceraceae have light purple or purplish green, winged fruits, each consisting of a pair of samaras which

| Family          | No. of species | Genera   | No. of species |
|-----------------|----------------|----------|----------------|
| Ranunculaceae   | 34             | Pedicularis | 34             |
| Scrophulariaceae| 32             | Rhododendron | 31             |
| Ericaceae       | 18             | Gentiana | 16             |
| Compositae      | 16             | Corydalis | 16             |
| Gentianaceae    | 14             | Silene | 13             |
| Rosaceae        | 13             | Delphinium | 12             |
| Caryophyllaceae | 13             | Corydalis | 16             |
| Furmariacea     | 13             | Cremanthodium | 8             |
| Primulaceae     | 11             | Saussurea | 8              |

Table 2. Analysis of the life-form of endemic wild ornamental plants in northwestern Yunnan.

| Life form (species) | Percentage |
|---------------------|------------|
| Herb                | 70.2       |
| Shrub               | 25.2       |
| Tree                | 4.6        |

Table 3. Approximate flowering times of 262 wild ornamental plants endemic to northwestern Yunnan.
| Species | Life form | Color | Fl or Fr time | Habitat |
|---------|-----------|-------|---------------|---------|
| Delphinium ceratophorum | Perennial herbs | purple-blue | July–Sept. | Alpine meadow at 3,600–4,000 m |
| Corylopsis glaucescens | Perennial herbs | yellow | July–Aug. | Alpine meadow at 3,700–4,000 m |
| Corydalis heterocentra | Perennial herbs | blue | Aug.–Sept. | Alpine meadows at 3,700–4,000 m |
| Corydalis delavayi | Perennial herbs | blue | July–Oct. | Alpine meadows at 3,700–4,000 m |
| Corydalis cheirifolia | Perennial herbs | blue | Aug.–Sept. | Alpine meadows at 3,700–4,000 m |
| Corylopsis yui | Perennial herbs | purple-blue | Aug.–Sept. | Alpine meadows at 3,700–4,000 m |
| Cotinus nana | Woody vines | white, red | June, Aug. | Alpine meadow at 4,150 m |
| Crataegus oresbia | Perennial herbs | yellow | June | Alpine meadows at 3,700–4,000 m |
| Cremanthodium chungtienense | Perennial herbs | blue | July–Aug. | Alpine meadows at 3,700–4,000 m |
| Cypripedium margaritaceum | Perennial herbs | yellow | July–Aug. | Alpine meadows at 3,700–4,000 m |
| Delphinium brevisepalum | Perennial herbs | blue | July–Aug. | Alpine meadows at 3,700–4,000 m |
| Cotinus nana | Woody vines | white, red | June, Aug. | Alpine meadow at 4,150 m |
| Crataegus oresbia | Perennial herbs | yellow | June | Alpine meadows at 3,700–4,000 m |
| Cremanthodium chungtienense | Perennial herbs | blue | July–Aug. | Alpine meadows at 3,700–4,000 m |
| Cypripedium margaritaceum | Perennial herbs | yellow | July–Aug. | Alpine meadows at 3,700–4,000 m |
| Delphinium brevisepalum | Perennial herbs | blue | July–Aug. | Alpine meadows at 3,700–4,000 m |

Table 3. Inventory of wild ornamental plants endemic to northwestern Yunnan; Fl = flower, Fr = fruit, Fo = foliage.
| Species | Life form | Color | Fl or Fr time | Habitat |
|---------|-----------|-------|---------------|---------|
| **Delphinium himatum Fr** | Perennial herbs | F1 blush-purple | F1 Sept.–Oct. | Alpine meadow at 2,900–3,300 m |
| **Delphinium latiflorum WC Wang** | Perennial herbs | F1 blue | F1 Aug.–Sept. | Alpine meadow at 2,900 m |
| **Delphinium skimmianum Fr** | Perennial herbs | F1 green | F1 Aug.–Sept. | Alpine meadow at 3,400–4,500 m |
| **Delphinium nodiflorum Fr** | Perennial herbs | F1 white | F1 Aug.–Sept. | Alpine meadow at 2,600–3,800 m |
| **Delphinium elatum Fr** | Perennial herbs | F1 blue | F1 Aug.–Sept. | Alpine meadow at 3,300–4,200 m |
| **Delphinium grandiflorum Fr** | Perennial herbs | F1 purple | F1 July–Aug. | Alpine meadow at 3,200–4,500 m |
| **Delphinium candidum Fr** | Perennial herbs | F1 purple | F1 July–Aug. | Alpine meadow at 3,200–4,500 m |
| **Delphinium griffithii Fr** | Perennial herbs | F1 yellow | F1 July–Aug. | Alpine meadow at 3,200–4,500 m |
| **Delphinium carinatum Fr** | Perennial herbs | F1 white | F1 June–Aug. | Alpine meadow at 3,200–4,500 m |
| **Delphinium tetrix Fr** | Perennial herbs | F1 purple | F1 July–Aug. | Alpine meadow at 3,200–4,500 m |
| **Delphinium grandiflorum Fr** | Perennial herbs | F1 purple | F1 July–Aug. | Alpine meadow at 3,200–4,500 m |
| **Delphinium candidum Fr** | Perennial herbs | F1 purple | F1 July–Aug. | Alpine meadow at 3,200–4,500 m |
| **Delphinium griffithii Fr** | Perennial herbs | F1 yellow | F1 June–Aug. | Alpine meadow at 3,200–4,500 m |
| **Delphinium carinatum Fr** | Perennial herbs | F1 white | F1 June–Aug. | Alpine meadow at 3,200–4,500 m |
| **Delphinium grandiflorum Fr** | Perennial herbs | F1 purple | F1 July–Aug. | Alpine meadow at 3,200–4,500 m |
| **Delphinium tetrix Fr** | Perennial herbs | F1 purple | F1 July–Aug. | Alpine meadow at 3,200–4,500 m |
| **Delphinium grandiflorum Fr** | Perennial herbs | F1 yellow | F1 June–Aug. | Alpine meadow at 3,200–4,500 m |
| **Delphinium carinatum Fr** | Perennial herbs | F1 white | F1 June–Aug. | Alpine meadow at 3,200–4,500 m |
| **Delphinium grandiflorum Fr** | Perennial herbs | F1 purple | F1 July–Aug. | Alpine meadow at 3,200–4,500 m |
| **Delphinium tetrix Fr** | Perennial herbs | F1 purple | F1 July–Aug. | Alpine meadow at 3,200–4,500 m |
| **Delphinium griffithii Fr** | Perennial herbs | F1 yellow | F1 June–Aug. | Alpine meadow at 3,200–4,500 m |
| **Delphinium carinatum Fr** | Perennial herbs | F1 white | F1 June–Aug. | Alpine meadow at 3,200–4,500 m |
| **Delphinium grandiflorum Fr** | Perennial herbs | F1 purple | F1 July–Aug. | Alpine meadow at 3,200–4,500 m |
| **Delphinium tetrix Fr** | Perennial herbs | F1 purple | F1 July–Aug. | Alpine meadow at 3,200–4,500 m |
| **Delphinium griffithii Fr** | Perennial herbs | F1 yellow | F1 June–Aug. | Alpine meadow at 3,200–4,500 m |
| **Delphinium carinatum Fr** | Perennial herbs | F1 white | F1 June–Aug. | Alpine meadow at 3,200–4,500 m |
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| **Delphinium carinatum Fr** | Perennial herbs | F1 white | F1 June–Aug. | Alpine meadow at 3,200–4,500 m |
| **Delphinium grandiflorum Fr** | Perennial herbs | F1 purple | F1 July–Aug. | Alpine meadow at 3,200–4,500 m |
| **Delphinium tetrix Fr** | Perennial herbs | F1 purple | F1 July–Aug. | Alpine meadow at 3,200–4,500 m |
| **Delphinium griffithii Fr** | Perennial herbs | F1 yellow | F1 June–Aug. | Alpine meadow at 3,200–4,500 m |
| **Delphinium carinatum Fr** | Perennial herbs | F1 white | F1 June–Aug. | Alpine meadow at 3,200–4,500 m |
| **Delphinium grandiflorum Fr** | Perennial herbs | F1 purple | F1 July–Aug. | Alpine meadow at 3,200–4,500 m |
| **Delphinium tetrix Fr** | Perennial herbs | F1 purple | F1 July–Aug. | Alpine meadow at 3,200–4,500 m |
| **Delphinium griffithii Fr** | Perennial herbs | F1 yellow | F1 June–Aug. | Alpine meadow at 3,200–4,500 m |
| **Delphinium carinatum Fr** | Perennial herbs | F1 white | F1 June–Aug. | Alpine meadow at 3,200–4,500 m |
| **Delphinium grandiflorum Fr** | Perennial herbs | F1 purple | F1 July–Aug. | Alpine meadow at 3,200–4,500 m |
| **Delphinium tetrix Fr** | Perennial herbs | F1 purple | F1 July–Aug. | Alpine meadow at 3,200–4,500 m |
| **Delphinium griffithii Fr** | Perennial herbs | F1 yellow | F1 June–Aug. | Alpine meadow at 3,200–4,500 m |
| **Delphinium carinatum Fr** | Perennial herbs | F1 white | F1 June–Aug. | Alpine meadow at 3,200–4,500 m |
| **Delphinium grandiflorum Fr** | Perennial herbs | F1 purple | F1 July–Aug. | Alpine meadow at 3,200–4,500 m |
| **Delphinium tetrix Fr** | Perennial herbs | F1 purple | F1 July–Aug. | Alpine meadow at 3,200–4,500 m |
| **Delphinium griffithii Fr** | Perennial herbs | F1 yellow | F1 June–Aug. | Alpine meadow at 3,200–4,500 m |
| **Delphinium carinatum Fr** | Perennial herbs | F1 white | F1 June–Aug. | Alpine meadow at 3,200–4,500 m |
| **Delphinium grandiflorum Fr** | Perennial herbs | F1 purple | F1 July–Aug. | Alpine meadow at 3,200–4,500 m |
| **Delphinium tetrix Fr** | Perennial herbs | F1 purple | F1 July–Aug. | Alpine meadow at 3,200–4,500 m |
| **Delphinium griffithii Fr** | Perennial herbs | F1 yellow | F1 June–Aug. | Alpine meadow at 3,200–4,500 m |
| **Delphinium carinatum Fr** | Perennial herbs | F1 white | F1 June–Aug. | Alpine meadow at 3,200–4,500 m |
| **Delphinium grandiflorum Fr** | Perennial herbs | F1 purple | F1 July–Aug. | Alpine meadow at 3,200–4,500 m |
| **Delphinium tetrix Fr** | Perennial herbs | F1 purple | F1 July–Aug. | Alpine meadow at 3,200–4,500 m |
| **Delphinium griffithii Fr** | Perennial herbs | F1 yellow | F1 June–Aug. | Alpine meadow at 3,200–4,500 m |
| **Delphinium carinatum Fr** | Perennial herbs | F1 white | F1 June–Aug. | Alpine meadow at 3,200–4,500 m |

Table 3 (continued). Inventory of wild ornamental plants endemic to northwestern Yunnan; Fl = flower, Fr = fruit, Fo = foliage.
| Species | Life form | Color | Fl or Fr time | Habitat |
|---------|-----------|-------|---------------|---------|
| *Pedicularis micrantha* HL Li | Perennial herbs | F1 rose-red | F1 July–Aug. | Alpine meadow at 1,300–4,150 m |
| *P. alba* | | | | |
| *P. alpina* | | | | |
| *P. alpina* | | | | |
| *P. septentrionalis* | | | | |
| *P. sibirica* | | | | |
| *P. sibirica* | Perennial herbs | F1 purple-red | F1 July–Aug. | Alpine meadow at 1,300–4,150 m |
| *P. sibirica* | | | | |
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Spiraea calcicola
Spiraea compsophylla
Sorbus poteriifolia
Smithorchis calceoliformis
Solms-Laubachia pulcherrima
T. Tang et FT Wang
Silene yunnanensis
Silene rosi
Silene otodonta
Silene melanantha
Silene longipes

or alpine meadow, alpine gravel desert, conifer
are evergreen broad-leaved forest, subalpine
The predominant habitats in the study sites
there are 15 species endemic to northwestern
Yunnan. These species are dominated by
ornamental foliage, the inventory indicates that

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flowers are richest in the vegetation types of
alpine scrub and alpine meadow, followed
by alpine Rhododendron scrub, which means
that endemic wild flowers are most abundant
at elevations between 2,500 and 4,500 m
(Table 4).

Subalpine meadow, alpine scrub and alpine
gravel desert are special habitats for northwestern
Yunnan. The Hengduan mountains are the
consequence of the upheaval of the Qinghai-
Xizang Plateau after the collision between the
Indian plate and Eurasian plate (Wu, 1988),
thus the vegetation types mentioned above
were formed through rapid species differen-
tiation. Alpine gravel desert is the high, cold
desert plateau zone vegetation type, for which
the typical ecological conditions are very
low temperatures, a very short or nonexistent
growing season, severe drought, high wind,
and barren, rocky soil (Chang, 1981). In this
harsh environment, plants formed adaptive
physiological and ecological characteristics,
developing into cushion plant communities.
Most of these cushion plants, small in size and
peculiar in shape, grow in rock cracks, and
their flowers are very bright and showy, thus
they have excellent potential as rock gardens
plants. For example, the genera Primula,
Rhododendron, Meconopsis, Gentiana, and
Lilium are all found in alpine gravel desert, with
Primula and Meconopsis especially abundant
in this habitat. In addition to these genera, many
other alpine flowers, such as Aconitum spp.,
Delphinium spp., Corydalis spp., Draba spp.,
Solms-laubachia spp., Sedum spp., Rhodiola
spp., Silene spp., and Saussurea spp. are also
widely distributed in alpine gravel desert.

Subtropical evergreen broad-leaved forest
only occurs at elevations of 2,300 to 3,000
m in northwestern Yunnan. This subtropical
evergreen vegetation is the result of an unusual
local environment, so it is not surprising that
it has created a niche for many endemic wild
ornamental plants. For example, P. forrestii
with deep gold-yellow flowers, P. uncinita
with blue flowers and P. sinolisteri with light
red flowers often grow intermixed.

Another interesting habitat are the barren
gravelly areas that occur in the saddles between
peaks at elevations of 3,900 m to 4,600 m.
These gravelly areas were formed by glacial
deposits during past colder climates. These

Table 3 (continued). Inventory of wild ornamental plants endemic to northwestern Yunnan; Fl = flower, Ff = foliage.

| Species | Life form     | Color               | Fl or Ff time       | Habitat                                      |
|---------|---------------|---------------------|--------------------|----------------------------------------------|
| Silene linarifolia CY Wu | Perennial herbs | Fl purple           | Fl Aug.–Oct.       | Alpine shrubs at 2,700–2,900 m               |
| Silene lineosperma (Post) D. | Perennial herbs | Fl purple           | Fl after Aug.      | Subalpine meadow, alpine shrubs at 3,300–4,000 m |
| Silene melanantha Fr | Perennial herbs | F deep purple       | F July–Sept.       | Alpine shrubs and meadow at 3,200–4,150 m    |
| Silene crassicaulis Fr | Perennial herbs | Fl light red        | Fl after Sept.     | Subalpine meadow at 2,100–2,500 m             |
| Silene philippica Fr | Perennial herbs | Fl deep purple      | Fl after July      | Subalpine meadow at about 1,800 m             |
| Silene pulchella Fr | Perennial herbs | Fl reddish          | Fl after July      | Alpine shrubs at about 3,200 m                |
| Silene rosi Fr | Perennial herbs | Fl reddish          | Fl May–July       | Alpine shrubs, alpine gravel desert at 1,900–2,600 m |
| Silene scapularis Fr | Perennial herbs | Fl dark purple      | Fl July–Aug.      | Alpine meadow, alpine gravel desert at 4,000 m   |
| Silene yunnanensis Fr | Perennial herbs | Fl deep purple      | Fl June–Sept.     | Alpine shrubs, alpine gravel desert at 2,400–3,900 m |
| Silene yunnanensis Fr | Herbs          | Fl white            | Fl Dec.            | Evergreen broad-leaved forest at 1,000–2,100 m |
| Solms-Laubachia pulcherrima Muschler | Perennial shrublike herbs | Fl bluish, Fr purplish-red | Fl Apr.–June, Fl July–Aug. | Alpine gravel desert at 3,400–4,500 m                |
| Sorbus balfouriana (Balfour et WW Sm.) Rehder | Trees | Fl white | Fl May–June | Evergreen broad-leaved forest at 2,100–3,500 m             |
| Sorbus kiautschoviczii TT Yu | Shrubs or trees | Fl white, Fr red   | Fl May–June       | Evergreen broad-leaved forest at 3,400–4,000 m           |
| Sorbus poteriifolia Hand.–Mazz. | Small shrubs | Fl pinkish-white, Fr white | Fl May–June, Fl Sept.–Oct. | Subalpine shrubs and meadow at 3,000–3,500 m |
| Silene calycina WW Sm. | Shrubs          | Fl white            | Fl May–June       | Subalpine shrubs and meadow at 2,900–3,800 m                |
| Silene cardiophylla Hand.–Mazz. | Shrubs | Fl white | Fl July–Sept. | Shrub and meadow at 1,450–2,450 m                |
| T. Tang et FT Wang | Perennial herbs | Fl dark purple      | Fl July–Aug.      | Alpine shrubs and meadow at 3,400–4,500 m             |
| T. Tang et FT Wang | Perennial herbs | Fl deep purple      | Fl June–Sept.     | Alpine shrubs, alpine gravel desert at 2,400–3,900 m |

Table 4. The relationships between endemic wild ornamental plants and their habitat.

| Habitat                                      | Endemic wild ornamental plants (species) | Percentage |
|----------------------------------------------|-----------------------------------------|------------|
| Alpine shrub                                 | 73                                      | 27.8       |
| Alpine meadow                                | 70                                      | 26.6       |
| Rhododendron scrub                           | 29                                      | 11.0       |
| Evergreen broad-leaved forest                | 28                                      | 10.6       |
| Alpine gravel desert                         | 27                                      | 10.3       |
| Subalpine or alpine meadow                   | 20                                      | 7.6        |
| Comifer and broad-leaved mixed forest        | 17                                      | 6.6        |
| Dry-hot valley scrub                         | 5                                       | 1.9        |

Fig. 2. Primula baileyana Forr. Taken in Yulong snow Mountains, meadows, altitude 2,700 m, in Lijian, northwestern Yunnan.
Fig. 4. Solms-Laubachia pulcherrima Muschler. Taken in Daxueshan (big snow mountains, altitude 4,100 m), Zhongdian, Yunnan.

barren areas are exposed, windswept habitats, which suppresses the development of woody vegetation and limits the kinds of plants that can grow. Consequently, all plants in these areas are with stemless aboveground: the stems are either below ground, or the vegetative parts arise directly from subterranean bulbs, corms or rhizomes. In these exposed gravel habitats, the only parts of the plants visible above the ground are the leaves and flowers. Among the more common and conspicuous herbaceous plants that have evolved in these environments are Saussurea and Solms-Laubachia pulcherrima (Figs. 3 and 4). Saussurea species have interconnected underground stems with short branches that bear leaves and inflorescences at the soil surface. What appears to be a small colony of several individual plants is actually a single plant with a turf of leaves at the end of each branch and inflorescences clustered in the center of the leaves. Similarly, Solms-Laubachia pulcherrima have the main stem and branches totally below ground level and only the leaves, flowers and fruits appear above the soil surface.

In contrast to the compact and low habit of other species in exposed environments, members of the genus Meconopsis (a member of the poppy family, Papaveraceae) often send their flowering stems well above the associated vegetation in defiance of the wind. This genus is characteristic of high elevation areas in northwestern Yunnan and its habit in these exposed sites is rather amazing, since the flowers of Meconopsis appear to be extremely delicate. One important species, Meconopsis delavayi (Fig. 5), is grown for its beautiful flowers. The small, cup-shaped, pendant, lavender-blue flowers are borne singly on long, thin stems, in late spring and early summer, however, the heights of stems differ considerably among the varieties, ranging from 0.3 to 2 m.

Another example of a genus characteristic of northwestern Yunnan is Gentiana (Fig. 6). This genus tends to be particularly abundant in alpine meadows at altitudes of 4,500 m to 4,700 m. Of special interest to botanists in northwestern Yunnan are Gentianas that are annual or biennial herbs as their flowers are very colorful, ranging from dark red, purple, light yellow, green, white, and even to bright-blue which is especially uncommon. Therefore, this genus is considered to have great potential for the future development of ornamental wildflower species.

Conclusions

As an initial regional ethnobotanical study of this area, it is clear that northwestern Yunnan is rich in endemic ornamental species. During the course of this study, we identified 262 taxa, belonging to 64 genera and 28 families, endemic to this region with potential ornamental value. This high number of endemic species reflects the diverse environment and taxonomic significance of northwestern Yunnan. Encouraging the use of natural ornamental plants in these regions can make considerable contributions to the economy and the culture of these rural regions. Therefore, the taxonomic investigation of these plants and the use of them by gardeners should be encouraged. These wild ornamental plants in northwest Yunnan not only are the ancestors for existing cultivated plants, but also are the rare basis for the cultivation of various new breeds in the future, as well as they are very important genetic resources, which could be used for introducing and conserving plants from the field. We hope that this work will help the researchers and people who are interested in wild ornamental plants.

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Fig. 5. *Mecanopsis delavayi* (Fr) Fr ex Prain. Taken in Yulong snow Mountains, alpine grasslands at alt. 3,800 m, in Lijian, northwestern Yunnan.

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Fig. 6. *Gentiana chungtiensis* C. Marquand. Taken in alpine meadows, altitude 3,200 m, Xiaozhongdian, Yunnan.