

# *Pararuellia glomerata* (Acanthaceae), a new species from Yunnan, China

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**ABSTRACT.** *Pararuellia glomerata* Y. M. Shui & W. H. Chen is described and illustrated as new species from Yunnan, China. It is similar to *P. cavaleriei* (H. Lév.) E. Hossain and *Pararuellia delavayana* (Baillon) E. Hossain, but differs by its cylindrical spike and dense imbricate homomorphic bracts. Pollen grains, seeds and cross sections of the leaf epidermis are reported for this species of arid environments.

**Keywords:** Acanthaceae; China; Leaf cross section; Leaf epidermis; New species; *Pararuellia glomerata*; Pollen; Seeds.

## INTRODUCTION

In May 2004, during a survey of the limestone flora in SE Yunnan, China, we found three populations, each containing 20-50 individuals, of an unusual plant of the Acanthaceae, which we determined to be *Pararuellia* Bremek. (Acanthaceae). *Pararuellia* is distinguished from *Ruellia* by its terminal, dense spike, and Asiatic distribution (Bremekamp and Nannenga-Bremekamp, 1948). *Pararuellia* contains about eight species in SE Asia, Indochina, and Malaysia, and four in China (Tsui, 2002) (*P. alata* H. P. Tsui, *P. cavaleriei* [H. Lév.] E. Hossain, *P. hainanensis* C. Y. Wu & H. S. Lo, and *P. delavayana* [Baill.] E. Hossain).

The region where this plant was found has high temperature, little rain, and thin soil. The yearly averages of rainfall are about 800 mm, and the yearly averages of temperature are about 23.70°. The vegetation is dominated by shrubs and grasses. Of the plants we found, two were moved to the botanical garden of the Kunming Institute of Botany, Chinese Academy of Sciences. The plants flowered and fruited the following year, and there are now more than 30 individuals in cultivation.

The unusual species appears to be rare and endemic to the hot and dry valleys in SE Yunnan. Further examination of some herbaria (KUN, PE) revealed a collection from near Nansha, Yuanyang Xian, Yunnan, in 1973. The locality is only one kilometer from the localities found in 2004. So far, the total area of distribution covers no more than fifteen square kilometers along the Hong He (Red River) Valley of SE Yunnan. If the species is as rare as collections indicate, it is urgently in need of protection.

The plant is characterized by constricted internodes, subrosulate leaves, a terminal dense spike with imbricate flowers, ovules 5 or 6 per carpel, and 3-pored globose pollen grains with alveolate exine. These characters clearly place it in the genus *Pararuellia*. After consulting the literature (Benoist, 1935; Tsui, 2002; Hu and Tsui, 2006) and examining specimens, we determined these plants to be a previously undescribed species, which we here describe and illustrate.

***Pararuellia glomerata*** Y. M. Shui & W. H. Chen, sp. nov.—TYPE: China, Yunnan Province, Gejiu, 200 m, 30 Apr 2004, Y. M. Shui, W. H. Chen, M. D. Zhang 40746 (holotype: KUN; isotypes: IBSC, PE).

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Figures 1, 3

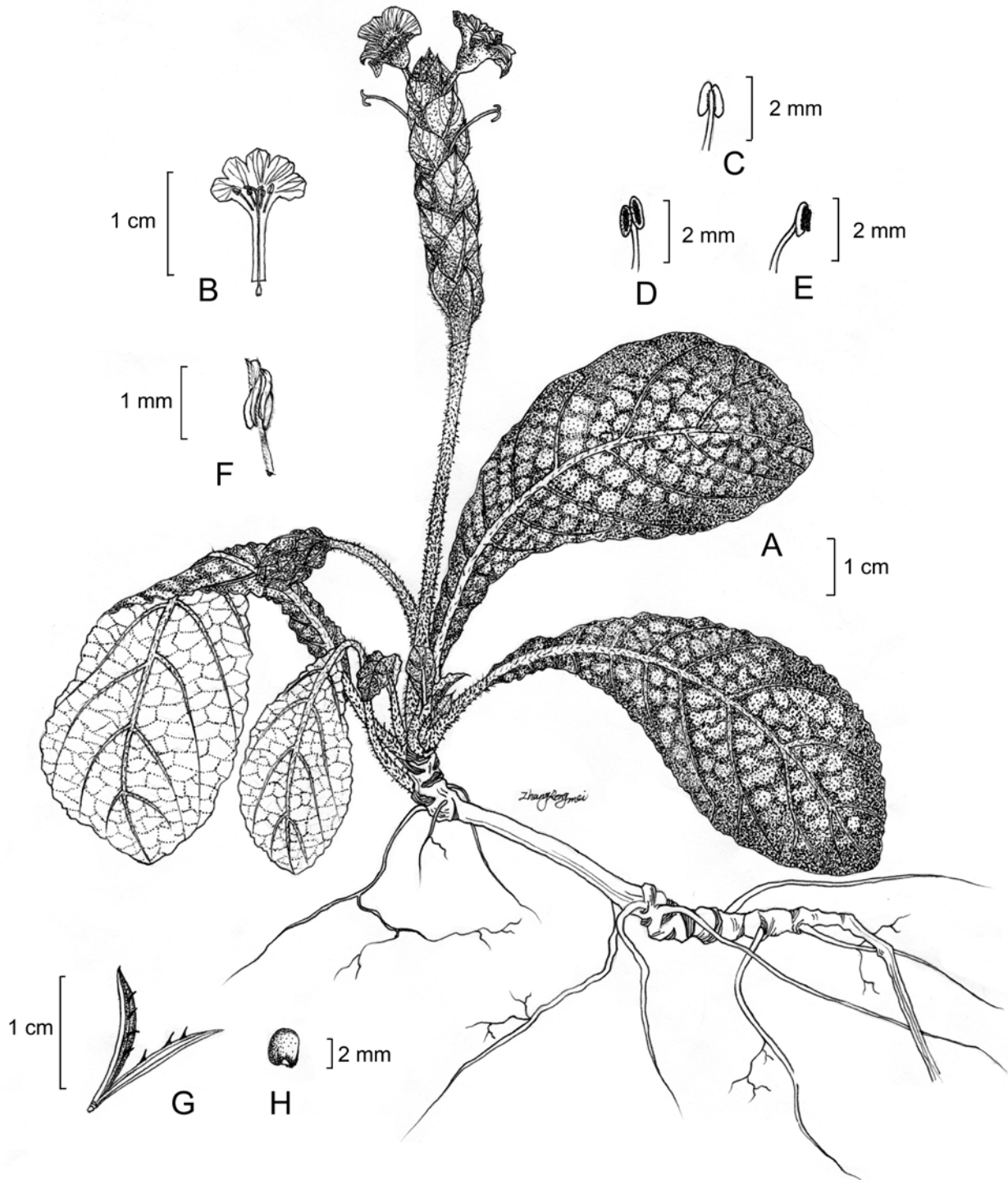
*Species nova spicis cylindratis et bracteis omnino homomorphis imbricatis a congeneribus valde differt.*

Perennial herbs. Stems 1-2 cm long; internodes 2-4, constricted, 0.5-1.1 cm long, nodes adventitiously rooted when touching ground, forming a new stem. Leaves opposite, subrosulate; petiole 1.3-3.4 cm long, densely hispid; blade oblanceolate, obovate-oblong or spatulate, 4-6.2 × 1.8-3.2 cm, base gradually narrowed and decurrent into petiole, margin erose or crenate, apex round to acute, abaxially densely hispid, adaxially slightly hispid, lateral nerves 6-9 pairs, prominent on both surfaces. Spike terminal, cylindrical, (0.6-)3.2-5.4 cm long, 0.8-1.1 cm in diam., of numerous verticillate cymes; cyme contracted, 1- or 2-flowered. Peduncle 0.7-5 cm long, densely hispid, elongate to ca. 13 cm in fruit. Rachis (0.6-) 3.0-5.5 cm long, densely hispid, nodes (3 or) 4-10, elongate to 7 cm in fruit. Bracts numerous, homomorphic, distributed along rachis, imbricate, ovate, or spatulate, 8-10 × 6-9 mm, pinninerved, densely hispid, apex acute. Bracteoles linear-

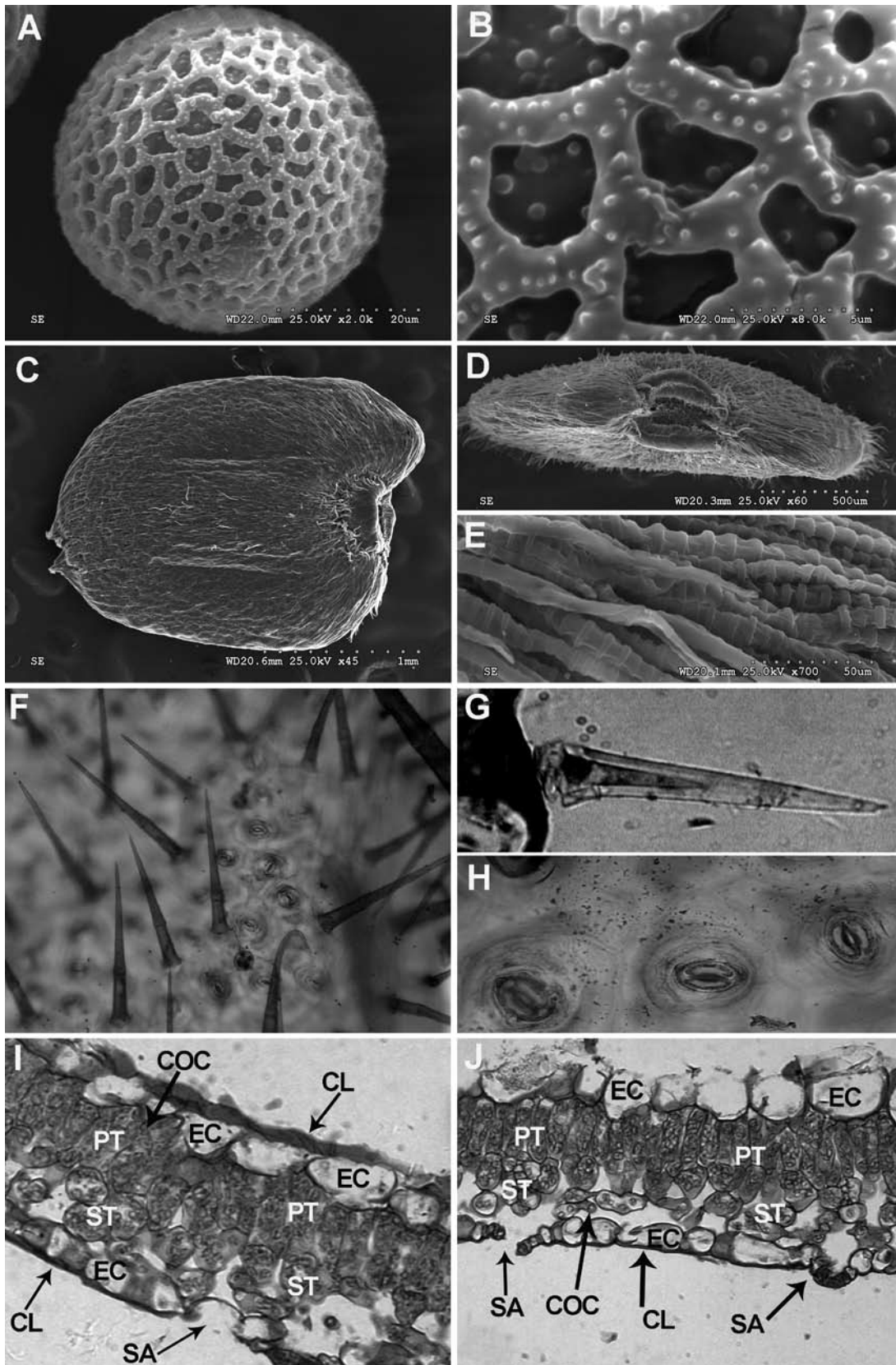
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lanceolate,  $3-4 \times$  ca. 1 mm, apex acuminate, basal part of adaxial surface sparsely hispid, apical part of adaxial surface densely hispid. Calyx 5-lobed nearly to base, tube ca. 1 mm long, lobes linear, subequal, ca.  $4 \times 0.7$  mm, hispid, elongate, to ca. 6 mm long in fruit. Corolla light purple, bluish or pink, outside slightly hispid, inside glabrous; corolla tube 0.8-1.3 cm long, 1.5-2 mm in diam.,

outside sparsely hispid, inside glabrous, throat oblique and inflated, 2.5-4 mm long, 3-4 mm in diam., limb 5-lobed, lobes equal, nearly round or trapeziform,  $7-8 \times 5-7$  mm, apex round or truncate. Stamens 4, didynamous, anthers elliptic, ca. 1.1 mm long, filaments glabrous, the longer filaments 1.5-3 mm long, inserted 0.8-1.5 mm from base of throat, shorter ones ca. 0.5 mm long, inserted at base



**Figure 1.** Illustration of *Pararuellia glomerata* Y. M. Shui & W. H. Chen (drawn by Rong-Mei Zhang from the holotype). A, Plant; B, Flower; C, Dorsal view of anther; D, Anterior view of anther; E, Lateral view of anther; F, Opened anther; G, Fruit; H, Seed.



**Figure 2.** *Pararuellia glomerata*. A, Pollen grain; B, Exine ornamentation of pollen grain; C, Seed; D, Basal view of seed; E, Hairs on surface of seed; F, Cells and stomata on lower leaf surface; G, Articulatory attachments like cuticularized hairs; H, Stomata on lower leaf surface; I and J, Cross sections of leaf blade, showing epidermal cells, palisade tissue and spongy tissue of leaf blade, corneous layer, calcium oxalate crystals in cells of leaf blade, stomata, and air chambers. Reference: CL: corneous layer; COC: calcium oxalate crystals; EC: epidermal cells; PT: palisade tissue; SA: stomata; ST: spongy tissue.

of throat. Ovary cylindrical, 2-2.5 mm long, ca. 1 mm in diam., glabrous, ovules 5 or 6 per locule; style 0.8-1.4 cm long, pubescent, stigma 2-lobed, linear, longer lobe 2.3-2.6 mm long, shorter lobe ca. 1.3 mm long, pubescent. Capsules cylindrical, 1-1.5 cm long, 2-3 mm in diam., pubescent, 2-valved, seeds 5 or 6.

*Additional specimens examined.* China, Yunnan Province, Gejiu, 29 Apr 2004, alt. 360 m, Y. M. Shui, W. H. Chen, M. D. Zhang 40729 (KUN); Yuanyang, near Nansha, 12 Nov 1973, roadsides, 330 m, D. D. Tao 1433 (KUN, PE).

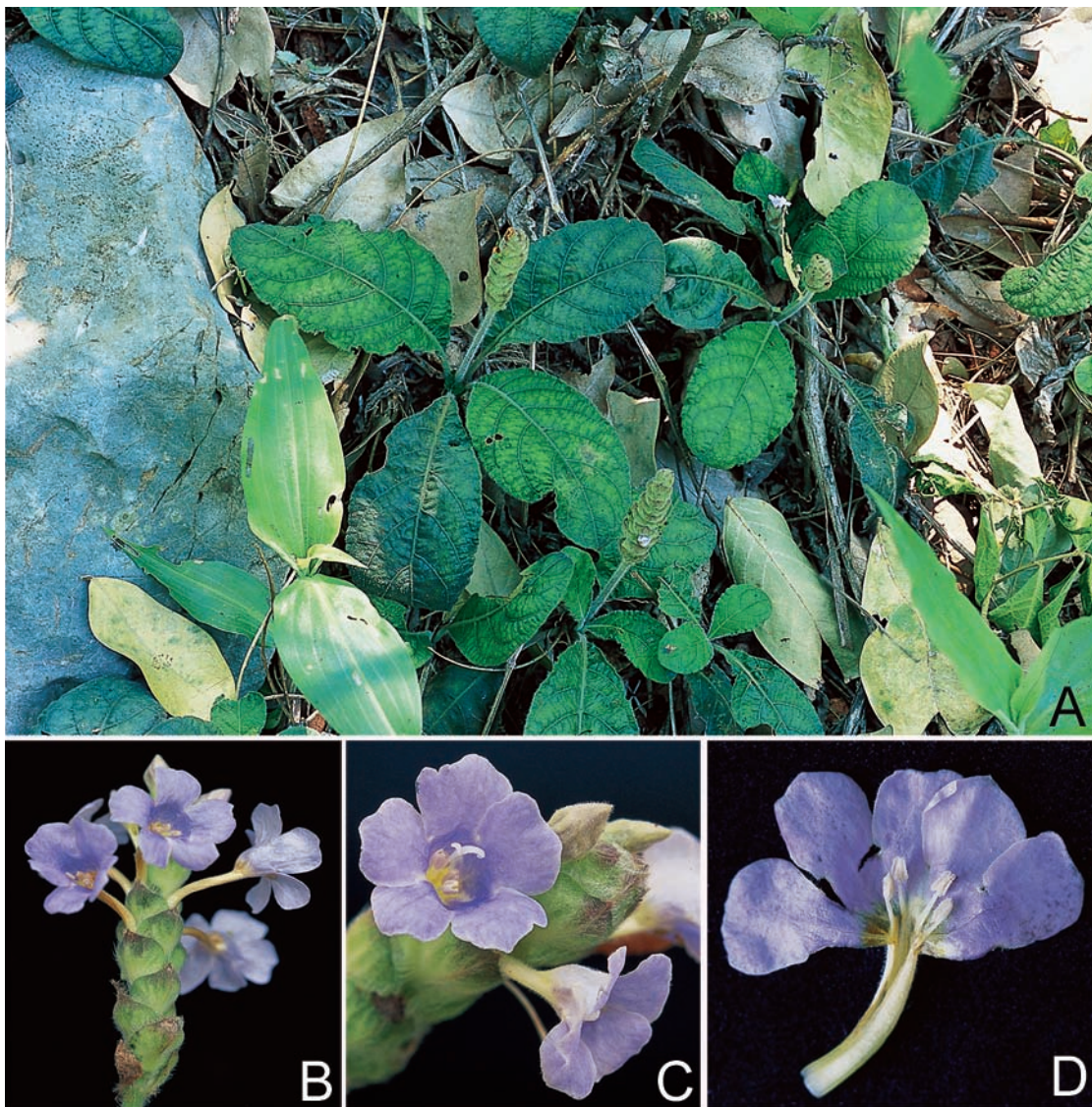
*Etymology.* The epithet *glomerata* refers to the densely arranged bracts of the inflorescence.

*Phenology.* Flowering Apr to Jul; fruiting Jun to Aug.

*Distribution and Habitat.* Restricted to limestone thickets at 200-500 m in hot dry valley of the Hong He (Red River) in SE Yunnan, China. The accompanying

species are depauperate. For example, *Sapium insigne* (Royle) Benth. ex Hook. f. is only 4-6 m tall (vs. to 40 m tall in tropical rain forests in SE Asia). Other associated small trees and shrubs include *Bauhinia viridescens* Desv., *Bauhinia yunnanensis* Franch., *Burretiodendron kydiifolium* Y. C. Hsu & R. Zhuge, *Cycas hongheensis* S. Y. Yang & S. L. Yang ex D. Y. Wang, *Euphorbia royleana* Boiss., *Garuga forrestii* W. W. Smith, *Grewia celtidifolia* Juss., *Lannea coromandelica* (Houtt.) Merr., *Millettia cubittii* Dunn and *Wrightia arborea* (Dennst.) Mabberley. *Jasminum yuanjiangense* P. Y. Bai, *Secamone sinica* Hand.-Mazz. are associated vines, and *Calophanoides yunnanensis* (W. W. Sm.) C. Y. Wu is a common herb.

*Notes.* *Pararuellia glomerata* is similar to *P. cavaleriei* (H. Lévl.) E. Hossain and *Pararuellia delavayana* (Baill.) E. Hossain, but differs in its robust cylindrical spikes and homomorphic imbricate bracts. *Pararuellia cavaleriei* and *Pararuellia delavayana* have heteromorphic bracts (viz.



**Figure 3.** The field images of *Pararuellia glomerata*. A, Plant; B, Inflorescences; C, Face and side views of flowers; D, Flower, expanded. All images from holotype specimen. Photographed by Y. M. Shui.

foliose at base of rachis, and gradually reduced distally), spikes slender with free bracts. *Pararuellia glomerata* also differs from *P. cavaleriei* by its larger bracts (8-10 mm vs. 1-2 mm long), and from *P. delavayana* by its spikes with (3-) 4-10 nodes (vs. 1 or 2 [or 3] nodes). The following key can be used to distinguish the Chinese species of *Pararuellia* (Acanthaceae).

- 1a. Bracts of rachis longer than internodes, imbricate, homomorphic; spikes robust, cylindrical ..... *Pararuellia glomerata*
- 1b. Bracts of rachis shorter than internodes, free, usually heteromorphic; spikes usually slender, flagelliform.....2
  - 2a. Nodes of spike usually 1 or 2 (rarely 3) ..... *P. delavayana*
  - 2b. Nodes of spike usually 4.....3
    - 3a. Rachis straight, wingless .....4
    - 3b. Rachis usually zig-zag, winged below nodes ..... *P. alata*
    - 4a. Bracts oblong, elliptic or ovate ..... *P. cavaleriei*
    - 4b. Bracts cordate or suborbicular ..... *P. hainanensis*

We also examined the pollen and leaf morphology, the results of which are described below.

## MATERIALS AND METHODS

### Plant materials

The pollen for SEM work was taken from the type specimen. Seeds and leaves were taken from living plants of the type location. Voucher specimens are deposited in the Herbarium of the Kunming Institute of Botany (KUN).

### Micromorphology of pollens grains and seeds under SEM

Mature and dry pollen grains and seeds were cleaned in water using ultrasound. For SEM they were air-dried, affixed to aluminum specimen holders and sputter-coated with gold. Morphological observations and micrographs were made using a Hitachi-S-3000N ESEM. Terminology for pollen morphology of Acanthaceae follows Erdtman (1971) and Punt et al. (2007).

### Morphology and anatomy of leaf blade under LM

Epidermal characters of leaves were observed. Fresh leaves were fixed in FAA (formaldehyde: 100% acetic acid: 70% alcohol = 5:5:90) and dissociated using Jeffrey's reagent (10% nitric acid: 10% potassium dichromate = 1:1). The leaf epidermis was stained in a 0.5% safranin solution, dehydrated via an alcohol series, and mounted on a microscope slide. The slides were sealed in neutral balsam and observed under an Olympus microscope.

Anatomical characters of leaves were observed in

paraffin sections. Leaves were fixed in FAA, dehydrated via an alcohol series, embedded in paraffin and sectioned at 12  $\mu\text{m}$  thickness with a sliding microtome, stained in a safranin and fast green solution, sealed in neutral balsam, and observed under an Olympus microscope.

## RESULTS

### Pollen and seed morphology

Pollen grains are globose, 45-45.3  $\mu\text{m}$  in diam. The exine ornamentation is alveolate, with thickish, spiny muri, irregularly shaped lumina, and three distinct pores (Figure 2A-B). These characters are consistent with those of *Pararuellia* (Bremekamp and Nannenga-Bremekamp, 1948), especially with the characters of the pollen of *Pararuellia alata* and *P. delavayi* (Hu et al., 2005), confirming *Pararuellia glomerata* to be a member of the genus *Pararuellia*.

The seeds are lenticular, broadly ovate or suborbicular in face view, 1-1.5  $\times$  1-1.5 mm. The base of the seed is glabrous, but the remaining surface is covered with dense, long, white, appressed hairs (Figure 2C-E).

### Characteristics of leaf epidermis and leaf cross section

Leaf epidermal terminology follows Dilcher (1974) and Wilkinson (1979). *Pararuellia glomerata* has hypostomatic leaves. The epidermal cells of the lower leaf surface are irregular and the anticlinal walls of the cells are undulate. The cell walls are thick (Figure 2F). Anisocytic stomata are randomly scattered over the entire leaf surface (Figure 2F). The subsidiary cells around the guard cells are elliptic, lunate or arcuate, but vary in size (Figure 2H).

The leaves of *Pararuellia glomerata* are bifacial in cross section. There is one layer of epidermal cells, these with a thickened corneous layer on both surfaces. The palisade tissue has one or two cell layers and is distinct. Spongy tissue is inconspicuous. The cells of the entire palisade layer and some of the spongy layer are full of multifarious calcium oxalate crystals (Figure 2I-J). Air chambers are under the stomata (Figure 2J). Many articulated cuticularized hairs are on both leaf surfaces (Figure 2F, G).

## DISCUSSION

*Pararuellia glomerata* is distinct in the genus *Pararuellia*. It is distributed only in poor soils in the karst region of the hot and dry Hong He valley. As an adaptation to the extreme environment, the plants have developed many xerophytic characteristics, e.g. distinct palisade tissue, inconspicuous spongy tissue, appressed epidermal cells, hypogenous stomata with large air chambers, and leaf surfaces densely covered with hairs, which decrease transpiration and irradiation (Li et al., 2007b).

Calcium oxalate crystals in the leaf cells may aid in the

survival of the plants. First, *Pararuellia glomerata* appears to accumulate calcium (Li et al., 2007a). Second, calcium oxalate crystals in the leaf cells of the entire palisade layer and some of the spongy layer may provide support to the leaves, without which the leaves may wither quickly when dried (Franceschi and Horner, 1980). Third, calcium oxalate crystals in the leaf cells may reflect light toward photosynthetic cells, especially in shaded situations (Kuo-Huang et al., 2007).

*Pararuellia glomerata* mainly depends on vegetative reproduction. Few young independent individuals occur in the field and in the botanical garden. Most individuals, however, easily give rise to adventitious roots when touching the ground and form new shoots, especially in the botanical garden. Our observations indicate that *Pararuellia glomerata* can flourish and may even become invasive in the Kunming Botanical Garden.

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## 中國雲南產爵床科地皮消屬一新種：球穗地皮消

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本文報導了中國產的地皮消屬 *Pararuellia* 一新種：球穗地皮消 *Pararuellia glomerata* Y. M. Shui & W. H. Chen。該種近似於羅甸地皮消 *Pararuellia cavaleriei* (Lévl.) E. Hossain 及地皮消 *Pararuellia delavayana* (Baill.) E. Hossain 兩種，主要區別在於本種圓柱狀的圓錐花序和互相覆蓋的同型苞片。此外，在掃描電鏡下觀察了花粉及種子的形態特徵，在光學顯微鏡下觀察葉表皮特徵及葉片內部解剖學特徵，並討論了與旱生相適應的特徵。

**關鍵詞：**爵床科；中國；葉表皮；葉橫切；新種；球穗地皮消；花粉；種子。

