

## *Paraboea hekouensis* and *P. manhaoensis*, two new species of Gesneriaceae from China

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Two new species of Gesneriaceae, *Paraboea hekouensis* Y.M. Shui & W.H. Chen and *P. manhaoensis* Y.M. Shui & W.H. Chen, are described and illustrated. The former species is similar to *P. nutans* in possessing a basal leaf rosette, centrally positioned styles and slightly twisted fruits, but differs from it by having a dense golden-brown and long pubescence on the abaxial surface of the leaves, smaller white flowers and two basal staminodes. The latter is similar to *P. crassifolia* in possessing basal obovate leaves, centrally positioned styles, and a thick matted indumentum on the lower surface of the leaves, but differs by its smaller white flowers, shorter corolla tubes and only slightly twisted fruits. The leaf surface characters and various types of indumentum of the above four species are also observed in detail and discussed. An identification key to the Chinese and Vietnamese species with a rosulate habit in *Paraboea* is provided.

### Introduction

The genus *Paraboea* (Gesneriaceae) has recently been redefined to accommodate species of *Trisepalum* and *Phylloboea*, and now includes about 120 species (Puglisi *et al.* 2011). They are mostly distributed in limestone karst habitats in Bangladesh, Bhutan, Cambodia, China, India, Indonesia, Laos, Malaysia, Myanmar, Philippines, Thailand and Vietnam (Burt 1984, Xu & Burt 1991, Xu *et al.* 2008, Puglisi *et al.* 2011). Eighteen species, including nine endemics, are recorded from China, and fifteen species, including four endemics, from Vietnam (Wang 1990, Wang *et al.* 1998, Li & Wang 2004, Chen *et al.* 2008, Xu *et al.* 2008).

During botanical explorations of the border region between China and Vietnam from 2003 to 2009, we collected several specimens belonging to the genus *Paraboea*. One of these, *P. trisepala*, a species possessing a tripartite calyx, was recently described (Chen *et al.* 2008). After careful observations in the field and comprehensive examination of *Paraboea* specimens from China and adjacent countries (Barnett 1961, Wang 1990, Li 1991, Xu 1994, Fang *et al.* 1995, Pham-Hoang 2000, Li & Wang 2004, Xu & Wei 2004, Xu *et al.* 2008), we describe a further two new species here.

Leaf epidermis characters have a great taxonomic potential (Bongers *et al.* 1973, Zhang *et al.* 2008, Chen *et al.* 2009, Grace *et al.* 2009,



**Fig. 1.** Localities of two new species of *Paraboea* in China, *P. hekouensis* (square) and *P. manhaoensis* (star).

Mill & Stark-Schilling 2009, Moon *et al.* 2009, Pi *et al.* 2009, Wang *et al.* 2009). Although the epidermis cells and stomata have been shown to possess some taxonomic relevance in the Neotropical Gesneriaceae, data from the palaeotropical Gesneriaceae are scarce (Weber 2004).

Burt and Tan (1984) gave excellent illustrations for the genus *Paraboea* of calcium accumulation and excretion as observed on herbarium specimens, and discussed their ecological significance. In respect to leaf characters, the indumentum possesses highly diagnostic characteristics for species differentiation (Xu *et al.* 2008). There are seven types described (arachnoid, matted, simple pubescence, simple long pubescence, multi-branched hairs, sessile glands, and glandular hairs), and their diverse combinations and different colours can be used to define species. However, the description of the indumentums is sometimes not clear because of the lack of knowledge of their exact composition or cell structure at the micro-morphological level.

To make best use of epidermis and indumentum characters in future identification in the genus *Paraboea*, a detailed observation of the two new species was made on living specimens

under a light microscope (LM) and illustrated in detail in the present paper.

## Material and methods

### Plants

Plants were collected from limestone tropical seasonal forests in the border region between China and Vietnam (Fig. 1). Specimens were collected directly from the field, and the first set was deposited at the herbarium of Kunming Institute of Botany (KUN), Chinese Academy of Sciences. During field surveys over several summers, the natural habit and morphology of the new species was observed in detail and photographically documented (Fig. 2).

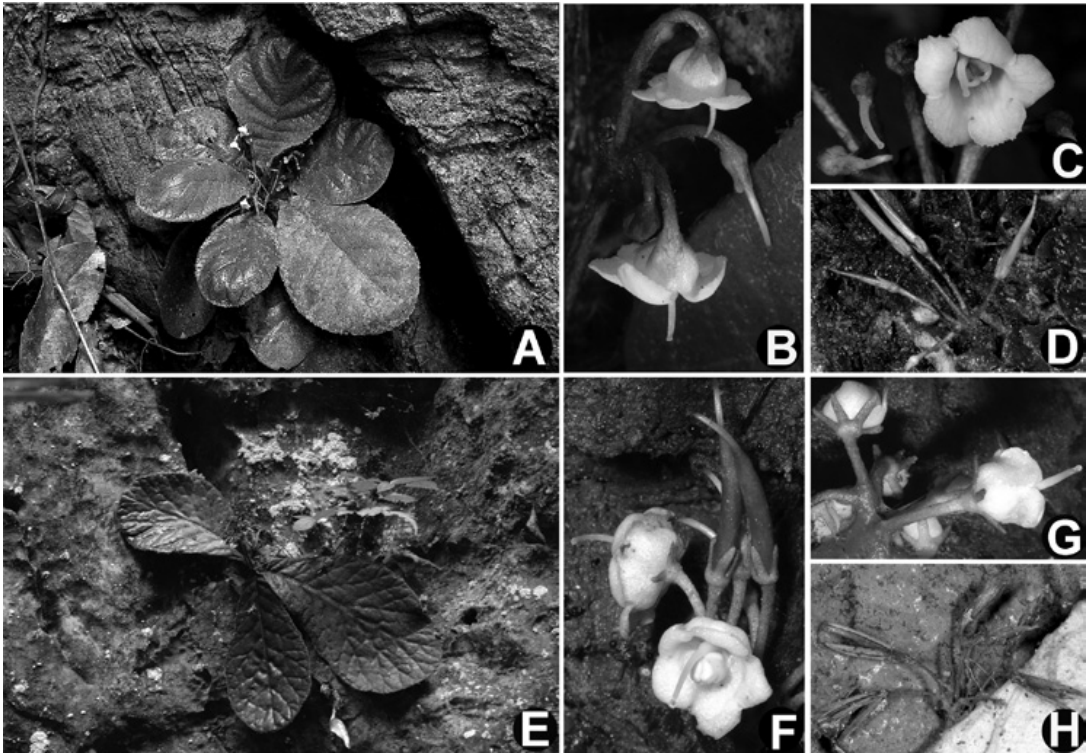
### Morphology of leaf surfaces

Leaf epidermal characters were observed on leaves fixed in FAA (30% formaldehyde:100% acetic acid:70% alcohol, 1:1:18) and dissociated using Jeffrey's reagent (10% nitric acid:10% potassium dichromate, 1:1). The leaf epidermis was peeled off and stained in a 0.5% safranin solution, and observed with a Leica DM 1000 brightfield light microscope (Leica, Solms, Germany). The epidermis characters were determined based on 20 leaf samples. Leaf epidermal terminology follows Dilcher (1974), Wilkinson (1979) and Prabhakar (2004).

### Taxonomic treatment

***Paraboea hekouensis*** Y.M. Shui & W.H. Chen, *sp. nova* (Figs. 2A–D and 3)

*Paraboeae nutanti arcte affinis, sed nervis foliorum abaxialibus conspicue reticulatis dense et longe pubescentibus (in illa nervis abaxialibus planis dense arachnoideis), lobis calycis 2.5–3 × 0.5 mm externe dense et longe chryso-brunneolis pubescentibus (in illa lobis calycis 5–6 × 2.5–3 mm externe sparse et brevi brunneolis arachnoideis), corollis albis minoribus 6–7 mm longis 6–7 mm diam. (in illa corollis purpureo-venosis*



**Fig. 2.** Photographic images of two new species of *Paraboea* in the field (by Yu-Min Shui). — **A–D:** *Paraboea hekouensis*. — **A:** Habitat. — **B:** Lateral view of flowers. — **C:** Face view of a flower. — **D:** Fruits. — **E–H:** *Paraboea manhaoensis*. — **E:** Habitat. — **F:** Flowers and fruits. — **G:** Calyces. — **H:** Dry fruits.

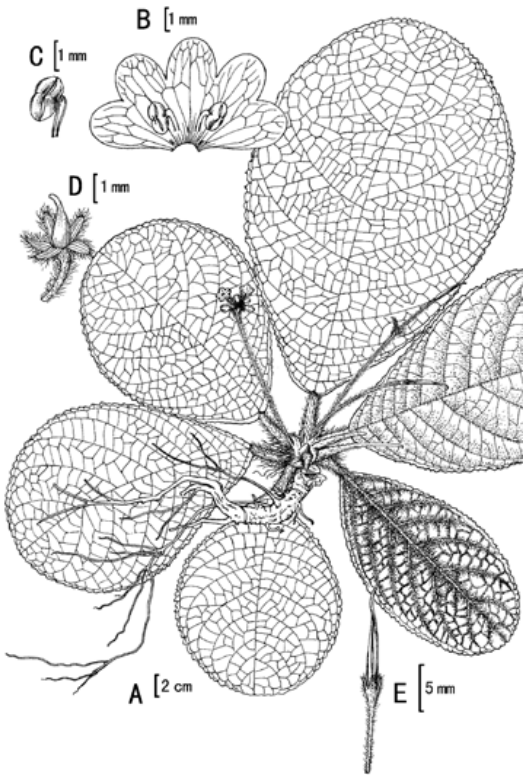
10–11 mm longis 15–16 mm diam.), tubo corollae 3–4 mm longo (nec ca. 7 mm longo), staminodiis 2 (nec 3) differt.

**HOLOTYPE:** China. Yunnan Province, Hekou county, Nanxi community, 22°41'N, 104°01'E, 700 m, in dense forests on limestone hillsides, in flower and fruit, 19 June 2003 *Y. M. Shui et al.* 32129 (KUN; isotypes E and PE). — **PARATYPES:** China. Yunnan Province, Hekou county, 750–1000 m, on cliffs in dense forests on limestone hills, in fruit, 2001 *Y. M. Shui et al.* 15107 (KUN); at the same locality, 1000–1200 m, in seasonal limestone forests, 2002 *Y. M. Shui et al.* 20576 (KUN); at the same locality, 900 m, on cliffs in dense limestone forests, in fruit, 2005 *Y. M. Shui et al.* 44548 (KUN); at the same locality, Nanxi community, 1000 m, on moist cliffs of limestone hillsides, in flower, 2009 *Y. M. Shui et al.* 83055 (KUN); at the same locality, Nanxi community, 1255 m, flowers white, 2011 *Y. M. Shui et al.* 92477 (KUN).

**ETYMOLOGY.** The new species is named after the type locality, Hekou county, in the province of Yunnan in China. Hekou (formerly Hokou) is an important centre of plant diversity in the border region between China and Vietnam.

Rosette herbs, 0.1–0.2 m tall. Leaves basal, leaf blade obovate or panduriform, 7–18.5 × 4.4–

10.6 cm, leathery, adaxially with dense golden-brown long hairs and grey arachnoid indumentum when young, later glabrescent, abaxially with a dense grey matted indumentum, base shallowly and obliquely cordate or retuse, never decurrent, margin densely serrate, apex rounded; midrib depressed adaxially, prominent abaxially, covered with 3–5 mm long hairs; lateral veins 8–11 pairs, adaxially obscure, abaxially distinct; venation distinctly reticulate; petiole 0.5–3 cm long, densely covered with golden-brown long hairs. Cymes axillary; peduncles 2–4 cm long in flower, 4–6 cm long in fruit, distinctly shorter than leaves, densely covered in golden-brown long hairs; pedicel ca 1 cm long, densely covered in golden-brown pannose hairs when young and becoming gradually glabrescent; bracts lanceolate, ca. 5 × 2 mm in fruit, with golden-brown long hairs in flower, secondary bracts linear lanceolate, 0.3 × 0.1 cm. Calyx 5-sect from base; segments lanceolate-oblong, 2.5–3 × 0.5 mm, outside densely covered with golden long hairs,



**Fig. 3.** *Paraboea hekouensis* (drawn from the holotype by Xi-Lin Wu). — **A:** Habit. — **B:** Flower, cut open showing stamens and staminodes. — **C:** Stamen. — **D:** Ovary. — **E:** Mature capsule.

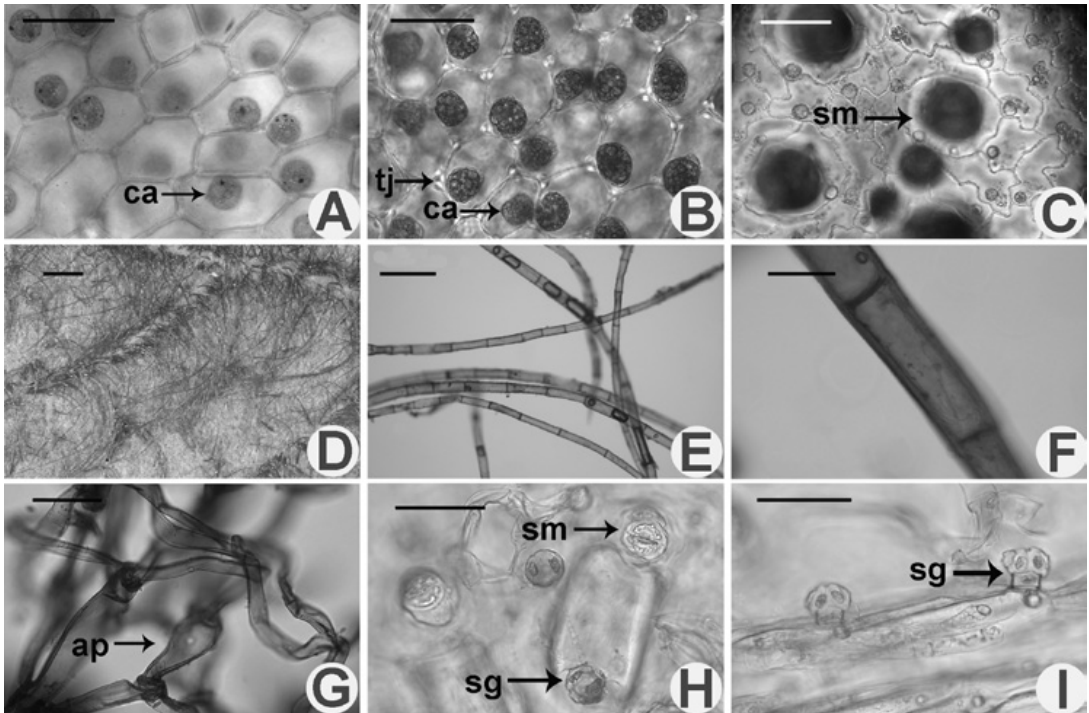
3-veined. Corolla white, scarcely zygomorphic, 6–7 mm long, glabrous, 6–7 mm across; tube 3–4 mm long; upper lip 2-lobed, lobes 2.5 × 4 mm; lower lip 3-lobed, lobes 3 × 3 mm. Stamens 2, included; filaments 1.5 mm long, not inflated, glandular puberulent, adnate to 0.8 mm from the base of the corolla tube; anthers 2 mm long, confluent at apex, dehiscing longitudinally, apex acute; staminodes 2, 0.3 mm long, almost adnate to the base of the corolla tube. Ovary oblong, 2–3 mm long, subglabrous. Style linear, 0.4 mm long, situated in the centre of the corolla, with an undivided stigma. Disc inconspicuous. Capsules very slightly twisted (about 1/2 turn), cylindrical, 1.5–2.2 cm long, 1.8 mm in diameter, subglabrous, with a 0.2–0.4 cm long permanent style at the apex, with persistent calyx. Seeds numerous, ovoid, 0.4 mm long. Flowering from June to July, fruiting from July to October.

**DISTRIBUTION AND HABITAT.** *Paraboea hekouensis*

is only known from the type locality, Hekou county in SE Yunnan, China, just ca. 2 km away from the border between China and Vietnam. It grows on cliffs in limestone forests at altitudes of 700–1200 m (Fig. 2A). The forests are composed predominantly of the following broad-leaved trees: *Paviasia anamensis*, *Clausena excavata*, *Xantolis boniana*, *Yunnanopilia longistaminea*, and the coniferous trees *Podocarpus wangii*, *P. nerifolius* and *Taxus chinensis*. Many epiphytic orchids grow on their trunks, such as *Aphyllorchis montana*, *Bulbophyllum cylindraceum*, *B. delitescens*, *B. rufinum*, *Cheirostylis yunnanensis*, *Epigeneium amplum*, and *E. clemensiae*.

*Paraboea hekouensis* has dorsiventralized and hypostomatic leaves. The epidermis cells are irregularly hexagonal (occasionally pentagonal, rarely tetragonal) and  $51.1 \times 26.3 \mu\text{m}$  on the upper surface (Fig. 4A and B). The epidermis walls are straight and usually thickened in the corners of epidermis cells (Fig. 4B). The epidermal cells are irregularly elliptic with irregular walls on the lower surface (Fig. 4C). The epidermis cell walls have numerous thickened areas at each junction where three cells meet on both surfaces (Fig. 4B). Calcium accumulations are easily visible at the joint of epidermis cells on the upper leaf surface (Fig. 4B). The stomata are basically anisocytic with two guard cells and six lunate subsidiary cells (Fig. 4C). The guard cells are  $16 \times 7.5 \mu\text{m}$ , the subsidiary cells  $18\text{--}32 \times 4.5\text{--}7.6 \mu\text{m}$  long. There are 2–3 epidermis cells between adjacent stomata. Stomata only occur on the lower leaf surface, and are covered by a thick matted indumentum.

*Paraboea hekouensis* has four types of indumentum: a white matted indumentum on the lower leaf surface and all its veins, petioles, peduncles, pedicels and sepals (Fig. 4G), a grey arachnoid indumentum on the upper surfaces of young leaves, golden-brown simple long trichomes on the upper surface of young leaves, on the main, lateral and fine veins on the lower leaf surface, petioles, peduncles and pedicels (Fig. 4D–F), and golden sessile glands on the lower leaf surfaces, main and lateral veins, petioles, peduncles and filaments (Fig. 4H and I). *Paraboea hekouensis* shares the matted and sessile indumentum types with *P. nutans*, but



**Fig. 4.** Leaf epidermis characteristics of *Paraboea hekouensis* (from Y. M. Shui *et al.* 32129). — **A:** Upper leaf surface under LM, showing hexagonal (occasionally heptagonal, rarely tetragonal) epidermis cells and round calcium accumulations (ca) in these cells. — **B:** Upper leaf surface under LM, showing thickened walls at the joint of epidermis cells (tj) and round calcium accumulations (ca). — **C:** Lower leaf surface under LM, showing irregularly elliptic epidermis cells and extrusive stomata (sm). — **D:** Lower leaf surface as seen by naked eye, showing long brown pubescence on veins and white matted indumentum on lower epidermis. — **E:** Long brown pubescence on veins of lower leaf surface under LM. — **F:** Individual cell of long hairs, showing slightly thickened walls and dark colour. — **G:** Ampullaceous uniseriate cells (ap) of matted indumentum under LM. — **H:** Two stomata (sm) and two subsessile glands (sg) on lower leaf surface under LM. — **I:** Subsessile glands (sg) on veins of lower leaf surface under LM, showing two terminal cells and 1–2 basal cells. Scale bars: **A–C, F–I** = 50  $\mu$ m; **D** = 2 mm; **E** = 200  $\mu$ m.

differs in its arachnoid indumentum and simple long pubescence (Table 1).

*Paraboea hekouensis* resembles *P. nutans* by both having basal and obovate leaves and axillary inflorescences, but they differ mainly by the former having dense long golden-brown hairs on the abaxial surface of the leaves, a distinct reticulate venation on the abaxial leaf surface, smaller calyces of 2.5–3 mm length, smaller white corollas 6–7 mm long and 6–7 mm across, and shallower corolla tubes 3–4 mm long and 2 staminodes. *Paraboea nutans* has a dense arachnoid indumentum on the abaxial leaf surface, calyces 5–6 mm long, violet corollas 10–11 mm long and 15–16 mm in diameter, and longer corolla tubes ca. 7 mm long and three staminodes.

***Paraboea manhaoensis*** Y.M. Shui & W.H. Chen, *sp. nova* (Figs. 2E–H and 5)

*Paraboeae crassifoliae arcte affinis, sed corollis albis minoribus (nec purpureis majoribus), tubo corollae ca. 3 mm longo (nec ca. 8–11 mm), filamentis glabris et rectis (in illa dense pilosis et contortis), capsula paene recta (in illa valde contorta) differt.*

**HOLOTYPE:** China. Yunnan province, Gejiu city, Manhao community, 23°01'N, 103°24'E, on cliffs at the margin of forests, 500 m, herb ca. 10 cm, flowers white, young fruits green, 12 July 2007 Y. M. Shui *et al.* 71674 (KUN). — **PARATYPES:** China. Yunnan, Gejiu city, Manhao community, on cliffs along the margin of forests, 700 m, with flowers and fruits, 27 July 2005, M. D. Zhang and Z. D. Wei 311 (KUN); Yunnan, Gejiu city, Manhao community, on cliffs in rain forests in valleys, on limestone hillsides, 450–500 m, 2005 Y.

*M. Shui et al. 44318* (KUN); at the same locality, with fruits, 1995 *S. H. Huang 95164* (KUN); near the above locality, on cliffs, with fruits, 2005 *Y. M. Shui et al. 44488* (KUN, HAST); Maguan county, voucher, 120 m, 2002 *Y. M. Shui et al. V-136* (KUN); Mengzi county, Shuitian community, 22°59'N, 103°26'E, 729 m, with dehisced fruit, 15 June 2011, *Y. M. Shui et al. s.n.* (KUN); at the same locality, 729 m, flowers white, 2011 *Y. M. Shui et al. 92466* (KUN).

**ETYMOLOGY.** The species is named after the type locality, Manhao community of Gejiu county in Yunnan (China), where it grows. Manhao was a small port on the Honghe river from China to Vietnam in the 19th century.

Rosette herbs. Leaves basal, 3–5; leaf blade obovate, 10–16 × 6–10 cm, leathery, adaxially densely arachnoid when young and glabrous when mature, abaxially with a dense grey matted indumentum, base cuneate, margin entire and slightly undulate, apex rounded; midrib adaxi-

ally depressed, abaxially prominent; lateral veins 6–8 pairs, obscure adaxially, distinct abaxially; petiole short, 0.2–0.8 cm long, with a dense grey matted indumentum. Cymes axillary, with 5–7 inflorescences, 9–11-flowered; peduncle 6.6–8 cm, basally with a grey matted indumentum; bracts linear lanceolate, 2 × 0.8 mm; pedicel 0.7–1 cm long, with a sparse grey matted indumentum. Calyx 5-sect from base, base slightly inflated; segments linear to narrowly lanceolate, 3 × 0.5 mm, outside with a sparse grey matted indumentum, 3-veined. Corolla white, 5.5 mm long, 6 mm in diam., glabrous; tube 3 mm; adaxial lip 2-lobed, 1 × 2.5 mm, apex rounded; abaxial lip 3-lobed, lateral lobes 1.5 × 2 mm, central lobe longer, 1.8 × 2 mm, apex rounded. Stamens 2, included; filaments 1.5 mm long, glabrous, adnate

**Table 1.** Comparison of indumentums among *Paraboea hekouensis* [holotype, *Y. M. Shui et al. 32129* (KUN)], *P. nutans* [isotype, *D. Fang & D. H. Qin 79634* (GXMI)], *P. manhaoensis* [holotype, *Y. M. Shui et al. 71674* (KUN)], and *P. crassifolia* [*Y. M. Shui et al. 43016* (KUN)].

Characters	<i>P. hekouensis</i>	<i>P. nutans</i>	<i>P. manhaoensis</i>	<i>P. crassifolia</i>
<b>Matted indumentum</b>				
lower leaf surface	white	white	grey to brown	brown
veins on the lower leaf surface	main, lateral and fine white	main and lateral white	–	main and lateral grey
petioles	white	white	–	grey
peduncles	white	white	–	–
pedicels	white	–	–	–
sepals	white	white	–	–
<b>Arachnoid indumentum</b>				
upper leaf surface in young	grey	white	white	brown
leaf margin	–	brown	–	–
main and lateral veins on the lower leaf surface	–	brown	grey	–
petioles	–	brown	grey	–
peduncles	–	brown	grey	–
pedicels	–	brown	–	–
sepals	–	brown	–	–
<b>Simple long pubescence</b>				
upper leaf surface in young	golden-brown	–	–	–
main, lateral and fine veins on the lower leaf surface	golden-brown	–	–	–
petioles	golden-brown	–	–	–
peduncles	golden-brown	–	–	–
pedicels	golden-brown	–	–	–
<b>Subsessile glands</b>				
lower leaf surface	golden	golden	golden	golden
main and lateral veins on the lower leaf surface	golden	golden	golden	golden
petioles	golden	golden	golden	golden
peduncles	golden	golden	golden	golden
filaments	golden	golden	golden	white

to abaxial side of corolla tube and 0.5 mm apart at base; anthers 2 mm long, confluent at apex, apex obtuse; staminodes 3, 0.4 mm long, adnate to adaxial side of corolla tube and near base. Pistil glabrous; ovary oblong, 2–3 mm long; style linear, 3–5 mm long, stigma 1, undivided; disc inconspicuous. Capsule slightly twisted (about 1 turn), 0.9–1.5 cm long, 0.1–0.15 cm in diam., glabrous, with 0.3–0.5 cm long permanent style at apex and persistent calyx, dehiscing into 4 valves. Seeds numerous, oblong, 0.4 mm long. Flowering from June to July; fruiting from July to October.

**DISTRIBUTION AND HABITAT.** *Paraboea manhaoensis* is only known from limestone localities in SE Yunnan, China (Gejiu and Maguan counties), ca. 20 km from the border between China and Vietnam. It grows on cliffs in limestone forests (Fig. 2E). The main companion species are calcicolous plants, such as *Caryota urens* (Palmae), *Actephila excelsa*, *Croton damayeshu* and *Cleidion brevipetiolatum* (Euphorbiaceae). There are also many terrestrial species, such as *Parashorea chinensis* (Dipterocarpaceae), *Pometia tomentosa*, *Sapindus rarak* (Sapindaceae), *Tetrastigma cauliflorum* (Vitaceae), *Alphonsea boniana* and *Goniothalamus leiocarpus* (Annonaceae). Several endemic species grow here as well, such as *Begonia manhaoensis*, *B. huangii*, *B. longistyla* (Begoniaceae), *Elatostema manhaoense* and *E. attenuatoides* (Urticaceae).

*Paraboea manhaoensis* has dorsiventralized and hypostomatic leaves. The epidermis cells are regularly hepta- or hexagonal and  $52.3 \times 46.5 \mu\text{m}$  on the upper surface (Fig. 6A). The epidermis walls are straight and usually thickened in the corner of the cells (Fig. 6A). The epidermal cells are regularly elliptic but with undulate walls on the lower surface (Fig. 6B). Calcium accumulations are absent in *Paraboea manhaoensis* (Fig. 6A). The stomata are basically anisocytic with 2 guard-cells and 6 irregularly lunate subsidiary cells (Fig. 6B and C). Like the above species, the guard cells are  $16 \times 7.5 \mu\text{m}$ , the subsidiary cells  $18\text{--}32 \times 4.5\text{--}7.6 \mu\text{m}$  long. There are 2–3 epidermis cells between adjacent stomata. Also as in the above species, stomata only occur on the lower leaf surface and are covered by a thick matted indumentum.

*Paraboea manhaoensis* has three types of indumentum, a grey to brown matted indumen-

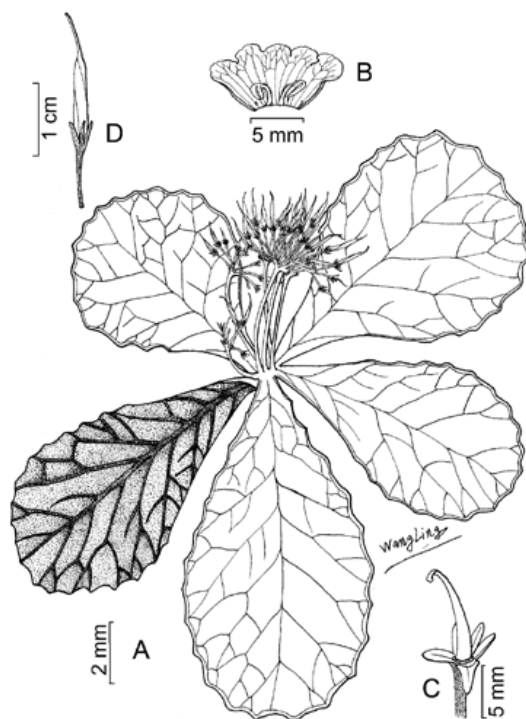
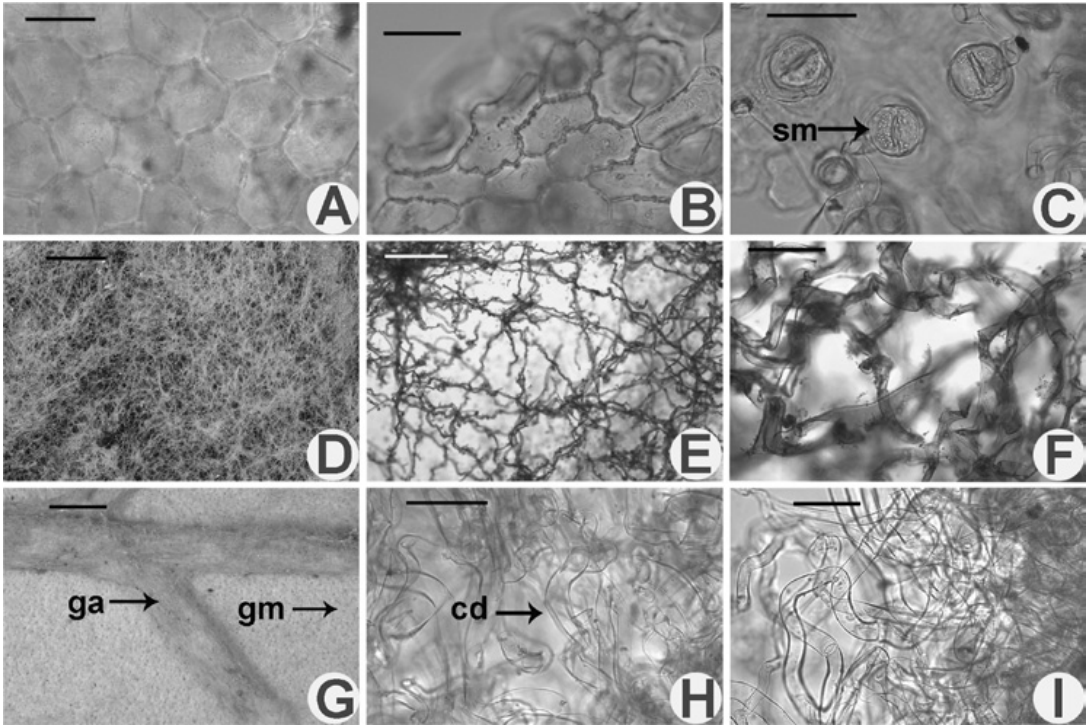


Fig. 5. *Paraboea manhaoensis* (drawn from the holotype by Ling Wang). — A: Habit. — B: Flower, cut open showing stamens. — C: Ovary. — D: Mature capsule.

tum on the lower leaf surfaces (Fig. 6G–I), a grey or white arachnoid indumentum on the upper surface in young leaves on the main and lateral veins, petioles and peduncles (Fig. 6D–F), and golden sessile glands on lower leaf surfaces on the main and lateral veins, petioles, peduncles and filaments (Fig. 6C). Thus, *P. manhaoensis* is similar to *P. crassifolia* with which it shares sessile glands and the absence of simple long trichomes, but they differ in the distribution of the matted and arachnoid indumentum types (Table 1).

*Paraboea manhaoensis* resembles *P. crassifolia* with its basal obovate leaves, centrally positioned styles, and the thick matted indumentum on the lower leaf surface, and differs by its white flowers, smaller corolla ca. 5.5 mm long, ca. 6 mm in diam., shorter corolla tubes 3 mm long and only slightly twisted fruits. In *P. crassifolia* the flowers are violet, the corollas ca. 12 mm long and ca. 10 mm in diam., with corolla tubes of ca. 7 mm length, and the fruits are strongly spirally-twisted.



**Fig. 6.** Leaf epidermis characteristics of *Paraboea manhaoensis* (from Y. M. Shui et al. 71674). — **A:** Upper leaf surface under LM, showing regularly hepta- or hexagonal epidermis cells. — **B:** Elliptic epidermis cells on lower leaf surface under LM. — **C:** Stomata (sm) on lower leaf surfaces under LM. — **D:** Arachnoid indumentum on upper surface of young leaf at low magnification as seen by naked eye. — **E:** Interwoven arachnoid indumentum under LM. — **F:** Uniseriate cells of arachnoid indumentum of young leaf under LM. — **G:** Lower leaf surface at low magnification as seen by naked eye, showing grey matted indumentum (gm) between veins and grey arachnoid indumentum (ga) on veins. — **H:** Thick matted indumentum on lower leaf surface under LM, showing tightly interwoven cylindrical-celled trichomes (cd). — **I:** Long multicellular trichomes of matted indumentum under LM. Scale bars: **A–C, F, H, I** = 50  $\mu$ m; **D, G** = 2 mm; **E** = 200  $\mu$ m.

**Key to Chinese and Vietnamese species with a rosulate habit in *Paraboea***

- |  |                       |   |                       |
|--|-----------------------|---|-----------------------|
| 1. Fruits straight or slightly (1/2–1 turn) twisted .....                          | 5                     | 7. Calyx lobes 3 (rarely 5 in isolated flowers of an individual plant) (China) .....          | <i>P. trisepala</i>   |
| 1. Fruits strongly twisted ( $\geq 2$ turns) .....                                 | 2                     | 7. Calyx lobes 5 .....  | 8                     |
| 2. Leaf blades elliptic or rounded .....   | 4                     | 8. Corolla white, nearly actinomorphic .....  | 9                     |
| 2. Leaf blades obovate or oblanceolate .....                                       | 3                     | 8. Corolla blue or violet, distinctly zygomorphic .....                                       | 11                    |
| 3. Bracts ovate or elliptic, ca. 1.5 mm long (China, Burma) .....                  | .....                 | 9. Leaf blade peltate at the base, corollas $\geq 7$ mm in diam. (China) .....                | <i>P. peltifolia</i>  |
| .....  | .....                 | 9. Leaf blade round or cuneate at the base, corollas $< 7$ mm in diam. ....                   | 10                    |
| .....  | .....                 | 10. Leaves with a short matted indumentum on abaxial leaf veins, anthers obtuse (China) ..... | <i>P. manhaoensis</i> |
| 3. Bracts linear, 2–5 mm long (China) .....  | <i>P. neurophylla</i> | 10. Leaves with a long pubescence on abaxial leaf veins, anthers acute (China) .....          | <i>P. hekouensis</i>  |
| 4. Flowers violet (Vietnam) .....  | <i>P. evrardii</i>    | 11. Leaves sessile (China) .....  | <i>P. hainanensis</i> |
| 4. Flowers white (Vietnam to Thailand, India) .....                                | .....                 | 11. Leaves petiolate .....  | 12                    |
| .....  | .....                 | 12. Leaf blade obovate or oblanceolate, lateral veins 7–11 (China) .....                      | <i>P. nutans</i>      |
| .....  | <i>P. multiflora</i>  | 12. Leaf blade obovate-elliptic or elliptic, lateral veins 5–6 (China) .....                  | <i>P. guilinensis</i> |
| 5. Leaf blade usually $< 6$ cm long .....  | 6                     |   |                       |
| 5. Leaf blade usually $\geq 6$ cm long .....                                       | 7                     |   |                       |
| 6. Stem erect, leaf blade $\pm$ peltate at the base, flowers white (China) .....   | <i>P. velutina</i>    |   |                       |
| 6. Stemless, leaf blade cuneate at the base, flowers white or bluish (China) ..... | <i>P. filipes</i>     |   |                       |



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## References

- Barnett, E. C. 1961: Contribution to the Flora of Thailand, LV. — *Kew Bulletin* 15: 249–259.
- Bongers, J. M., Jansen, W. T. & van Staveren, M. G. 1973: Epidermal variation and peculiarities in Winteraceae, Celastraceae and Icacinaceae. — *Acta Botanica Neerlandica* 22: 250–251.
- Burt, B. L. 1984: Studies in the Gesneriaceae of the Old World, XLVII. Revised generic concepts for *Boea* and its allies. — *Notes from the Royal Botanic Garden, Edinburgh* 41: 401–452.
- Burt, B. L. & Tan, K. 1984: Studies in the Gesneriaceae of the Old World, XLVIII. Calcium accumulation and excretion in *Paraboea*. — *Notes from the Royal Botanic Garden, Edinburgh* 41: 453–456.
- Chen, W. H., Möller, M., Shui, Y. M. & Zhang, M. D. 2008: A new species of *Paraboea* (Gesneriaceae) from a karst cave in Guangxi, China, and observations on variations in flower and inflorescence architecture. — *Botanical Journal of the Linnean Society* 158: 681–688.
- Chen, W. H., Shui, Y. M., Sima, Y. K., Zhang, R. M. & Wei, Z. D. 2009: *Pararuellia glomerata* (Acanthaceae), a new species from Yunnan, China. — *Botanical Studies* 50: 261–267.
- Dilcher, D. L. 1974: Approaches to identification of angiosperm leaf remains. — *Botanical Review* 40: 1–157.
- Fang, D., Qin, D. H., Rao, W. Y. & Zeng, L. 1995: New plants of Gesneriaceae from Guangxi and Guizhou of China (Cont. II). — *Acta Phytotaxonomica Sinica* 33: 602–607.
- Grace, O. M., Simmonds, M. S. J., Smith, G. F. & van Wyk, A. E. 2009: Taxonomic significance of leaf surface morphology in *Aloe* section *Pictae* (Xanthorrhoeaceae). — *Botanical Journal of the Linnean Society* 160: 418–428.
- Li, H. W. 1991: Gesneriaceae. — In: Wu, C. Y. (ed.), *Flora Yunnanica*, vol. 5: 512–688. Science Press, Beijing.
- Li, Z. Y. & Wang, Y. Z. 2004: *Plants of Gesneriaceae in China*. — Henan Science and Technology Publishing House, Zhengzhou.
- Mill, R. R. & Stark-Schilling, D. M. 2009: Cuticle micro-morphology of *Saxegothea* (Podocarpaceae). — *Botanical Journal of the Linnean Society* 159: 58–67.
- Moon, H. K., Hong, S. P., Smets, E. & Huysmans, S. 2009: Phylogenetic significance of leaf micromorphology and anatomy in the tribe Mentheae (Nepetoideae: Lamiaceae). — *Botanical Journal of the Linnean Society* 160: 211–231.
- Pham-Hoang, H. 2000: *An illustrated flora of Vietnam*, vol. 3: 12–29. — Youth Publishing House, Ho Chi Minh City.
- Pi, E. X., Peng, Q. F., Lu, H. F., Shen, J. B., Du, Y. Q., Huang, F. L. & Hu, H. 2009: Leaf morphology and anatomy of *Camellia* section *Camellia* (Theaceae). — *Botanical Journal of the Linnean Society* 159: 456–476.
- Prabhakar, M. 2004: Structure, delimitation, nomenclature and classification of stomata. — *Acta Botanica Sinica* 46: 242–252.
- Puglisi, C., Middleton, D. J., Triboun, P. & Möller, M. 2011: New insights into the relationships between *Paraboea*, *Triseptum* and *Phylloboea* (Gesneriaceae) and their taxonomic consequences. — *Taxon* 60: 1693–1702.
- Wang, W. T. 1990: Gesneriaceae. — In: Wang, W. T. (ed.), *Flora Reipublicae Popularis Sinicae*, vol. 69: 125–581. Science Press, Beijing.
- Wang, W. T., Pan, K. Y., Li, Z. Y., Weitzman, A. L. & Skog, L. E. 1998: Gesneriaceae. — In: Wu, C. Y. & Raven, P. H. (eds.), *Flora of China*, vol. 18: 362–267. Science Press, Beijing & Missouri Botanical Garden Press, St. Louis.
- Wang, Q., Zhou, S. D., Deng, X. Y., Zheng, Q. & He, X. J. 2009: Comparative morphology of the leaf epidermis in *Fritillaria* (Liliaceae) from China. — *Botanical Journal of the Linnean Society* 160: 93–109.
- Weber, A. 2004: Gesneriaceae. — In: Kubitzki, K. (ed.), *The families and genera of vascular plants*, vol. 7: 63–158. Springer, Berlin & Heidelberg.
- Wilkinson, H. P. 1979: The plant surface (mainly leaf). — In: Metcalfe, C. R. & Chalk, L. (eds.), *Anatomy of the Dicotyledon*, 2 ed.: 97–161. Clarendon Press, Oxford.
- Xu, L. & Wei, Y. G. 2004: *Paraboea guilinensis* L. Xu & Y. G. Wei, a new species of Gesneriaceae from Guangxi, China. — *Acta Phytotaxonomica Sinica* 42: 380–382.
- Xu, Z. R. & Burt, B. L. 1991: Towards a revision of *Paraboea* (Gesneriaceae): I. — *Edinburgh Journal of Botany* 48: 1–18.
- Xu, Z. R. 1994: A new species of *Paraboea* Ridley from Thailand. — *Acta Phytotaxonomica Sinica* 32: 359–361.
- Xu, Z. R., Burt, B. L., Skog, L. E. & Middleton, D. J. 2008: A revision of *Paraboea* (Gesneriaceae). — *Edinburgh Journal of Botany* 65: 161–347.
- Zhang, R. M., Chen, W. H., Shui, Y. M., Chen, S. Y. & Wei, Z. D. 2008: Characters of leaf epidermis of *Begonia* (Begoniaceae) from China and their taxonomic significance. — *Acta Botanica Yunnanica* 30: 665–678.