

# A new combination in *Polygonatum* (Asparagaceae) and the reinstatement of *P. mengtzense*

Aaron Floden

TENN Herbarium, Department of Ecology and Evolutionary Biology, University of Tennessee, Knoxville, TN 37996, USA (e-mail: afloden@utk.edu)

Received 7 July 2013, final version received 26 Nov 2013, accepted 2 Dec. 2013

Floden, A. 2014: A new combination in *Polygonatum* (Asparagaceae) and the reinstatement of *P. mengtzense*. — *Ann. Bot. Fennici* 51: 106–116.

*Heteropolygonatum urceolatum* J.M.H. Shaw (Asparagaceae), is transferred to *Polygonatum* based on morphological and cytological evidence. *Polygonatum mengtzense* F.T. Wang & T. Tang is reinstated to specific status and its description amended based on examination of ample living and herbarium material. Chromosome counts and karyotypes are presented for both species that provide evidence that the two are most closely related to the Himalayan *P. punctatum*. Data on their distribution and habitat are provided. A key morphological trait of *Heteropolygonatum*, terminal inflorescences, is discussed in relation to the generic value of this character and shown not to be diagnostic.

## Introduction

An increase in the availability of cultivated living material of several species of *Polygonatum* and *Heteropolygonatum* (both Asparagaceae) have made observations possible that facilitates clarification of generic and specific boundaries of two enigmatic species that exhibit superficially similar morphology, one of which was recently described in *Heteropolygonatum*, and the other in *Polygonatum* in 1936.

The recently described species, *Heteropolygonatum urceolatum* J.M.H. Shaw was placed within *Heteropolygonatum* based on its terminal borne inflorescence and perianth lobes “imbricate in bud” (Shaw 2010). My interpretation of the tepal morphology based on living material from whence the type originated is significantly different from the interpretation of Shaw (2010). Notably, the tepal lobes are valvate in bud and connate for over two-thirds of their length. *Polygonatum*

species have a perianth tube that is fully connate with the valvate lobes less than one-third the total perianth length (Tamura & Ogisu 1997). On the other hand, *Heteropolygonatum* species have distinctly imbricate tepals with the margins apparent along the whole length of the perianth and the tepals are only connate for up to half the length of the perianth (Tamura & Ogisu 1997). When the perianth of *H. urceolatum* is compared with a typical perianth of *Heteropolygonatum*, there are distinct and notable differences in the filament morphology and in the clearly imbricate tepals seen in other *Heteropolygonatum* species. Surprisingly, Shaw (2010) also mentioned the presence of bracts (bracteoles) on the pedicels and peduncles which are unknown in *Heteropolygonatum* (Chen & Tamura 2000). The valvate perianth, filament morphology, and the inflorescence bracts cast some doubt on its generic placement.

*Heteropolygonatum urceolatum* from the same source as the type material has been in

the author's cultivated collection for nearly a decade. While it is apparent that this is a previously unnamed species distinct from the known *Heteropolygonatum*, its morphology suggests that it belongs in *Polygonatum*. The presence of terminal inflorescences suggests that this morphological feature is not unique to *Heteropolygonatum*. Secondly, its relationship within *Polygonatum*, based on morphology and cytology, is to a species with which it is sympatric in parts of their respective distributions and that species is also examined herein.

*Polygonatum mengtzense* F.T. Wang & T. Tang has been considered a synonym of the Himalayan *P. punctatum* Royle (Chen & Tamura 2000). Even the authors of the former name treated it as a synonym of *P. punctatum* (Tang 1978). Jeffrey (1980) was the most recent author to treat it at specific status based on the conspicuously many-flowered racemes seen on the types. Despite the distinctive inflorescences on the types, most specimens do not have many-flowered racemes. Other morphological characters that serve to distinguish it from *P. punctatum* are not as discernible on specimens as they are in live plants. Nonetheless, the two are allopatric and have different morphologies that serve to separate them. Identifications of *P. mengtzense* and *P. urceolatum* in herbaria are usually as *P. punctatum*. Here, I present morphological and geographic data that support the recognition of two distinct and allopatrically distributed species.

*Heteropolygonatum* and *Polygonatum* are sister genera that differ in chromosome number, the presence of a terminal inflorescence in the former, and perianth morphology (Tamura & Ogisu 1997, Tamura *et al.* 1997, Wu *et al.* 2000). *Heteropolygonatum* has a base chromosome number of  $n = 16$ , axillary and terminal inflorescences, imbricate tepals connate for less than half their length, and short-tapered filaments, whereas *Polygonatum* has a variable base number of  $n = 9-15$ , valvate tepals connate for over one-half their length, variable filament morphology, and it has been considered to have only axillary inflorescences (Tamura & Ogisu 1997, Tamura *et al.* 1997, Bao *et al.* 1998, Chen & Tamura 2000, Tamura & Xu 2001, Yamashita & Tamura 2001). The presence of both terminal and axillary inflorescences is one of the defin-

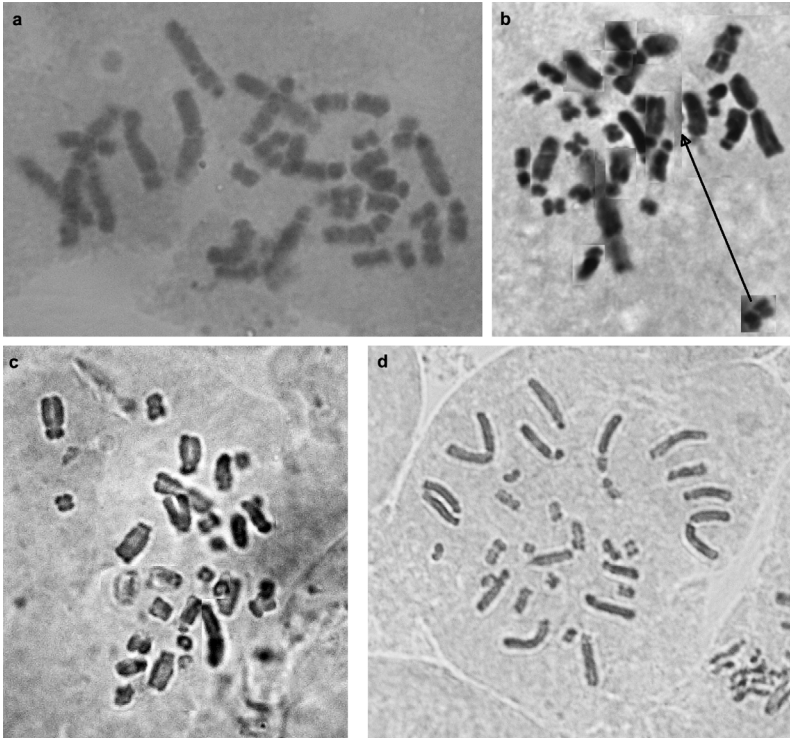
ing generic characters separating *Heteropolygonatum* from *Polygonatum* with strictly axillary inflorescences (Tamura & Ogisu 1997, Tamura *et al.* 1997, Bao *et al.* 1998, Chen & Tamura 2000). Nonetheless, my observations of type specimens of several *Polygonatum* species, cultivation of *P. mengtzense*, *P. punctatum*, and *H. urceolatum*, and accounts in floristic treatments (Noltie 1994) show that this character is not exclusive to *Heteropolygonatum*.

*Polygonatum* is a relatively large genus containing an estimated 60 species (Conran & Tamura 1998, Chen & Tamura 2000). It has a boreal distribution with its greatest diversity in both form and species number in the Himalaya and China (Conran & Tamura 1998). In contrast, *Heteropolygonatum* comprises five largely allopatric species in southwest China from central Guangxi west to west-central Sichuan growing epiphytically at upper elevation *Abies*-forest or temperate evergreen forest (Tamura *et al.* 1997, Bao *et al.* 1998, Yamashita & Tamura 2001, Tamura & Xu 2004).

In this study, the cytology and morphology of *Heteropolygonatum urceolatum* and *Polygonatum mengtzense* are compared to determine the generic placement of the former and the specific status of the latter. Fieldwork in Lao Cai and Lai Chau provinces of northern Vietnam enabled *in situ* observations of *P. mengtzense*. Examination of a syntype of *P. mengtzense* (MO), additional specimens of the other species at MO, and cultivated plants of *P. mengtzense*, *P. punctatum*, and *H. urceolatum* have enabled morphological and cytological comparisons that necessitate the transfer of *H. urceolatum* to *Polygonatum* and support the reinstatement of *P. mengtzense* as a species distinct from the allopatric *P. punctatum*. These morphological and karyological data also provide evidence that suggest these three species form a closely related group within *Polygonatum*.

## Methods

Chromosome analyses were performed on several cultivated accessions of *H. urceolatum* received from the same source as the type material (Shaw 2010), and several accessions of *P. mengtzense* from both of its elevation-delim-



**Fig. 1.** Mitotic squash preparations of (a and b) *Polygonatum urceolatum* and (c and d) *P. mengtzensense*. Both species have  $2n = 30$ . — a: Two cultivated plants from the same source as the type material (C. Yi s.n., TENN). — b: A composite of in-focus parts of several different focal-depth images, the arrow shows where a chromosome is present, but not in focus. — c: Red-flowered form (FMWJ13372, TENN). — d: Greenish-white-flowered form (BWJ861, TENN).

ited forms (see Results below). Preparation of the root tips followed the aceto-orcein method of Tamura (1990). Material was then squashed following standard procedures. Multiple cells in metaphase were observed and photographed with a Zeiss Axioskop microscope and images were taken at a magnification of  $1000\times$  using AxioVision Rel. 4.8 (Carl Zeiss MicroImaging GmbH, Germany). Classification of the karyotype followed Levan *et al.* (1964).

Observations of stem morphology, phyllo-taxy, leaf measurements, and inflorescence characters were facilitated through examination of live material and herbarium material primarily at MO where an isotype of *P. mengtzensense* is preserved. Digital images of specimens were observed from BM, E, IBK, K, KATH, KUN, L, NY, P, and PE. Internal perianth morphology is based on living collections. SEM images of the adaxial leaf surface of the higher elevation form of *P. mengtzensense* from Vietnam were taken with a Hitachi SU3500 from fresh material off cultivated plants.

Fieldwork in 2011 allowed the author first-hand observation of the plants and habitat in

Lai Chau and Lao Cai provinces of northern Vietnam.

## Results

Chromosome numbers of both *P. mengtzensense* and *H. urceolatum* are  $2n = 30$  (Fig. 1) The karyotypes are asymmetric with the longest pair with a median constriction and a secondary terminal constriction, the next seven abruptly shorter medium size pairs have subterminal constrictions, and the remaining shorter pairs with median constrictions with no satellites observed. Their karyotypes are  $2n = 14m + 2sm + 14t$  (Fig. 2), but their lengths differ. *Heteropolygonatum urceolatum* has chromosome lengths that range from 1.9 to  $9.2\ \mu\text{m}$ , and in *P. mengtzensense* from 1.8 to  $9.3\ \mu\text{m}$ . The ratios of the longest to the shortest are 4.8 and 5.2, respectively.

Cultivation of seven accessions of *P. mengtzensense*, two of *P. punctatum*, and four of *H. urceolatum* as well as two other species of *Heteropolygonatum* over several growing seasons showed several distinctive characters that serve

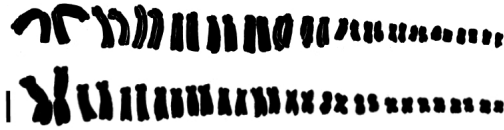


Fig. 2. Karyotypes of *Polygonatum mengtzense* (top, BSWJ861, TENN) and *P. urceolatum* (bottom, C. Yi s.n., TENN). Scale bar 5  $\mu$ m.

to distinguish *H. urceolatum* from *Heteropolygonatum*: perianth morphology, filament shape, and growth cycle. No differences in the value of morphological features were noted between herbarium specimens and those from cultivated accessions, but characters of the staminal filament epidermis are sometimes obscured due to their size and fragility in specimens. Only the largest stems of the *Heteropolygonatum* species and these *Polygonatum* discussed herein occasionally bear terminal inflorescences, otherwise inflorescences were restricted to the lower and middle leaves of the stem. The perianth of *H. urceolatum* has a distinctly connate tube and valvate tepals whereas *Heteropolygonatum* species have distinctly imbricate tepals with the margins of the lobes decurrent along the tubes (Fig. 3). The filaments of *H. urceolatum* are not distinctly tapered (Fig. 4). Furthermore, at the point of anther attachment there is a gibbous protrusion in *H. urceolatum* that differs from any known *Heteropolygonatum* species, but is similar to both *P. mengtzense* and *P. punctatum* (Fig. 5). A distinctive growth cycle also serves to distinguish *H. urceolatum* from the other *Heteropolygonatum*. *Heteropolygonatum urceolatum* is distinctly evergreen and has coriaceous leaves with a prominent



Fig. 3. Perianth characters showing the valvate tepals of *Polygonatum* and imbricate tepals of *Heteropolygonatum*. — a: *Polygonatum urceolatum* (in anthesis, but lobes not fully recurved). — b: *Heteropolygonatum* sp. (B. Olsen s.n., TENN). Scale bars 1 mm.

abaxial midrib while all *Heteropolygonatum* are deciduous (pers. obs. from cultivated plants and examination of specimen collection dates) and have subcoriaceous to chartaceous leaves without a prominent abaxial midrib.

The suite of morphology that distinguish *H. urceolatum* from *Heteropolygonatum* suggest a close relationship to *P. mengtzense* and *P. punctatum*, though cultivation and examination of specimens shows that there are ample characters that delimit these species from one another (Table 1). They differ from one another in their phyllotaxy, stems characters, inflorescence types, and perianth characters.

Morphological differences between the taxa discussed herein are corroborated by examination of herbarium specimens. More importantly, the examination of specimens, especially type



Fig. 4. Perianth dissected to show inner morphology and position of filament insertion. — a: *Polygonatum mengtzense* (BSWJ551, TENN). — b: *P. urceolatum* (C. Yi s.n., TENN). — c: *P. punctatum* (BSWJ2395, TENN). Scale bars 1 mm.



**Fig. 5.** Anther filaments of the species showing the distinctive gibbon protrusion seen in the *Punctatum*-group of species in comparison. — **a:** *Polygonatum mengtzense* (BSWJ 8246, TENN). — **b:** *P. urceolatum* (C. Yi s.n., TENN). — **c:** *P. punctatum* (BSWJ2395, TENN). Scale bars: 0.5 mm for **a** and **b**, and 0.7 mm for **c**.

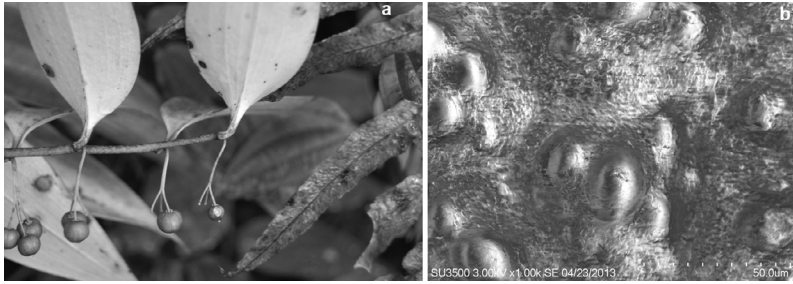
material, showed that inflorescences at the terminal leaf are not exclusive to *Heteropolygonatum*, but are found in *Polygonatum mengtzense*, *P. nervulosum*, *P. punctatum*, and *H. urceolatum* (Fig. 6).

The primary range of *P. mengtzense* is through the northwest–southeast trending Hoang Lein Son in southeast Yunnan, China and north-west Vietnam (Fig. 7). Field examination of *P. mengtzense* in northern Vietnam in two provinces, Lai Chau and Lao Cai, shows that there are two morphologically distinguishable forms which occur in elevation delimited habitats. A greenish-white-flowered form occurs at ca. 1400–1800 m in broadleaved evergreen forest with some deciduous elements, whereas the reddish-flowered form (referred to as the ‘higher

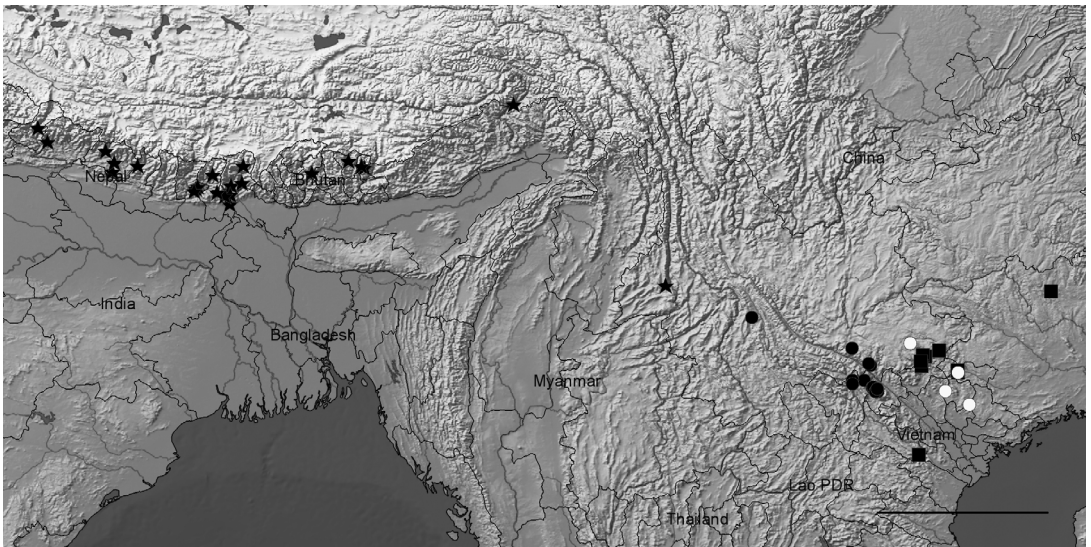
elevation form’) occurs at 2000–2600 m in upper montane cloud forest habitat with an overstory of *Tsuga* and *Abies* and the understory dominated by shrubs in the Ericaceae. No overlap in the distribution of these two forms was seen despite their close proximity to one another. These forms are morphologically separable with the higher elevation form differing by the following: the presence of papillose epidermal cells on the adaxial surface of the leaves which provide an iridescent quality to the leaves (Fig. 6) as well as potentially aiding in light capture and transfer towards the mesophyll; the whole plant is reddish-pigmented (possibly due to anthocyanins); the stem is distinctly zigzag in the upper part; and the stem, leaf margins, and peduncles of the inflorescences are scabrous. Cultivation of

**Table 1.** Morphological comparisons of the relevant morphological features by which *Polygonatum mengtzense*, *P. punctatum*, and *P. urceolatum* can be separated.

Species	<i>P. mengtzense</i>	<i>P. punctatum</i>	<i>P. urceolatum</i>
Stem	terete, smooth to scabrous, arching	sulcate, ridges papillose, erect	sulcate, ridges smooth, erect
Phyllotaxy	alternate	spirally alternate, opposite, whorled	alternate
Inflorescence & flower no.	racemose to sub-umbellate, 1–14	fascicle, 1–2	sub-umbellate 1–5
<b>Perianth</b>			
length (mm)	8–13	8–12	10–12
color	greenish-white, reddish maculate	white, pink maculate	white
<b>Filaments</b>			
insertion	proximal of middle	distal of middle	proximal of middle
length (mm)	0.9–1.6	1–1.5	0.8–1
surface	scabrous dorsally	smooth	rugulose



**Fig. 6.** — **a:** *Polygonatum mengtzense* in the field in Lao Cai Province, Vietnam, November 2011, shows the pseudoterminal inflorescence frequently produced in this species. — **b:** Abaxial surface cells of the upper elevation forms of *P. mengtzense* (FMWJ13292, TENN), showing the distinctive raised verrucae on the surface of each adaxial epidermis leaf cell.



**Fig. 7.** Map of the distribution of the *Polygonatum punctatum* group from specimens and field observations. Points are estimated GPS coordinates from label information when coordinates are not provided. *Polygonatum mengtzense*: black dots represent the primary distribution and white dots are the disjunct limestone plateau populations; *P. punctatum*: stars; *P. urceolatum*: squares. Scale bar is 350 km. The absence of *P. punctatum* in northeast India and northern Myanmar is attributed to the lack of collections and not discontinuity between populations.

both forms in a common garden shows that their distinct characters are not phenotypically plastic. Notwithstanding their dissimilarities, the two forms did not differ in their karyotypes, inner perianth morphologies, growth habit, or in preliminary molecular analyses, and are recognized as variation within the species with no formal designation. It should be noted that the types, of which *Henry 11145* was red-flowered and *Henry 13668* was white-flowered, were reportedly collected from near the same elevation despite my field observations in Vietnam where the two color forms occupy different elevations. Whether

this elevation-restricted separation of forms is also present in China remains to be examined.

Some populations of *P. mengtzense* occur at lower altitudes in the limestone hills near Weixi (Yunnan), reaching Guangxi in the southeast, and the limestone plateau in Cao Bang Province in northern Vietnam where it is sympatric with *H. urceolatum* (Fig. 7). The only previous distribution reported for *H. urceolatum* is that it occurs in Sichuan (Shaw 2011). Examination of specimens and photos taken *in situ* showed that this species is not documented there. These two species are allopatric with *P. punctatum* which

occurs in the Himalaya from eastern Nepal to northwest Yunnan.

Based on the data presented *P. mengtzense* is reinstated to specific status and *H. urceolatum* is transferred to *Polygonatum*.

## Typification and taxonomy

Two collections of *P. mengtzense* comprising four sheets at K were used as syntypes: *Henry 11145*, with red flowers; and *Henry 13668*, with white flowers (Wang & Tang 1936). All but one of the specimens at K has the inscription; “*Polygonatum mengtzense* Wang et Tang sp. nov.” Since no single specimen was specifically designated to serve as the holotype from the four sheets I designate herein the first collection (*Henry 11145*), which is also the most widely distributed, to serve as the lectotype (specimen barcoded K000820706) in accordance with Art. 9.6 (McNeill *et al.* 2006).

### *Polygonatum mengtzense* F.T. Wang & T. Tang (Figs. 1 and 2)

Bull. Fan Mem. Inst. Biol. 7: 84. 1936. — TYPE: China. Yunnan: Mengtze, S.W. mts., on rocks, alt. 5000 ft., *Henry 11145*, (lectotype, here designated: K!; isotypes: image E!, image K!(2), MO!, image US!).

Plants perennial, evergreen or tardily (Jan.–Feb.) deciduous. Rhizomes moniliform to torulose, 1–2 cm diam., densely fleshy rooted, purple maculate. Stems erect to arching, glabrous, green or purple maculate, 20–80 cm tall, cataphylls 2–3, heavily purple maculate. Leaves alternate, petiole short, 1–3 mm long, leaf lamina green to olive green (purplish in upper elevation forms), lustrous (iridescent in upper elevation forms due to 1–5 papillae (1–5) on surface of each cell), lanceolate falcate, 3–10 × 0.5–2 cm, 3–7-veined, glabrous, base round, apex acuminate obtuse, margin scaberulous. Inflorescences axillary and terminal (on vigorous plants), secund, racemose to sub-umbellate, 1–12-flowered, peduncles 1–5 cm long, rachis 0.2–3 cm long; pedicels 0.3–1.2 cm long, terete and glabrous (minutely scaberulous in upper elevation forms); bracteoles absent or present, subulate, caducous, ca. 2 mm.

Perianth greenish to brownish and purple maculate, or greenish white and not or faintly maculate, urceolate, 7–13 mm long, lobes 2–3 mm long, ovate-lanceolate, recurved, midvein scabrous outside, filaments inserted just proximal of middle, 0.9–1.5 mm long, tapered downward, papillose proximally, then abruptly tapered near anther, these cells elongate, with a gibbous, papillose protrusion at point of attachment to anther; anthers 1.5–2 mm long, basi-dorsifixed; ovary elliptic-ovoid, 2–4 mm long, style 1.8–2 mm long, stigma tri-lobulate, shorter than stamens. Infructescence erect to deflexed, berries red, ca. 0.5 cm diam., pulp sticky, 6–9 seeded; seeds ca. 1–1.5 mm diam., ovoid. Flowering April–May, fruiting October–December. 2n = 30.

OTHER SPECIMENS EXAMINED [asterisk (\*) denotes chromosome vouchers]: **China.** Guangxi: *Li 602266* (IBK); Yunnan Prov.: *A. Henry 13668* (paratypes: E, K); *C.W. Wang 82728* (PE); *C.W. Wang 82739* (PE); *C.W. Wang 82164* (PE); *H.T. Tsai 62219* (KUN, PE); *H.T. Tsai 60949* (PE); *Sino-Soviet Yunnan Exp. 1170* (PE, KUN); *M.K. Li 2029* (PE); *Fung 11828* (KUN). **Vietnam.** Cao Bang Prov.: *L. Averyanov et al. CBL 473* (MO); *P.H. Hoang & L. Averyanov CBL 1417* (MO); Lai Chau Prov.: *N.T. Hiep, L.V. Averyanov, P.K. Loc, P. V. The & N.T. Vinh HAL10588* (MO); Lao Cai Prov.: *Poilane 17073* (P); *Poilane 17146* (P); Aaron Floden, *Dr. T. Mitchell & B. Wynn-Jones 1851* (TENN); Aaron Floden, *Dr. T. Mitchell & B. Wynn-Jones 1863* (TENN); Aaron Floden, *Dr. T. Mitchell & B. Wynn-Jones 1869* (TENN); Aaron Floden, *Dr. T. Mitchell & B. Wynn-Jones 1872* (TENN); Aaron Floden, *Dr. T. Mitchell & B. Wynn-Jones 1886* (TENN); Aaron Floden, *Dr. T. Mitchell & B. Wynn-Jones 1890* (TENN)\*.

Introduced into cultivation by Bledodyn and Sue Wynn-Jones (Crüg Farm Plants) from numerous collections; *HWJ 573*, *HWJ567*, *HWJ588*, *HWJ861\**, *BSWJ8231*, *BSWJ8246*, and the *FMWJ* collections listed above.

### *Polygonatum urceolatum* (J.M.H. Shaw) Floden, *comb. nova*

*Heteropolygonatum urceolatum* J.M.H. Shaw, The Plantsman 3: 174–175. 2010. — TYPE: China. Sichuan, cultivated in the United Kingdom (holotype WSY).

OTHER SPECIMENS EXAMINED: **China.** Guangxi: near Hechi, and Baise County, *in situ* photos; Vietnam: Cao Bang Prov., 1999, *P.K. Loc, P.H. Hoang & L. Averyanov CBL 1283* (MO); 1998, *P.K. Loc, P.H. Hoang & L. Averyanov CBL 1397* (MO); 1999, *P.K. Loc, P.H. Hoang & L. Avery-*

anov CBL 1395 (MO); Ha Giang Prov., 1999, P.K. Loc, P.H. Hoang & L. Averyanov CBL 1790 (MO); D.K. Harder, N.T. Hiep, L.V. Averyanov, N.Q. Hieu, K. Daria 4793 (MO); 2000, D.K. Harder, N.T. Hiep, L.V. Averyanov 5178 (MO); 1999, P.K. Loc, P.H. Hoang & L. Averyanov CBL 1781.

The chromosome number reported here for *Polygonatum urceolatum*,  $2n = 30$  ( $x = 15$ ), is consistent with its placement in *Polygonatum* rather than *Heteropolygonatum*. Cytology of *Heteropolygonatum* has been established as  $x = 16$  (Tamura *et al.* 1997, Yamashita & Tamura 2001). *Polygonatum urceolatum* differs consistently in base chromosome number and its asymmetric vs. distinctly bimodal karyotype seen in *Heteropolygonatum* (Tamura *et al.* 1997, Yamashita & Tamura 2001).

The karyotypes of *P. mengtzense* and *P. urceolatum* presented here and a previous report for *P. punctatum* are similar in both chromosome structure and number (Kurosawa 1966). All have the longest pair with primary median constriction and a secondary terminal constriction, the following seven shorter chromosomes have terminal constrictions, pair nine is subterminal, and the remaining short chromosomes have median constrictions. *Polygonatum mengtzense* and *P. urceolatum* only differ slightly in their lengths from one another, but this may be an artifact of the condensation of the chromosomes during treatment and the squash preparation. The similarity of the karyotypes of *P. mengtzense* and *P. urceolatum* to the karyotype of *P. punctatum* from Nepal supports a hypothesized close relationship between these species.

A closer comparison in both morphology and cytology of *P. urceolatum* can be made with its close phylogeographic neighbor *P. mengtzense* and to *P. punctatum* from the Himalaya. Within *Polygonatum*, these species form a closely related group based on the aforementioned cytological similarities and the following morphology: (1) alternate or spirally arranged coriaceous leaves; (2) moniliform to torulose rhizomes; (3) axillary and terminal inflorescences; (4) short subulate, persistent bracteoles; (5) urceolate perianths; (6) short tapered filaments with a gibbous protrusion near the stamen; (7) subequal ovaries and styles; (8) red fruit color; and (9) epiphytic to lithophytic habitat.

*Polygonatum mengtzense* has consistently alternate, distichous leaves more similar in appearance to those of *P. urceolatum* while *P. punctatum* is spirally alternate, sometimes opposite and whorled terminally. The stem of *P. mengtzense* is terete and glabrous, or terete and scabrous in the higher elevation form. *Polygonatum punctatum* and *P. urceolatum* both have sulcate stems that are roughened to scabrous on the ridges. The leaf shapes of *P. mengtzense* and *P. urceolatum* are similar to one another with rounded bases and attenuate apices with the broadest part of the lamina below the middle. The leaves of *P. punctatum* are elliptic that are broadest at the middle with attenuate apices and bases.

The presence of terminally borne inflorescences in these and other species of *Polygonatum* deserves discussion because it has been considered to be one of the defining morphological features delimiting *Heteropolygonatum* from *Polygonatum* (Bao *et al.* 1998, Chen & Tamura 2000, Tamura & Ogisu 1997, Tamura *et al.* 1997, Tamura & Xu 2001, Yamashita & Tamura 2001). This feature was one of the reasons that led to the description of *P. urceolatum* in *Heteropolygonatum* (Shaw 2010). It must first be noted that the descriptions of these as terminal inflorescences are inaccurate because the inflorescences are not produced on an extension of the stem, such as the inflorescences of *Maianthemum*, but are produced either on a pedicel or on a peduncle in the axil of the terminal leaf. Thus, these are inflorescences at the terminal leaf (pseudoterminal) and not a truly terminal inflorescence. Despite the terminology, *Heteropolygonatum* taxa generally have, or have the capability to produce an inflorescence at the terminal leaf whereas *Polygonatum* are considered to not have these pseudoterminal inflorescences. However, observations of numerous specimens and living collections of multiple species of *Polygonatum* showed that the production of inflorescences at the terminal leaf is not unique to *Heteropolygonatum*. *Polygonatum mengtzense*, *P. urceolatum* and *P. punctatum* frequently have these pseudoterminal inflorescences in addition to those borne along the stem as opposed to occasional teratological abnormalities (*P. punctatum* can even have them on the cauline cataphyll which is deciduous!).



*Polygonatum punctatum* regularly bears terminal flowers as evidenced by cultivated specimens in the authors collection (BSWJ2395; Pradhan s.n.), and herbarium specimens (S.B. Lyon 113, Ludlow, Sherrif & Hicks 18774 (BM); LLSH 20593 (BM); Griffith 5848 (P02058135); and Hooker & Thompson (P02058134)). Examination of types of *P. punctatum* also shows that some of these bear terminal flowers (E00394062, P00687123, P00687124). In addition to these two species, the holotype of *P. nervulosum* (K410574) has two stems on the sheet, one of which bears an inflorescence at the terminal leaf. Noltie (1994) mentioned that terminal flowers are regular occurrences in *P. nervulosum* and *P. punctatum*. Thus, terminal inflorescences are not indicative of *Heteropolygonatum* as previously suggested and have no diagnostic value in generic delimitation, but may still serve as characters in floristic keys.

The syntypes on which *P. mengtzense* is based are notable for their distinctly racemose, many-flowered inflorescences. Field observations showed this trait to be atypical with the average plant with few flowered racemes. I observed two specimens from Vietnam that had distinctly long pedunculate racemose inflorescences; HAL10588 (MO) and FMWJ 1886 (TENN) from Lai Chau and Lao Cai provinces, respectively. The long racemose inflorescence is not the typical form, but is usually seen as a subumbellate inflorescence or reduced raceme on a pendent peduncle. *Polygonatum urceolatum* has similarly subumbellate inflorescences, but these are usually more umbel-like on thick deflexed peduncles. The inflorescence of *P. punctatum* is distinctly different with multiple inflorescences from each leaf; some one-flowered, and others with two flowers on short erect peduncles. The infrutescences of these species are sometimes held erect or at horizontal when ripe.

Despite the similarities in the shape of the urceolate perianth of *P. mengtzense*, *P. punctatum*, and *P. urceolatum* there are substantial differences in color. *Polygonatum mengtzense* can vary in color from a greenish-white (low elevation form) to greenish with reddish maculation (higher elevation form). *Polygonatum punctatum* is usually nearly white with large pink maculate spots even within the perianth and on

the ovary, and *P. urceolatum* is usually creamy to pure white.

The inner perianth morphology of these species provides ample delimiting characters to distinguish one from the other: the insertion levels of the filaments in the perianth tube; filament lengths; surface textures; and their orientation all differ. This group has short filaments that are abruptly tapered distally with a distinctive gibbous protrusion at the point of anther attachment that is not seen in other species of *Polygonatum*. The filaments of *P. mengtzense* are inserted just proximal of the middle of the tube and slightly orientated inward towards the stigma, but surpass the stigma (Fig. 4). The gibbous protrusion in *P. mengtzense* is more pronounced and distinctly papillose (Fig. 5). In *P. urceolatum* the filaments are inserted proximal of the middle and orientated inward, but do not surpass the stigma. These are thicker without being abruptly tapered near the anther and the whole surface is rugulose. In contrast, *P. punctatum* has the filaments inserted at the middle or just distal of the middle of the tube and they are slightly orientated inward to nearly parallel to the tube (Figs. 4 and 5). The filaments in *P. punctatum* are smooth, but the gibbous protrusion is papillose like that of *P. mengtzense*.

The distribution of this group of *Polygonatum* species lies within areas of Sino-Himalayan floristic affinities that extends from the Himalaya and southeastward into southwest China and Indochina (Xiwen & Walker 1986, Averyanov *et al.* 2003) (Fig. 7). In the area where *P. mengtzense* and *P. urceolatum* are sympatric, there are plants that are marginally distinctive in morphology and may represent introgression between the two species. They differ in their consistently narrower, nearly elliptic, falcate leaves, and larger plant size than those in the primary range. Distribution and habitat preference of *P. mengtzense* in its primary range is nearly matched by the distribution of *Shortia sinensis* which was also collected by Henry near Mengzi at 5000 ft. (ca. 1524 m) and was only recently reported for Vietnam on Fanxipan (Nuraliev 2010). Field observations of the habitat of *P. mengtzense* showed that it cohabitates with *S. sinensis* on Fanxipan and further north near the border of China (FMWJ 1890).

*Polygonatum urceolatum* had previously only been reported from Sichuan, China, presumably based on communication with Kaichen Nursery from which the plants were obtained, but without any precise locality or habitat preference (Shaw 2010). To the contrary, examination of specimens suggests that the species is not present in Sichuan and its occurrence in China is only confirmed by images of plants taken *in situ* in Baise County, Guangxi. Specimens have only been observed from the northeastern provinces of Vietnam; Cao Bang and Ha Giang, where it occurs on limestone. It should be expected in similar habitat in easternmost Wenshan County, Yunnan. If *P. urceolatum* occurs in south-central Sichuan the likely area of occurrence would be near Panzhihua and it would then be expected in adjacent northeast Yunnan and northwest Guizhou. This would not be unlikely because its known distribution seems to follow the eastern edge of the uplift of the Yunnan-Guizhou Plateau.

The exclusion of *P. mengtzense* from the synonymy of *P. punctatum* and the naming of *P. urceolatum* requires a reassessment of the distribution of *P. punctatum*.

The distribution reported for *P. punctatum* has included the Himalaya, noncontiguous locations through most of southwestern China, and from disjunct high elevation localities (> 1300 m) throughout the Indochinese Peninsula (Wang & Tang 1976, Chen & Tamura 2000), whereas Jeffrey (1980) provided a more strict circumscription of this species and a limited distribution reporting it only from the Myanmar border area of Yunnan with a single disjunct location near Mengzi (these now recognized as *P. mengtzense*). With the resurrection of *P. mengtzense* and transfer of *P. urceolatum*, and through examination of specimens, the distribution of *P. punctatum* in China is restricted to the Sino-Himalayan floristic area in westernmost Yunnan where it occurs west of the Gaoligongshan and in southeast Xixiang near Medog and from there westward along the axis of the Himalaya to eastern Nepal (Fig. 7). Its distribution is allopatric to both *P. mengtzense* and *P. urceolatum*.

*Polygonatum mengtzense*, *P. urceolatum*, and *P. punctatum* all have similarities in habitat;

they grow as epiphytes and/or lithophytes. My field observations of *P. mengtzense* in Vietnam show that it occurs as an epiphyte on various tree species, sometimes five meters into the sub-canopy. I also observed it in bryophyte mats on large granitic boulders. *Polygonatum urceolatum* specimens and *in situ* photographs document that it occurs predominantly as a limestone lithophyte at elevations below 2500 m. *Polygonatum punctatum* has been reported as an epiphyte and lithophyte (Noltie 1994).

## Acknowledgements

I thank Dr. Leonid Averyanov for comments about his collections from Vietnam, Dr. Solomon and the staff at MO for access to the collections, Nicky Sharp at E for images of the isosyntypes held there, the curators of BM, E, IBK, K, KATH, KUN, L, NY, P, and PE for digital images of specimens, the lab of Dr. J. Williams for facilitating cytological work, Dr. D. Joy for use of the SEM, the lab of Dr. E.E. Schilling for preliminary unpublished molecular work and for comments on the draft manuscript, Bjørnar Olsen, Tom Mitchell, Kelly Dodson, and Sue Milliken for living material, and I thank the Hesler fund at the University of Tennessee for monetary assistance during fieldwork in Vietnam in 2011.

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