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Delimitation in the *Veratrum mengtzeanum—V. chiengdaoense* complex (Melanthiaceae) in Thailand based on morphology, with commentary on conservation status

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Abstract

The two species of *Veratrum* in Thailand, *V. mengtzeanum* and *V. chiengdaoense,* are supported as conspecific with a detailed morphological study. Two distinct subspecies of *V. mengzeanum* s.l. are defined based on morphology and distribution, and a new subspecies, *Veratrum mengzeanum* subsp. *phuwae* is described. Conservation assessments are provided for both subspecies.

Introduction

Melanthiaceae comprise five tribes of mainly perennial herbs occurring in the temperate zones (occasionally extending to Arctic zones) of the Northern Hemisphere (APG 2009; Tamura 1998; Zomlefer *et al*. 2001, 2003). *Veratrum* (26-50 species) is the largest genus in tribe Melanthieae (Tamura (1998); Chen & Takahashi 2000; Stevens 2001 onwards; Govaerts 2012). The species inhabit a wide range of habitats and vary morphologically mainly in characters of habit, leaves, tepals and perigonal nectaries (Zomlefer *et al.* 2003). Synapomorphies for *Veratrum* include dendritic pubescence of the vegetative parts (at least upper stem/inflorescence) and broadly winged seeds (Zomlefer 1997; Zomlefer *et al.* 2003).

Initial revisionary work by the first author on *Veratrum* for the *Flora of Thailand* indicated two species: *Veratrum chiengdaoense* Larsen (1961: 346), a narrow endemic from Doi Chiangdao (Chiang Mai province) in northwestern Thailand (Larsen 1961) and *Veratrum mengtzeanum* Loesner (1926: 145), native to the southwestern Chinese provinces of Yunnan, Guizhou and Sichuan and disjunct to the Doi Phu Wae mountain in Doi Phu Kha National Park (Nan province), Thailand. Tanaka (2001) suggested these two species may be conspecific. The *World Checklist* (Govaerts 2012) has recognised them as separate species. Additionally, the restricted distribution of *V. chiengdaoense* raises conservation concerns. Confirmation of conspecificity with *V. mengtzeanum* would suggest a wider distribution and revised conservation status. We thus conducted a morphological study to clarify the taxonomic status of these two taxa.

Materials & Methods

A subset of 11 specimens including the types for each taxon was fully examined. These specimens were selected to represent *V. chiengdaoense* and *V. mengtzeanum* and geographical areas (Thailand and China). Additional specimens were also examined for the descriptions.

Floral dissections and measurements were made using a Leica M3Z microscope with a calibrated eyepiece. Vegetative and inflorescence characters were measured with a digital caliper. Measurements were

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taken of the largest and smallest exemplar for each organ and 7–10 exemplars of these organs of each specimen to establish the range. Measurements also indicate the widest point of an organ. Mean values and standard deviation were calculated and plotted on bar graphs (Fig. 1). Absolute numbers were plotted when characters or specimens with only one measurement were available (i.e. number of flowers per individual).

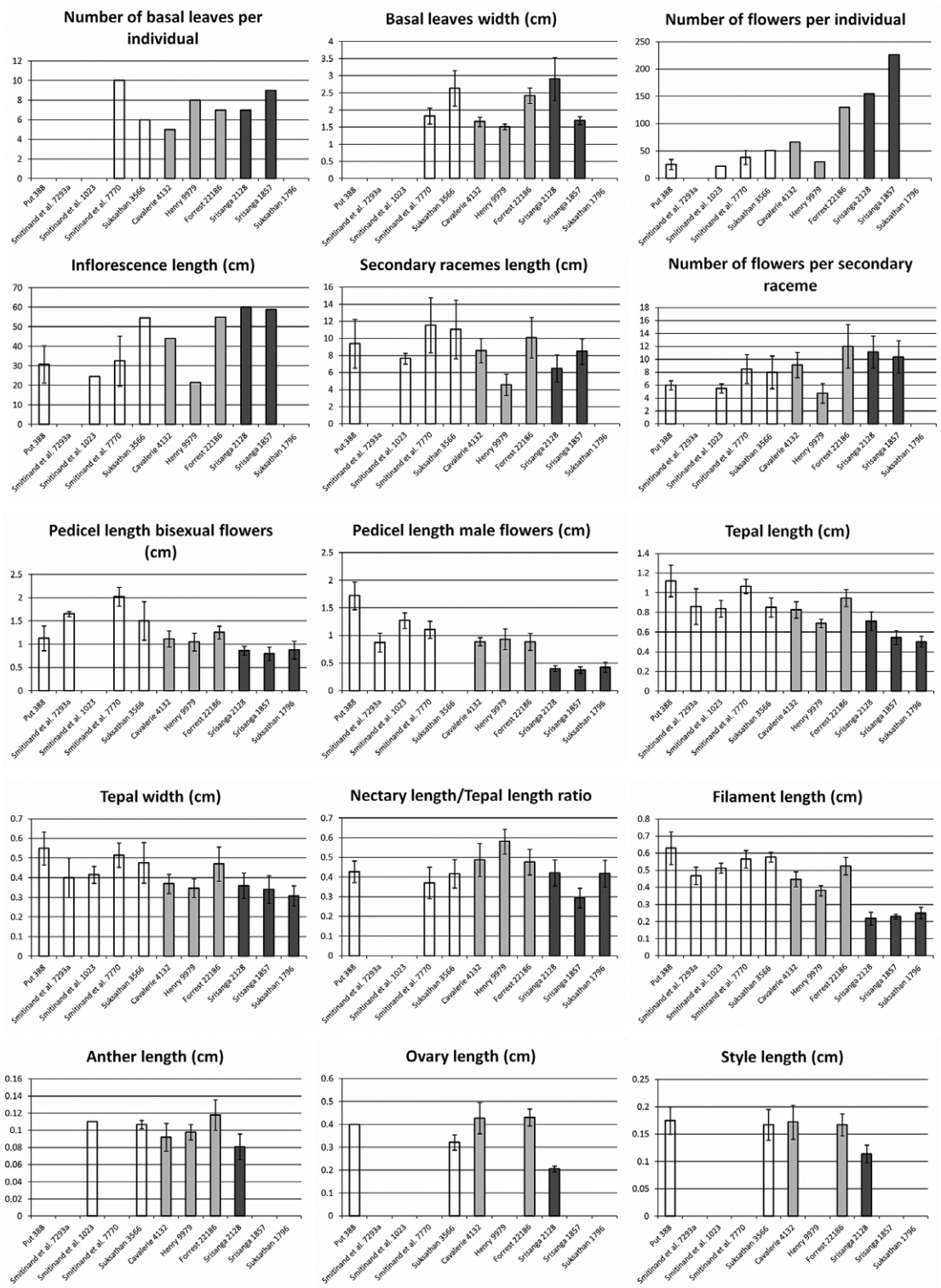

FIGURE 1. Bar graphs representing 15 morphological characters (x axis) plotted against 11 specimens (y axis). Whiskers represent standard deviation. White bars: *V. chiengdaoense*; Light grey bars: *V. mengtzeanum* from China; dark grey bars: *V. mengtzeanum* from Thailand. No bars depicted for unavailable data.

Results

Results are shown in Figure 1. Specimens of Thai *V. mengtzeanum* (dark grey bars) have shorter filaments and pedicels, particularly in male flowers, and a greater number of flowers per individual than those in the rest of its range. A limited number of specimens had gynoecia, and results show that the specimen of *V. mengtzeanum* from Thailand (*Srisanga 2128*) has shorter ovaries (generally by at least 1 mm). According to morphology, specimens of *V. chiengdaoense* (white bars) and Chinese *V. mengtzeanum* (light grey bars) represent a single entity.

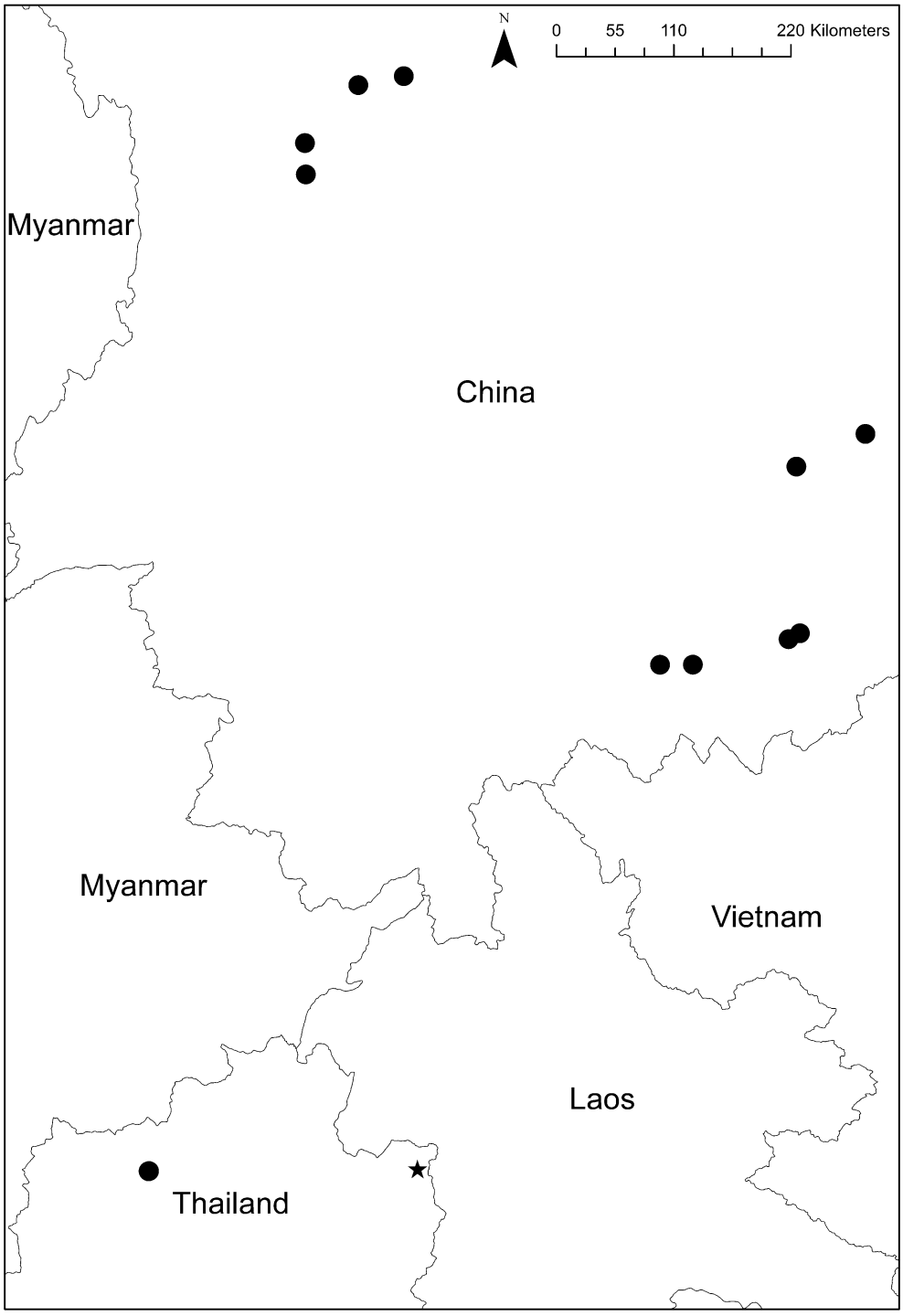

FIGURE 2. Distribution map of *Veratrum mengtzeanum* based on specimen data (dots represent subsp. *mengtzeanum*; stars represent subsp. *phuwae*).

Discussion

Morphological characters, especially pedicel length and number of flowers per individual, support two taxonomic entities. Most other characters overlap, for example, vegetative characters (Fig. 1). Flowers of Thai *V. mengtzeanum* specimens have shorter filaments, and inflorescences have a greater number of flowers per individual (Fig. 1: dark grey bars), along with a disjunct geographical distribution (Fig 2: star) support this entity as a subspecies. An increase in flower number per individual and reduced length of certain flower parts might suggest an adaptation to a specific suite of pollinators (Fenster *et al.* 2004). Further research is necessary to clarify potential speciation processes in these taxa.

With the limited number of specimens available, it is not known whether the range (Fig. 2) is continuous through Lao People's Democratic Republic and Burma or if the known populations (in China and Thailand) are disjunct. Such gaps in distribution may be the result of a number of factors, including habitat fragmentation, extinction events, environmental changes and dispersal pathways. Alternatively, distribution gaps may be an artefact of insufficient collecting in intervening areas. Further discussion on how this disjunction affects conservation status of these taxa can be found below .

Taxonomic treatment

Veratrum mengtzeanum Loesener (1926: 145). Lectotype (designated here):—CHINA. Yunnan: Mengtze (Mengtsz), 1829 m, 11 November 1937, *Henry 9979* (B!, electronic image with barcode B100365925); isolectotypes E (barcode E00061642), K! (barcode K000400441), NY! (electronic images with barcodes NY00319944, NY00319945), US! (electronic image with barcode US00091720).

Veratrum wilsonii Wright ex Loesener (1926: 145). Holotype:—CHINA. Without province: 13 August 1908, *Wilson seed No. 1567* (K!, electronic image with barcode K000400440)).

Veratrum chiengdaoense Larsen (1961: 346) as “chiengdaoënse”. Holotype:—THAILAND. Chiang Mai: Doi Chiangdao [as Chiengdao], 18 October 1926, *Put 388* (K!, electronic images with barcodes K000291993, K000291994); isotypes BK! (barcode 257143), BM! (barcode BM000071950)).

Plants to 1.5 m tall. Mostly andromonoecious, sometimes polygamous or androecious. *Bulb* 3.5–7.5 × 2.0–4.0 cm, with brownish papyraceous tunic becoming fibrous apically; rhizome not seen. *Scape* terete, stout, glabrous to pubescent. *Scape bracts* foliaceous, 5–10, basal and cauline, sessile, linear to narrowly lanceolate, 10.0–61.0 × 1.0–3.5 cm (diminishing in size towards the apex of the plant), base sheathing (particularly basal leaves), sheaths closed or absent, margin entire, apex acute, both surfaces glabrous but occasionally pilose on the proximal margin. *Inflorescence* lax with 16–226 flowers, 19–75 cm long, erect, with 1 terminal raceme and 2–15 basal secondary racemes, 3.1–17.0 cm long, spreading to ascending, tertiary racemes sometimes present, axes tomentose; bracts ovate to lanceolate, foliaceous, 0.8–5.5 cm long, tomentose; pedicels 2.6–22.0 mm long, exceeding bracts, tomentose. *Flowers* staminate or hermaphroditic, cup-shaped to rotate. *Tepals* 6, 4.0–13.0 × 2.5–7.0 mm, whitish or greenish, yellowing with age, spreading, elliptic-spatulate to elliptic-obovate, apex acute to rounded, base abaxially slightly tomentose, adaxially with two collateral prominent dark (when dry) basal glands, 1.3–5.5 mm long, clawed. *Stamens* 6, basally epitepalous; anthers 0.6–1.4 mm long, extrorse, hemispherical; filaments 1.2–7.5 mm long, filiform, free. *Ovary* (present on flowers of terminal raceme, sometimes of secondary), triloculate, 1.9–4.6 mm long, superior, ovoid, glabrous; styles 3, 1.1–2.1 mm long, reflexed. *Capsules* 0.8–3.1 × 0.7–1.9 cm, ovoid to ellipsoid, brown, erect, dehiscing in apical third. *Seeds* several per locule, 6.4–13.5 × 3.5–5.4 mm, flat, irregularly oblanceolate to obelliptic, winged, pale brown.

Ecology.—In thickets, scrub, grasslands and forests, often in dry, open sites in limestone formations.

Nomenclature notes.—Zimmerman (1958) suggested the syntype "*Henry 9979* pro parte" as the lectotype of *V. mengtzeanum*. However, this was not effectively published according to Article 30.7 of the Melbourne Code (McNeill *et al*. 2012), and lectotypification is effected here.

FIGURE 3. *Veratrum mengtzeanum* subsp. *mengtzeanum*: A-B Flowering habit. C. Inflorescence apex. D. Functionally staminate flower. E. Perfect flower. F. Fruit. G. Seed. A and C from Fig. 4-5. B, D and E from *Forrest 22186* (K). F and G from *Smitinand 7770* (BKF) (Drawings by Lucy Smith).

Key to the subspecies of *V. mengtzeanum*

1. Flowers per individual 16–130. Filament length 3.4–7.5 mm.....subsp. *mengtzeanum*
- Flowers per individual 155–226. Filament length 1.2–2.9 mm..... subsp. *phuwae*

1a. *Veratrum mengtzeanum* subsp. *mengtzeanum* (Figs. 3–5)

Inflorescence with 16–130 flowers. *Filaments* 3.4–7.5 mm long.

Distribution.—Northern Thailand (Chiang Mai); southwestern China (Yunnan, Guizhou, southwestern Sichuan).

Ecology.—1200–4000 m elev. Flowering and fruiting August to December.

Specimens examined.—CHINA. Without province: 13 August 1908, *Wilson seed No. 1567* (K). Guizhou: Houang ts'ao-pa [Xingyi], 1918, *J. Cavalerie 4132* (K); Houang ts'ao-pa [Xingyi], *Cavalerie 8080* (B). Szechuan: Mountains SE of Mu-li, 3358 m, August 1922, *Forrest 22186* (K); Mu-li, 2743 m, *Kingdon-Ward 4789* (B). Yunnan: Mengtze, 1829 m, *Henry 9979* (B, E, K, NY, US); Houang kia pin, 4 September 1882, *Delavay 366* (K); Likiang Snow Range, *Forrest 3039* (B); Inter pagos Yungning [Yongning] et Dschundien ("Chungtien")[Zhongdian], 2500-3200 m, 12 August 1915, *Handel-Mazzetti 7625* (WU); Prope pagum Yungning [Yongning], in regionis temperatae fruticetis ad austro-orient, 3150 m, 1914, *Handel-Mazzetti 3158* (WU); Prope urbem Lidjiang [Likiang], imprimis in monte Yülung-schan.[Jade Dragon Snow Mountain], 1914, *Handel-Mazzetti 4013* (WU); Geiju, October 1970, *s.coll. s.n.* (WUK); Luoping County, Fraxinus Hill, 3 August 1973, *s.coll. 8* (KUN); Yanshan County, bar-garh, 15 November 1939, *Wong 85016* (KUN); Yanshan County, Shiao-hwa-yuan-dzai, 22 October 1939, *Wang 84545* (PE). THAILAND. Chiang Mai: Doi Chiangdao, 18 October 1926, *Put 388* (BK, BM, K); southern slope Doi Chiang Dao, 1700 m, 5 August 2005, *Suksathan 3566* (QBG); Doi Chiangdao, 1900-2000 m, 10 November 1962, *Smitinand et al. 7770* (BKF); Doi Chiangdao, 2100 m, 3 December 1961, *Smitinand, & Anderson 7293a* (BKF); Doi Chiangdao, 1750 m, 16 August 1963, *Smitinand & Sleumer c. al. 1023* (BKF); Doi Chiang Dao Wilflife Sanctuary, ridge to closest peak to ranger station, 1728 m, 12 November 2011, *Trias-Blasi et al. 67* (K); below the summit of Doi Chiang Dao, 1900 m, 14 September 1967, *Shimizu et al. 10079* (QBG).

Conservation Assessment.—There are at least 13 populations of *V. mengtzeanum* subsp. *mengtzeanum* represented by 22 herbarium specimens (Fig. 2). Additional herbarium specimens have been observed within the same provinces as the georeferenced specimens used in the assessment, but it has been impossible to determine their exact localities. Using GeoCAT (Bachman *et al.* 2011; http://geocat.kew.org/), extent of occurrence (EOO) was calculated to be as 287,500 km^2 and area of occupancy (AOO) 48 km^2 based on a user defined cell width of 2 km. Chinese collections are generally old (1882 – 1939), and the most recent one was collected in 1973. No recent observations have been recorded, and the current status of these populations is unknown. Thai collections are more recent and have all been collected from Doi Chiangdao, where we also collected a specimen in 2011. There is a disjunction between Chinese and Thai populations. This species may occur in intermediate localities in Lao People's Democratic Republic and Burma. Additionally, a member of the editorial board (Mark Newman, pers. comm.) of the *Flore du Cambodge, Laos et Viêtnam* confirmed that this taxon has not been recorded for these countries. With an AOO of 48 km^2 this taxon could meet criterion B2 under Endangered. Until current Chinese populations are assessed, the data available do not suggest immediate threats to this taxon; its habitat is restricted to relatively high and inaccessible elevations (1,200–4,000 m), and it has a wide distribution (high EOO). These factors support a preliminary global assessment of Least Concern, based on the criteria of IUCN (2001).

One population of *V. mengtzeanum* subsp. *mengtzeanum*, represented by seven herbarium specimens, occurs in Thailand (Fig. 2). Using GeoCAT (Bachman *et al.* 2011; http://geocat.kew.org/), the AOO was calculated as 8 km^2 based on a user defined cell width of 2 km^2 and the EOO could not be calculated. Absence

of populations between China and Thailand suggests that the Thai populations may be genetically isolated. The regional assessment of this subspecies follows the reasoning as for the global assessment of *V. mengtzeanum subsp. phuwae* (see below). A preliminary assessment of Near Threatened (NT), based on the criteria of IUCN (2001), is indicated.

FIGURES 4–5. *Veratrum mengtzeanum* subsp. *mengtzeanum* (from: Doi Chiangdao, Chiang Mai province, Thailand; photos by Piyakaset Suksathan).

1b. *Veratrum mengtzeanum* subsp. *phuwae* Trias-Blasi *subsp. nov.* (Fig. 6)

Differs from *V. mengtzeanum* subsp. *mengtzeanum* in having a larger number of flowers per individual and shorter filaments.

Holotype:—THAILAND. Doi Phu Wae, Doi Phu Kha National Park, Chalerm Pra Kiat, 1700 m, 5 September 2001, *Srisanga 2128* (QBG!).

Inflorescence with 155-226 flowers. *Filaments* 1.2–2.9 mm long.

Distribution.—Northern Thailand (Nan).

Ecology.—1700–1800 m elev. Flowering and fruiting from September to January.

Etymology.— This subspecies is named after the Phu Wae mountain peak located in Doi Phu Ka National Park in the northern floristic region of Nan in Thailand, the only known locality. The specific ephithet "phuwae" is a noun in apposition and therefore does not have an additional Latin suffix.

Specimens examined.—THAILAND. Nan: Doi Phu Kha National Park, Phu Wae. 1800 m, 4 July 1999, *Srisanga et al. 884* (AAU, QBG); Phu Wae, Doi Phu Kha, 1790 m, 1 January 1999, *Suksathan 1796* (QBG); Doi Phu Wae, 1800 m, 13 November 2000, *Srisanga 1857* (QBG); Doi Phu Wae, Doi Phu Kha National Park, Chalerm Pra Kiat, 1700 m, 5 September 2001, *Srisanga 2128* (QBG).

Conservation Assessment.—The one population of *V. mengtzeanum* subsp. *phuwae* is represented by four herbarium specimens (Fig. 2). Using GeoCAT (Bachman *et al.* 2011; http://geocat.kew.org/), the AOO was

calculated as 4 km^2 based on a user defined cell width of 2 km^2, which suggests this taxon meets criterion B2 under Critically Endangered. The specimens only had general locality information, and thus georeferencing was imprecise; the EOO could not be calculated. It is likely that more individuals could be found in suitable habitats in nearby areas, in which case the EOO might increase to over 100 km^2, and this taxon might then be classed as Endangered. Even though specimens show that this population is still extant, it is strictly restricted to limestone outcrops, resulting in a fragmented distribution. Limestone habitats are generally threatened in Thailand by extraction for making concrete (Wilkin *et al.* 2012), but this population (IUCN locations) is in a National Park; thus, it is afforded a higher level of protection. This taxon meets some conditions for CR B1+2a and VU D2, but there are no observed declines or extreme fluctuations. However, the taxon needs to be carefully monitored in Thailand as the introduction of a threat of any kind would have an impact. A preliminary assessment of Near Threatened (NT), based on the criteria of IUCN (2001), is indicated.

FIGURE 6. *Veratrum mengtzeanum* subsp. *phuwae* Trias-Blasi *subsp. nov.* (from type locality; photo by Prachaya Srisanga).

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