



Thismia mucronata (Thismiaceae), a new species from Southern Vietnam

MAXIM S. NURALIEV^{1,2}, ANTON S. BEER², ANDREY N. KUZNETSOV^{1,3} & SVETLANA P. KUZNETSOVA¹

¹ Joint Russian-Vietnamese Tropical Scientific and Technological Center, Cau Giay, Hanoi, Vietnam. e-mail: max.nuraliev@gmail.com

² Faculty of Biology, M.V. Lomonosov Moscow State University, 1, 12, Leninskie Gory, 119234 Moscow, Russia.

³ A.N. Severtsov Institute of Ecology and Evolution of the Russian Academy of Sciences, Leninsky 33, Moscow, Russia.

Abstract

Thismia mucronata, a new species of Thismiaceae, is described and illustrated. The species was discovered in 2013 during a botanical survey of a forest in the vicinity of Bao Loc town (Lam Dong province, Southern Vietnam). *Thismia mucronata* is characterised by vermiform roots and mitriform inner tepals. It differs from related species mainly by the short and appressed to each other appendages of inner tepals, which together resemble a short mucro, the narrow mitre without foveae, the almost horizontal annulus and the absence of interstaminal glands. A key to Vietnamese species of *Thismia* is provided.

Keywords: *Thismia*, taxonomy, key, mycoheterotrophic plants, Southern Vietnam, Bao Loc, flora, biodiversity

Introduction

Thismia Griffith (1844: 221) is a genus of small, terrestrial, achlorophyllous, mycoheterotrophic, herbaceous plants. The genus along with four other genera of similar habit is currently placed in the family Thismiaceae, order Dioscoreales (Stevens 2001, Merckx *et al.* 2013) or less often Burmanniales (Takhtajan 2009). The exact phylogenetic relationships and taxonomic placement of this genus and its allies are still to be evaluated (APG 2009, Delin *et al.* 2010, Merckx *et al.* 2013). The main point of uncertainty is the phylogenetic position of *Tacca* Forster & Forster (1775: 69; Taccaceae), which appeared to be nested within Thismiaceae in some molecular-based phylogenetic reconstructions (Merckx & Bidartondo 2008, Merckx *et al.* 2009, 2010, Merckx & Smets 2014), making the family Thismiaceae paraphyletic. Moreover, the monophyly of *Thismia* itself has not been widely supported by cladistic analyses of molecular and morphological data sets (Merckx *et al.* 2006, 2009, Yokoyama *et al.* 2008, Merckx & Smets 2014).

The genus *Thismia* is the largest within Thismiaceae and includes about two thirds of its species (Govaerts *et al.* 2011, Merckx *et al.* 2013). Merckx & Smets (2014) listed 50 known species of *Thismia*, and at least three more species were described after their review (Li & Bi 2013, Dančák *et al.* 2013, Truong *et al.* 2014). The genus is distributed from subtropical Asia to temperate Australia and in America, mainly in tropical evergreen forests (Maas-Van de Kamer 1998, Li & Bi 2013, Dančák *et al.* 2013, Merckx *et al.* 2013, Merckx & Smets 2014), with the highest species diversity in Borneo and Malay Peninsula (Chantanaorrapint 2012, Tsukaya & Okada 2012).

Recently, many new species of *Thismia* have been discovered, in particular from various Asian countries. For instance, the number of species was estimated as around 35 several years ago (Yang *et al.* 2002, Chantanaorrapint 2008), which means description of ca. 15 species during the past decade. In Asia, new species have been recently reported from Taiwan (Yang *et al.* 2002, Chiang & Hsieh 2011), Yunnan (Li & Bi 2013), Vietnam (Larsen & Averyanov 2007, Truong *et al.* 2014), Thailand (Chantanaorrapint 2008, 2012) and Borneo (Kiew 1999, Tsukaya & Okada 2005, 2012, Dančák *et al.* 2013). Several significant range extensions in Asia have been also published (Chantanaorrapint & Sridith 2007, Chantanaorrapint & Chantanaorrapint 2009, Ho *et al.* 2009). Due to the paucity of collections, a considerable number of *Thismia* species are believed to be extremely rare. On the other hand, certain difficulties in field observations of these plants were pointed out, including their small sizes and ephemerality of above-ground parts (Stone 1980, Yang *et al.* 2002, Larsen & Averyanov 2007, Chantanaorrapint 2012, Tsukaya & Okada 2012, Dančák *et al.* 2013, Merckx & Smets 2014).

Four species of *Thismia* have been ever reported from Vietnam, but only one of them—*T. javanica* J.J. Smith (1910: 32)—is listed in the Flora of Vietnam (Pham Hoang Ho 2000). Two additions—*T. annamensis* K. Larsen & Averyanov (2007: 13) and *T. tentaculata* K. Larsen & Averyanov (2007: 16)—were made by Larsen & Averyanov (2007). The latter

authors also doubted the presence of *T. javanica* in Vietnam. The species is generally distributed in Southern Thailand and Indonesia (Jonker 1948, Larsen 1987) and shows highly similar external appearance with *T. tentaculata*. The fourth species, *T. okhaensis* Luu, Tich, G. Tran & Q.D. Dinh in Truong *et al.* (2014: 190), was discovered in 2013 and described recently. Here, we report a further new species of *Thismia* from Southern Vietnam. We also provide for the first time a key to the Vietnamese species of *Thismia*, which includes all five species known to date.

Material & Methods

The new species was collected during an expedition of the Russian-Vietnamese Tropical Centre in Lam Dong province of Vietnam, forestry in the vicinity of Bao Loc town in April 2013. The description and drawings are based on spirit collections and photographic materials of living plants. The measurements were performed for plants fixed and stored in 70% ethanol, using a vernier calliper under a dissecting microscope. In general, 15–20 plants were used for measurements of vegetative characters and external floral characters, one flower for androecium characters and three flowers for style and stigma characters.

Description of the new species

Thismia mucronata Nuraliev, *sp. nov.* (Fig. 1–3).

Thismia mucronata differs from related *T. angustimitra* and *T. mirabilis* by the presence of a mucro at the top of the convex mitre formed by appendages of the inner tepals, the absence of foveae, and the absence of interstaminal glands at the adaxial side of the anther tube. The following combination of morphological traits also characterises this species: entire margin of outer tepals, mitre white and narrower than the hypanthium, annulus almost horizontal and prominent styler column.

Type:—VIETNAM. Lam Dong province: Bao Lam district, Loc Bac municipality, 22,2 km NNW from Bao Loc town, in the forest, not far from river, elevation ca. 1000 m a.s.l., N 11° 44' 18", E 107° 43' 22", 13 April 2013, *M.S. Nuraliev 813* (MW! holotype), including plants with flowers in liquid collection at Moscow University.

Plant herbaceous, terrestrial, achlorophyllous, generally glabrous (Fig. 2), branching by the formation of root suckers (Fig. 1a); rhizomes absent. *Roots* few, clustered at the base of stem, vermiform, unbranched, thick, Ø 0.5–1 mm (Fig. 2d). *Stem* erect or sometimes ascending (if growing from under forest litter), unbranched, terete and slightly angled, grayish-white, 0.4–3.5 cm tall (without terminal flower), Ø 1.3–1.8 mm, bearing (1–)2 flowers (fig. 2b). *Leaves* 7–11, alternate, scattered, appressed to stem, scale-like, narrowly triangular, grayish-white, up to 7 mm long. Distal leaves up to 6 mm wide at their base, margin entire, apex acute. The leaves become crowded and smaller downwards, basalmost leaves 1 mm long. Involucral bracts 3, inserted less than 1 mm below the ovary and symmetrically arranged around it, equal, appressed to flower base, similar to upper leaves in colour and shape or slightly longer, up to 9 mm long. *Flower* terminal, actinomorphic, 1.2–1.7 cm long (Fig. 1b, 3); if flowers more than one then the lateral flower is located in the axil of one of the involucral bracts of the terminal flower and bears its own involucral bracts. *Hypanthium* obconic, ca. 1.5 times higher than involucral bracts, 7–10 mm high (with ovary), ca. 6 mm wide in the upper part, with 12 veins prominent and raised outside (Fig. 3a, b); outer surface irregularly papillose especially along veins, dark blue and gradually becoming darker distally but with a narrow whitish collar in the upper part, veins darker than surrounding tissue; inner surface without transversal bars, fenestrate, uniformly translucent dark blue but with a light orange collar in the upper part (above the level of stamen appendages). *Perianth* of 6 tepals in 2 whorls attached to the hypanthium top (Fig. 3a–e). Annulus almost horizontally covering the hypanthium to form a closed chamber, dome-shaped, fleshy, milky white, with roundish triangular orifice Ø ca. 1.5 mm (Fig. 3f). *Outer tepals* alternating with involucral bracts, broadly triangular, 1.5–2 mm long, 2–3 mm wide at their base, white and marginally translucent, margin entire, apex acuminate to rounded. *Inner tepals* at the same radii with involucral bracts, distally arching inward and apically broadly fused (inseparable without tearing) to form a thick convex-topped mitre ca. 1.5–2 mm high (excluding free basal tepal parts) and 4–5.5 mm wide with prominent sutures and leaving 3 broad arch-shaped apertures 3–3.5 mm wide, thick, broadly attached to annulus along its whole radius except its inner margin, basally ca. 2 mm wide, narrowed slightly above to ca. 1 mm wide and broadened towards the mitre; free parts each with marginal thickenings and with

prominent dorsal median keel which continues from one of the hypanthial veins; the keels continue till the mitre top where they prolongate into 3 free erect acute pyramidal appendages 0.5–1 mm high; the appendages initially tightly appressed to each other resembling a short but distinct mucro at the top of mitre, later slightly diverging (Fig. 2c); foveae absent; the narrowest parts of inner tepals outside blackish blue gradually becoming greenish brown basally and white distally, mitre outside milky white except the appendages, the latter dark to pale blue and later tinged with orange to light brown, the inner tepals including mitre inside uniformly black. *Stamens* 6, pendulous from the annulus and broadly connected to its inner surface by short and thick filaments, ca. 4–5 mm long (fig. 3g–k); anther connectives dilated, each with median longitudinal furrow at the inner (abaxial) side (fig. 3h) and projecting far beyond thecae into apical prolongation, fused laterally along the whole length except the rounded apices to form a stamen tube with 6 narrow holes remaining between the free filaments in the base of the tube; the apical prolongations bearing skirt-like appendages at the outer (adaxial) side slightly below thecae, concave adaxially below the appendages; each appendage (fig. 1d, 3j, k) wider than stamen, 1.5 mm wide, inclined towards and reaching the connective apex, with perpendicular marginal wing-like projections of lamina forming H-shaped structure which are attached to connective tissue so that proximal parts of projections triangularly attenuate and decurrent proximally to the thecae and distal parts rounded; appendages touching the inner surface of hypanthium and isolating the torus-shaped space between stamen tube and hypanthium except for 6 narrow gaps between the appendages of adjacent connectives; thecae 2 in each stamen, adaxial (facing the hypanthium) on the basal part of connective, separate, shallow, narrowly elliptic, longitudinally dehiscent, ca. 1 mm long; androecial indumentum of 3–4 papillae at the apex of each connective prolongation, stiff long needle-like hairs at the margin of appendages, and 2 rows of shorter glandular hairs on the sides of each theca (fig. 1c,d); interstaminal glands absent; stamens white except greenish blue distal portions of prolongations and translucent light orange appendages. *Ovary* inferior, outside not delimited from hypanthium, obconic, 2.5–3.5 mm long, 3–3.7 mm wide towards apex, flat-roofed, unilocular with 3 fusiform central placentas (Fig. 1c); placentas alternate with stylodia, joined at the apex and base of the loculus; ovules numerous, white; stylar column shortly cylindrical, ca. 0.5 mm long, Ø ca. 0.5 mm, dark blue; stylodia 3, ca. 2 mm below stamen apices, upright, appressed to each other, simple, rectangular, 0.8–1 mm long, bearing densely finely papillose stigmas, translucent light blue (fig. 3l). *Fruit* and seeds unknown.

Notes:—1. Since there is no direct way to distinguish mature flowers from floral buds, the lowermost measurements of sizes of flower and its parts may belong to immature structures and, if so, should not be taken into account.

2. In the taxonomic literature, including the papers cited in the Introduction, the floral parts of *Thismia* are usually named without strict relation to the floral elements: “floral chamber” or “perianth tube” are used for hypanthium and “annulus” (= “corona”, Thiele & Jordan 2002) as an organ *sui generis*. In this paper, we generally follow the morphological research by Caddick *et al.* (2000) in the interpretation and terminology of the floral structure. As shown by these authors, the hypanthium of *Thismia* represents an expansion of receptacle, the annulus is a result of basal connation (probably congenital) of all six tepals, the stamens are fused postgenitally and expose their adaxial surface outside and abaxial inside.

3. A drastic change of flower coloration was observed shortly after immersing the plants into alcohol. In less than a minute, all the dark parts of the flower became intensively orange. Later, the flowers gradually became colourless.

Taxonomic relationships:—Jonker (1938, 1948) grouped Southeast Asian species of *Thismia* with mitre-bearing flowers (excluding *Geomitra* Beccari, 1877: 250, and *Scaphiophora* Schlechter, 1921: 39, which were treated as separate genera on the basis of long free or connate mitre appendages) into sect. *Sarcosiphon* (Blume 1850: 65) Jonker (1938: 251). However, he also characterised this section as having coralliform underground parts. Since *Thismia mucronata* possesses vermiform roots, it seems to be morphologically more close to sect. *Rodwaya* Schlechter (1921: 38) sensu Jonker (1938), which was stated to be distributed out of Asia. A similar decision was made by Chiang & Hsieh (2011) in respect to the placement of *T. huangii* P.Y.Jiang & T.H.Hsieh (2011: 139). Since Asian species of *Thismia* (in its current broad circumscription) with simultaneous presence of mitre and vermiform roots were not known at the time of Jonker’s work, they cannot be placed in his system with confidence (see also Chantanaorrapit 2008). Nevertheless, some of these species were already placed into sect. *Sarcosiphon* (Larsen 1965, Truong *et al.* 2014) despite the mismatch in the type of root system. Thiele & Jordan (2002) pointed out the inadequacy of Jonker’s generic and infrageneric classification. According to Merckx & Smets (2014), who have extended the classification of Maas *et al.* (1986, see below), Asian species with such features should be treated within *Thismia* subgen. *Thismia* sect. *Sarcosiphon*, which makes this section morphologically heterogeneous and comprising species with both coralliform and vermiform roots. An exception was made for *T. huangii*, which was placed into sect. *Rodwaya* following Chiang & Hsieh (2011) due to its high similarity to *T. rodwayi* F.Mueller (1890: 115) and *T. americana* N.Pfeiffer (1914: 123). Merckx & Smets (2014) also showed non-monophyly of a number of sections of *Thismia* including *Sarcosiphon* and *Rodwaya* and concluded that the current classification of *Thismia* does not reflect natural relationships of its species.

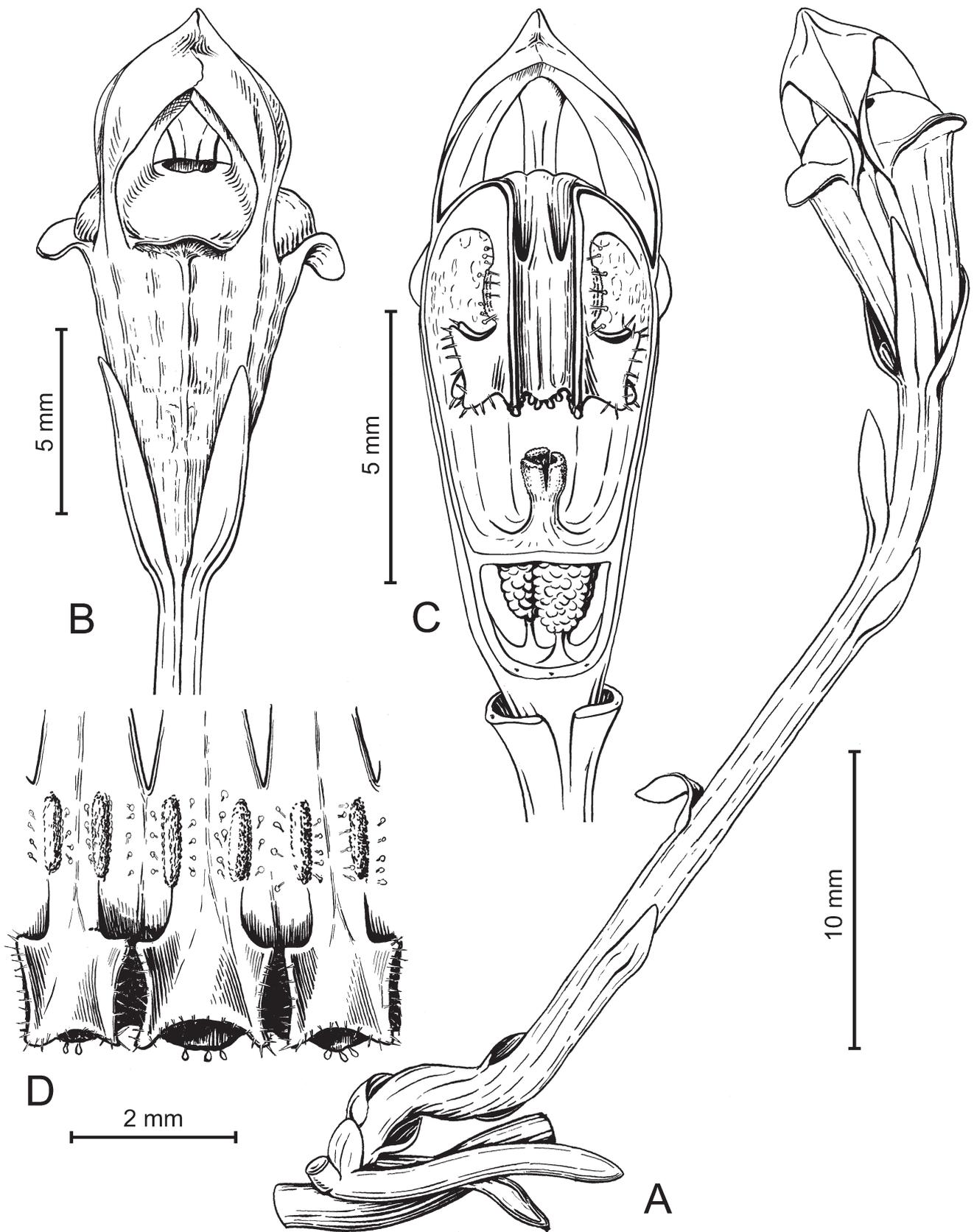


FIGURE 1. *Thismia mucronata*. A. Plant with flower. B. Flower, side view. C. Longitudinal section of flower. D. Part of stamen tube, detached and flattened; note papillae at connective apices, needle-like hairs at margin of appendages, and glandular hairs along thecae. All drawn from type *Nuraliev 813* by A.Beer.



FIGURE 2. *Thismia mucronata*. A. Plants in natural habitat; note young shoots (arrows). B. Flowering plant (above-ground part). C. Shoot with anthetic terminal flower (note divergent brownish mitre appendages) and preanthetic lateral flower. D. Plants with underground parts (liquid specimen); in central plant hypanthium removed. *Nuraliev 813*. All photos by M.Nuraliev.

Within classification of Maas *et al.* (1986), which was developed with main attention to the Neotropics, the genus *Thismia* was divided into two subgenera and all species with inner tepals fused into mitre fall within subgen. *Thismia*. *T. mucronata* fits *Thismia* subgen. *Thismia* sect. *Rodwaya* (Schltr.) Maas & H.Maas in Maas *et al.* (1986: 166) in having, besides the mitre, cylindrical (i.e. vermiform) roots, terete (not bisulcate) stem with scattered leaves, anther tube, separate thecae and central placentas. These features are shared by *T. mucronata* and several other species of the genus including *T. americana*, *T. angustimitra* Chantanaorrapint (2008: 524), *T. clavarioides* K.R.Thiele in Thiele & Jordan (2002: 766), *T. huangii*, *T. mirabilis* K.Larsen (165: 171), *T. okhaensis* and *T. rodwayi*. It should be noted that the taxonomic usefulness of the mitre was doubted (Thiele & Jordan 2002) due to morphological heterogeneity of this structure. Furthermore, some species, such as *T. abei* (Akasawa, 1950: 193) Hatusima (1976: 7), *T. gongshanensis*

Hong Qing Li & Y.K.Bi (2013: 25), *T. taiwanensis* Sheng Z.Yang, R.M.K.Saunders & C.J.Hsu (2002: 485) (see also Yang *et al.* 2010) and *T. tuberculata* Hatusima (1976: 4), demonstrate mitre-like perianth vernation with free and imbricate (rather than fused and valvate) inner tepals. The rhizomes reported for *T. clavarioides*, *T. huangii* and several species of *Thismia* with free inner tepals (e.g. Chantanaorrapint & Sridith 2007, Li & Bi 2013) could possibly represent roots that bear root suckers, as it occurs in *T. mucronata*. The absence of rhizomes is consistent with general characteristics of the genus *Thismia* (Maas *et al.* 1986).

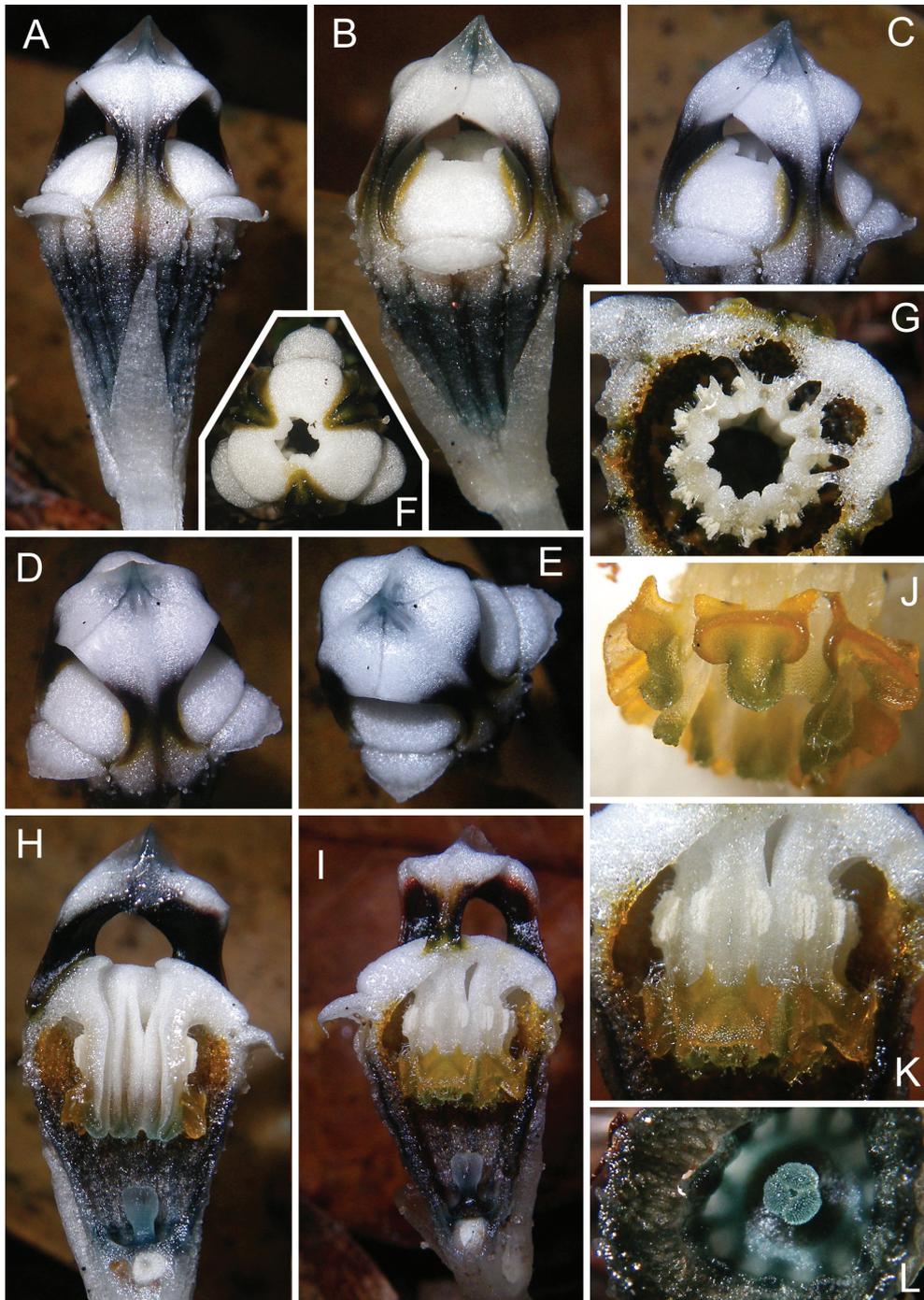


FIGURE 3. Flower of *Thismia mucronata*. A–C. Side view. D,E. Perianth. F. Annulus, top view (mitre removed). G. Cross section at the level of attachment of stamens. H. Longitudinal section. I. Side view with hypanthium partly removed. J. Stamen appendages, side-bottom view. K. Stamen tube, side view. L. Stylopedia, top view. *Nuraliev 813*. All photos by M.Nuraliev.



FIGURE 4. *Thismia angustimitra*. A. Plants in natural habitat. B. Flowers. All photos by P.Tripetch.

Thismia mucronata is morphologically most similar to *T. angustimitra* and *T. mirabilis*, both distributed in Thailand (Larsen 1965, 1987, Chantanaorrapint 2008) (and probably erroneously included in key to the Malaysian species by Tsukaya & Okada 2012). It also finely resembles them in the colour palette of the flower and in the remarkable colour change when immersed into alcohol as described by Larsen (1965). For the purpose of comparison with the newly described species, we also publish here for the first time photos of *T. angustimitra* (Fig. 4). These photos were taken by Pethch Tripetch at the type locality of this species. The new species differs from both *T. angustimitra* and *T. mirabilis* in short but prominent appendages of inner tepals which together look as a mucro at the top of the convex mitre (vs. flat-topped mitre without appendages), in the absence of foveae (vs. three foveae) and in the absence (vs. presence) of interstaminal nectariferous glands at the adaxial side of the anther tube. It also differs from *T. mirabilis* by a mitre that is more narrow (vs. more broad) than the hypanthium, by the horizontal (vs. erect) annulus and by the anthers fused (vs. free) at the level of thecae. Differences with *T. angustimitra* are entire (vs. crenate) margin of outer tepals, the prominent (vs. almost absent) stylar column, and the flower coloration including a mostly white (vs. purple to brownish) mitre. One more species, *T. okhaensis*, also apparently belongs to this morphologically distinct group and is characterised by uniquely large (up to 3 cm) flowers, broad mitre with glandular hairs under its top and tall erect annulus which leaves very narrow apertures below the mitre. Among *Thismia* species with mitre-bearing flowers, *T. okhaensis* appears to be most closely distributed geographically to *T. mucronata* with the distance between their populations about 150 km. The main morphological differences between these four species are summarized in Table 1.

TABLE 1. Morphological differences between *Thismia mucronata* and related species. The characters of previously described species are taken from the protologues and also from Larsen (1965).

| Characters | <i>T. mucronata</i> | <i>T. angustimitra</i> | <i>T. mirabilis</i> | <i>T. okhaensis</i> |
|--|---|-----------------------------------|--|--|
| Flower length | 1.2–1.7 cm | ca. 1 cm | < 2 cm | ca. 3 cm |
| Margin of outer tepals | entire | crenate | entire | entire |
| Mitre more broad or narrow than the hypanthium | more narrow | more narrow | more broad | more broad |
| Top of the mitre | convex and bearing three appendages, foveae or furrows absent | flat, with foveae | flat, with foveae | convex, with furrows |
| Annulus shape | horizontal | horizontal | erect | erect (according to figures, though described as incurved) |
| Level of anther fusion | along the whole connective length | along the whole connective length | along connective prolongations (free at the level of thecae) | along the whole connective length |
| Interstaminal glands | absent | present | present | absent |
| Stylar column | prominent, 0.5 mm long | almost absent | prominent, 0.5 mm long | prominent, 0.8 mm long |

Etymology:—The specific epithet “*mucronata*” is derived from the distinctive mucro at the top of the mitre, which differs this species from the most similar species *Thismia angustimitra*, *T. mirabilis* and *T. okhaensis*.

Distribution and habitat:—Currently only known from Lam Dong province in Southern Vietnam (Fig. 5). The species is probably abundant at the type locality where four compact groups of up to eight above-ground shoots were found. It was also observed in a locality (N 11° 44' 18", E 107° 42' 30", river bank) at a distance of 1.5 km from the type locality as well as in two other places around this point. It grows amongst forest litter, along the river banks as well as in the forest not far from the river under the canopy of long-boled monsoon tropical mountain forests of middle elevation with upper storey of the canopy formed by trees belonging to families Anacardiaceae, Magnoliaceae, Sapindaceae, Dipterocarpaceae, Euphorbiaceae, Fagaceae, Theaceae, Sapotaceae, Fabaceae, Altingiaceae, Hamamelidaceae, Elaeocarpaceae, Podocarpaceae, Lauraceae, Sterculiaceae. Wet season May to October, dry season December to March, mean annual precipitation about 2000 mm. The area is also inhabited by several mycoheterotrophic species of Orchidaceae: *Cephalanthera exigua* Seidenfaden (1975: 71), *Epipogium roseum* (D. Don, 1825: 30) Lindley (1857: 177) and *Vietorchis furcata* Averyanov & Nuraliev in Averyanov *et al.* (2013: 253).

Phenology:—In mid-April, *T. mucronata* was in the beginning of flowering with frequent immature above-ground shoots but no fruits or withered flowers. This is consistent with the general assumption that species of *Thismia* flower after rains (Ho *et al.* 2009). Furthermore, the majority of the collected shoots had a single (terminal) flower in anthetic or preanthetic condition, whereas second flower in the axil of the involucre bract was severely underdeveloped and not visible without a close examination. In some (older) shoots, the lateral flower was well developed and apparently functioned normally, which indicates that the lateral flowers are not abortive (which was suggested for *T. mirabilis* by Larsen 1965) at least in some cases (Fig. 2c). Possibly, the shoots can bear more than two flowers organized into a few-flowered monochasial inflorescence (cincinnus, according to Maas-Van de Kamer 1998, Larsen & Averyanov 2007) and blooming successively. This type of inflorescence is typical for many species of *Thismia*. It is also highly possible that the stem elongates significantly until the end of the flowering period, and the pedicel develops, as it was described for some other species (Chantanaorrapint 2008, 2012, Yang *et al.* 2002, 2010, Chiang & Hsieh 2011). The flower is initially white with blue and appearance of red or brown tinges probably indicates later flowering stages, along with diverging of appendages of inner tepals.

Flower and fruit biology:—Details of flower morphology and coloration of *T. mucronata* support the idea of myophily (Stone 1980, Maas *et al.* 1986) and correspond with the manner of pollinator behavior hypothesized by Thiele & Jordan (2002). As the latter authors suggested, the pollinator could pass inside the hypanthium chamber through the orifice of the annulus and the stamen tube, touch the stigmas, then follow up the hypanthium wall being constrained

by the stamen appendages in order to touch the thecae and leave the chamber through one of the gaps between stamen filaments and the annulus orifice. Floral biology has never been studied in the genus *Thismia*, but visitation by dipteran species was recorded once in *T. gongshanensis* (Li & Bi 2013). No nectar or nectaries were found in *T. mucronata*; this indicates the possibility of pollination by fungus gnats deceived through brood-site imitation (Maas *et al.* 1986, Maas-Van de Kamer 1998, Thiele & Jordan 2002), though pollination by pollen-eating insects cannot be excluded.

Key to the species of *Thismia* in Vietnam

1. Inner tepals free, with spreading filiform appendages longer than 6 mm2.
- Inner tepals fused apically into mitre, appendages absent or very short (less than 2 mm)4.
2. Inner and outer tepals subequal, both terminated by spreading filiform appendages 6.5–9 mm long; whole flower brownish.....
..... *Thismia annamensis*
- Inner and outer tepals unequal, outer tepals without appendages; flower white-, yellow- and red-colored3.
3. Anthers tridentate apically, each tooth terminated by a hair; hypanthium inside with longitudinal bars connected by several transversal bars; hypanthium pale orange outside at least at the upper part *Thismia javanica*
- Anthers bidentate apically without hairs at apex, hypanthium inside finely irregularly manicate-rugulose without transverse bars; hypanthium uniformly white outside..... *Thismia tentaculata*
4. Flowers large (ca. 3 cm); mitre broader than hypanthium, with digitally furrowed top, appendages absent *Thismia okhaensis*
- Flowers small (less than 2 cm); mitre narrower than hypanthium, bearing three short apical appendages initially appressed and resembling a mucro *Thismia mucronata*

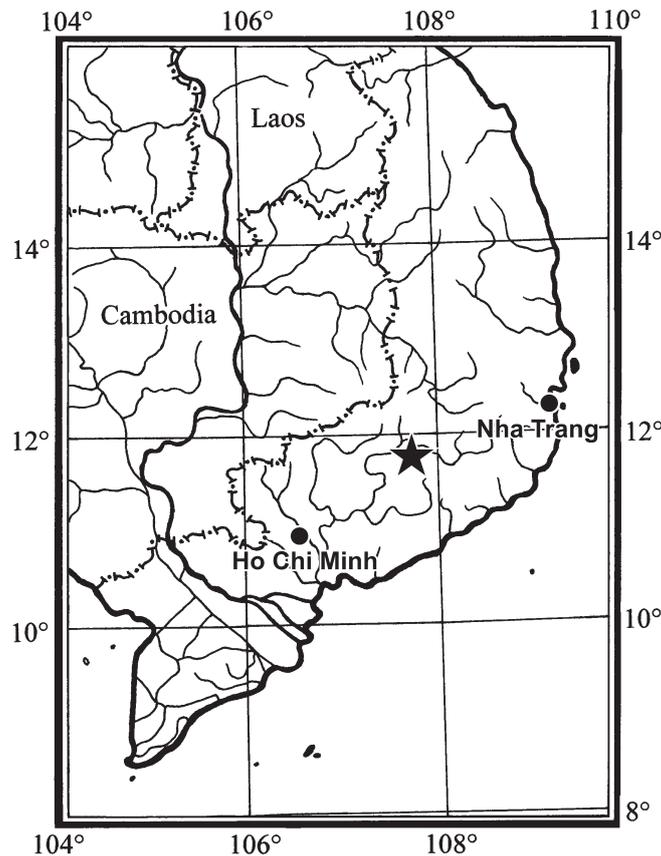


FIGURE 5. Map of Southern Vietnam with type locality of *Thismia mucronata*.

Acknowledgements

We thank A.V. Aleksandrova and D.N. Fedorenko for their help in finding the plants in the nature. We are very indebted to L.V. Averyanov, S. Chantanaorrapint, V.S.F.T. Merckx and D.D. Sokoloff for helpful discussion. P. Tripetch is gratefully acknowledged for providing his photo of *Thismia angustimitra* at its type locality. We are grateful to M.V. Remizowa for her help in improving our English, and two anonymous reviewers for helpful suggestions.

References

- Akasawa, Y. (1950) A new species of *Glaziocharis* (Burmanniaceae) found in Japan. *Journal of Japanese Botany* 25: 193–196.
- APG III (2009) An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG III. *Botanical Journal of the Linnean Society* 161: 105–121.
<http://dx.doi.org/10.1111/j.1095-8339.2009.00996.x>
- Averyanov, L.V., Nuraliev, M.S., Kuznetsov, A.N. & Kuznetsova, S.P. (2013) *Vietorchis furcata* (Orchidaceae, Vietorchidinae)—a new species from southern Vietnam. *Taiwania* 58: 251–256.
<http://dx.doi.org/10.6165/tai.2013.58.251>
- Beccari, O. (1877) *Malesia Raccolta*. Tip. del R. Istituto Sordo-muti, 379 pp.
- Blume, C.L. (1850) *Annales Musei botanici lugduno-batavi* 1. 567 pp.
- Caddick, L.R., Rudall, P.J. & Wilkin, P. (2000) Floral morphology and development in Dioscoreales. *Feddes Repertorium* 111: 189–230.
<http://dx.doi.org/10.1002/fedr.4911110313>
- Chantanaorrapint, S. (2008) *Thismia angustimitra*, a new species from Thailand. *Blumea* 53: 524–526.
<http://dx.doi.org/10.3767/000651908x607477>
- Chantanaorrapint, S. (2012) *Thismia filiformis*, a new species of Thismiaceae (formerly Burmanniaceae) from Thailand. *Kew Bulletin* 67: 1–5.
<http://dx.doi.org/10.1007/s12225-012-9340-1>
- Chantanaorrapint, S. & Chantanaorrapint, A. (2009) *Thismia clavigera* (Thismiaceae), a new record for Thailand. *Thai Forest Bulletin* 37: 27–31.
- Chantanaorrapint, S. & Sridith, K. (2007) *Thismia alba* (Thismiaceae), a new record for Thailand. *Thai Forest Bulletin* 35: 34–37.
- Chiang, P.Y. & Hsieh, T.H. (2011) *Thismia huangii* (Thismiaceae), a new species from Taiwan. *Taiwania* 56: 138–142.
[http://dx.doi.org/10.6165/tai.2011.56\(2\).138](http://dx.doi.org/10.6165/tai.2011.56(2).138)
- Dančák, M., Hroneš, M., Sochor, M., Koblrova, L. & Hedl, R. (2013) A new species of *Thismia* (Thismiaceae) from Brunei Darussalam, Borneo. *Phytotaxa* 125: 33–39.
<http://dx.doi.org/10.11646/phytotaxa.125.1.5>
- Delin, W., Dianxiang, Z. & Saunders, R.M.K. (2010) Burmanniaceae. In: Wu, Z.Y., Raven, P.H. & Hong, D.Y. (eds.), *Flora of China*, 23. Science Press and Missouri Botanical Garden, Beijing and St. Louis, pp. 121–124.
- Don, D. (1825) *Prodromus Florae Nepalensis*. J. Gale, London, 256 pp.
- Forster, J.R. & Forster, G. (1775) *Tacca*. *Characteres Generum Plantarum* 35: 69–70.
<http://dx.doi.org/10.5962/bhl.title.4448>
- Govaerts, R., Saunders, R.M.K., Maas-van de Kamer, H., Maas-van de Kamer, P. & Zhang, D.X. (2011) *World checklist of Burmanniaceae*. Kew: Royal Botanic Gardens. Available from: <http://apps.kew.org/wcsp/> (accessed: 04 April 2014).
- Griffith, W. (1844) On the root parasites referred by authors to Rhizantheae, and their allies. *Proceedings of the Linnean Society of London* 1: 221–223.
- Hatusima, S. (1976) Two new species of Burmanniaceae from Japan. *Journal of Geobotany* 24: 2–10.
- Ho, G.W., Mar, S.S. & Saunders, R.M.K. (2009) *Thismia tentaculata* (Burmanniaceae tribe Thismieae) from Hong Kong: first record of the genus and tribe from continental China. *Journal of Systematics and Evolution* 47: 605–607.
<http://dx.doi.org/10.1111/j.1759-6831.2009.00037.x>
- Jonker, F.P. (1938) A monograph of the Burmanniaceae. *Mededeelingen van het Botanisch Museum en Herbarium van de Rijks Universiteit te Utrecht (Utrecht)* 51: 1–279.
- Jonker, F.P. (1948) Burmanniaceae. In: van Steenis, C.G.G.J. (ed.) *Flora Malesiana* I (4): 12–26. Leiden.
- Kiew, R. (1999) *Thismia goodii* (Burmanniaceae), the blue-capped *Thismia*, a new species from Borneo. *Gardens' Bulletin Singapore* 51: 179–182.
- Larsen, K. (1965) Studies in the Flora of Thailand 27. Thismiaceae. *Dansk Botanisk Arkiv* 23: 169–174.
- Larsen, K. (1987) Thismiaceae. In: Smitinand, T. & Larsen, K. (eds.), *Flora of Thailand*, 5(1). Chutima Press, Bangkok, pp. 124–126.
- Larsen, K. & Averyanov, L.V. (2007) *Thismia annamensis* and *Thismia tentaculata*, two new species of Thismiaceae from central Vietnam. *Rheedea* 17: 13–19.
- Li, H.-Q. & Bi, Y.K. (2013) A new species of *Thismia* (Thismiaceae) from Yunnan, China. *Phytotaxa* 105: 25–28.
<http://dx.doi.org/10.11646/phytotaxa.105.1.4>
- Lindley, P. (1857) Contributions to the orchidology of India. No. 1. *Journal of the Proceedings of the Linnean Society of London. Botany* 1: 170–190.
<http://dx.doi.org/10.1111/j.1095-8339.1857.tb02444.x>
- Maas, P.J.M., Maas-van de Kamer, H., van Benthem, J., Snelders, H.C.M. & Rübsamen, T. (1986) Burmanniaceae. *Flora Neotropica*

Monograph 42: 1–189.

- Maas-Van de Kamer, H. (1998) Burmanniaceae. In: Kubitzki, K. (ed.) *Families and genera of vascular plants, Vol. 3: Monocotyledons, Lilianae (except Orchidaceae)*. Springer, Berlin, Heidelberg, New York, pp. 154–164.
- Merckx, V., Bakker, F.T., Huysmans, S. & Smets, E. (2009) Bias and conflict in phylogenetic inference of myco-heterotrophic plants: a case study in Thismiaceae. *Cladistics* 25: 64–77.
<http://dx.doi.org/10.1111/j.1096-0031.2008.00241.x>
- Merckx, V. & Bidartondo, M.I. (2008) Breakdown and delayed cospeciation in the arbuscular mycorrhizal mutualism. *Proceedings of the Royal Society B: Biological Sciences* 275: 1029–1035.
<http://dx.doi.org/10.1098/rspb.2007.1622>
- Merckx, V.S.F.T., Freudenstein, J.V., Kissling, J., Christenhusz, M.J.M., Stotler, R.E., Crandall-Stotler, B., Wickett, N., Rudall, P.J., Maas-van de Kamer, H. & Maas, P.J.M. (2013) Taxonomy and classification. In: Merckx, V.S.F.T. (ed.) *Mycoheterotrophy: The biology of plants living on fungi*. Springer Science+Business Media, New York, pp. 19–101.
http://dx.doi.org/10.1007/978-1-4614-5209-6_2
- Merckx, V., Huysmans, S. & Smets, E. (2010) Cretaceous origins of mycoheterotrophic lineages in Dioscoreales. In: Seberg, O., Petersen, G., Barfod, A.S. & Davis, J. (eds.) *Diversity, phylogeny, and evolution in the monocotyledons*. Aarhus University Press, Denmark, pp. 39–53.
- Merckx, V., Schols, P., Maas-van de Kamer, H., Maas, P., Huysmans, S. & Smets, E. (2006) Phylogeny and evolution of Burmanniaceae (Dioscoreales) based on nuclear and mitochondrial data. *American Journal of Botany* 93: 1684–1698.
<http://dx.doi.org/10.3732/ajb.93.11.1684>
- Merckx, V.S.F.T. & Smets, E.F. (2014) *Thismia americana*, the 101st anniversary of a botanical mystery. *International Journal of Plant Sciences* 175: 165–175.
<http://dx.doi.org/10.1086/674315>
- Mueller, F. (1890) Descriptions of new Australian plants, with occasional other annotations. *Victoria Naturalist* 7: 114–116.
- Pfeiffer, N.E. (1914) Morphology of *Thismia americana*. *Botanical gazette* 57: 122–135.
<http://dx.doi.org/10.1086/331235>
- Pham Hoang Ho (2000) Thismiaceae. *Cay co Viet Nam (An Illustrated Flora of Vietnam)*, vol. 3: 759. Youth Publishing House, Ho Chi Minh City, Vietnam.
- Schlechter, R. (1921) Die Thismieae. *Notizblatt des Botanischen Gartens und Museums zu Berlin-Dahlem* 8: 31–45.
<http://dx.doi.org/10.2307/3994508>
- Seidenfaden, G. (1975) Contributions to the orchid flora of Thailand IV. *Botanisk Tidsskrift* 70: 64–97.
- Smith, J.J. (1910) I. Zur Systematik von *Thismia javanica* J.J.Sm. *Annales du Jardin Botanique de Buitenzorg* 23: 32–35.
- Stevens, P.F. (2001 onwards) *Angiosperm Phylogeny Website*. Version 13. Available from: <http://www.mobot.org/MOBOT/research/APweb/> (accessed: 27 January 2014).
- Stone, B.C. (1980) Rediscovery of *Thismia clavigera* (Becc.) F.v.M. (Burmanniaceae). *Blumea* 26: 419–425.
- Takhtajan, A.L. (2009) *Flowering Plants*. 2nd ed. Springer, New York, 871 pp.
<http://dx.doi.org/10.1007/978-1-4020-9609-9>
- Thiele, K.R. & Jordan, P. (2002) *Thismia clavarioides* (Thismiaceae), a new species of fairy lantern from New South Wales. *Telopea* 9: 765–771.
- Truong, L.H., Tich, N.T., Gioi, T., Diep, D.Q., Long, V.N., Bach, N.L.X., Dung, N.T.T. & Trung N.T. (2014) *Thismia okhaensis* (Thismiaceae)—a new fairy lantern from Vietnam. *Phytotaxa* 164: 190–194.
<http://dx.doi.org/10.11646/phytotaxa.164.3.4>
- Tsukaya, H. & Okada, H. (2005) *Thismia mullerensis* (Burmanniaceae), a new species from Muller Range, central Kalimantan. *Acta Phytotaxonomica et Geobotanica* 56: 129–133.
- Tsukaya, H. & Okada, H. (2012) A new species of *Thismia* (Thismiaceae) from West Kalimantan, Borneo. *Systematic Botany* 37: 53–57.
<http://dx.doi.org/10.1600/036364412x616639>
- Yang, S.Z., Lin, J.S. & Hsu, C.J. (2010) Morphological characteristics of flower and seed coat of the endangered species of *Thismia taiwanensis* (Burmanniaceae). *Taiwania* 55: 78–81.
- Yang, S.Z., Saunders, R.M. & Hsu, C.J. (2002) *Thismia taiwanensis* sp. nov. (Burmanniaceae tribe Thismieae): first record of the tribe in China. *Systematic Botany* 27: 485–488.
- Yokoyama, J., Koizumi, Y., Yokota, M. & Tsukaya, H. (2008) Phylogenetic position of *Oxygyne shinzatoi* (Burmanniaceae) inferred from 18S rDNA sequences. *Journal of Plant Research* 121: 27–32.
<http://dx.doi.org/10.1007/s10265-007-0136-6>