



# *Thismia* (*Thismiaceae*): the first record of the mycoheterotrophic genus to the Flora of India with a new species revealing the phytogeographical significance of Western Ghats

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## Key words

Kerala  
mycoheterotrophy  
*Thismia*  
Western Ghats

**Abstract** *Thismia*, a genus of mycoheterotrophic plants, is reported for the first time from mainland India, from Neryamangalam forests in Idukki district of Kerala, along with a new species, *T. sahyadrica*. *Thismia sahyadrica*, described and illustrated here, is unique within *Thismia* in having a mitre with a single opening; five perianth lobes are fused into a mitre-like structure, while the sixth one is free, forming a lateral single opening of the flower. Due to its unique morphological characteristics, the taxonomic placement of the new species remains obscure, although some root and flower characters suggest an affinity with species from the sections *Glaziocharis*, *Sarcosiphon*, *Geomitra*, and *Scaphiophora*. Ecological specificity and phytogeographical peculiarities of the new species are also discussed.

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## INTRODUCTION

*Thismia* Griff. is a genus of mycoheterotrophic plants of the family *Thismiaceae* with a total of over 60 species mainly distributed in tropical America and Asia, with a few representatives in subtropical and temperate Asia, Australasia, and North America (Jonker 1938, Campbell 1968, Woodward et al. 2007, Cowie & Liddle 2016). According to Jonker (1948), the genus has two main centres of diversity, namely the Atlantic Rain Forest of South America, and Southeast Asia. In spite of intensive floristic studies conducted in erstwhile and modern India (Beddome 1869–1874, Wight 1838–1853, Hooker 1872–1897, Gamble 1915–1936, Hajra 1988, Nayar et al. 2014, Sasidharan 2014), this genus remained unknown from the mainland India. During floristic exploration in the Idukki district of Kerala, which falls under the Anamalai phytogeographical region of the Western Ghats, we have collected a mycoheterotrophic species in the humus-rich soil in a patch of evergreen forest at medium elevation. After critical examination, it turned out to be an undescribed species of *Thismia*. We therefore report this finding as the first record of the genus from India and describe it as a new species here.

Morphologically, the genus *Thismia* is characterized a reduced habit with scale-like leaves, and actinomorphic or rarely zygomorphic, urceolate to campanulate flowers. There are six perianth lobes, usually free or sometimes three inner lobes connivent at the apex forming an erect mitre with three openings (Jonker 1948). Uniquely for the genus, the new species has a mitre with only one opening, which is the major distinguishing character of the new species from other known species.

## *Thismia sahyadrica* Sujanapal, Robi & Dantas, sp. nov. — Fig. 1, 2

*Thismia sahyadrica* differs from all other species of *Thismia* in having a mitre with a single opening; it is further characterized by a brownish hypanthium, greenish yellow perianth lobes, a yellow ovary, and two fused outer perianth lobes and spreading third one. — Type: A.J. Robi & K.J. Dantas 28097 (holotype KFRI; isotypes CALI, K, L, MH), India, Kerala, Idukki dist., Neryamangalam, ± 500 m, 14 July 2014.

**Etymology.** The specific epithet '*sahyadrica*' refers to the Sahyadri Hills—Western Ghats, where the type locality of the species is located.

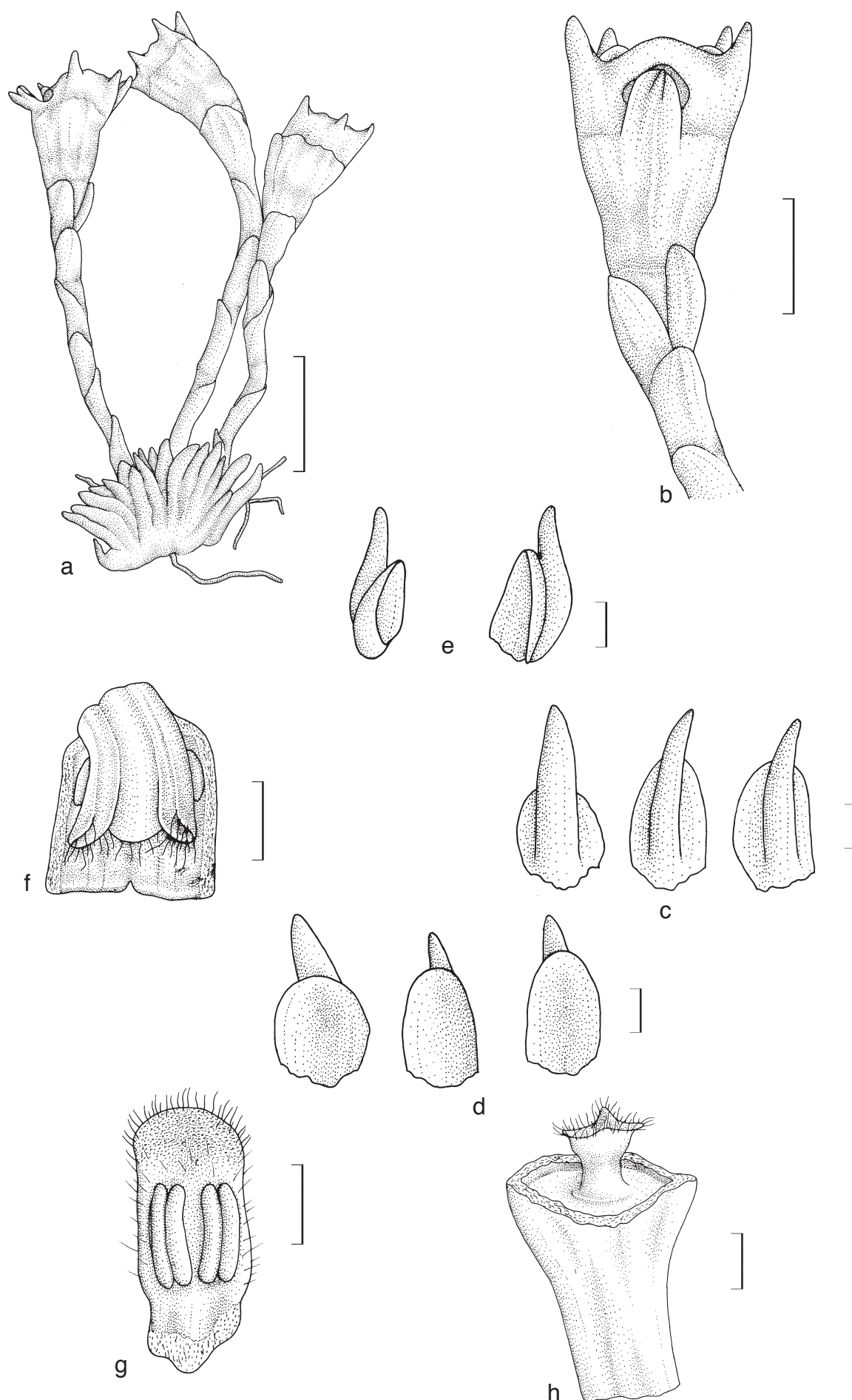
Terrestrial, achlorophyllous, mycoheterotrophic herb, c. 6 cm high. *Roots* vermiform, clustering at the base of stem, thick, unbranched, fleshy, puberulent, creamy-white, patent. *Stem* erect or slightly curved, simple, creamy-white or whitish, puberulent, 2–5 cm tall. *Leaves* scale-like, few, c. 6 by 2 mm, appressed, triangular-ovate to lanceolate, translucent, apex acute or acuminate. *Involucral bracts* 1–3, similar in shape to the leaves, c. 7 by 2–3 mm, obtuse or irregularly shaped at apex. *Flowers* solitary, terminal; perianth actinomorphic with 6 tepals, 5 of them fused into a mitre-like structure, the 6th tepal free and leaving a lateral aperture; tepals greenish yellow, c. 2–2.5 mm long, ovate, obtuse at apex, densely silky-puberulent outside; a horn-like appendage is attached to the dorsal side of each perianth lobe, all 6 appendages are free and upwardly pointing, with blunt apex, puberulent; hypanthium c. 1.5–2.0 cm long, obconical, faintly 6-ribbed, brownish with lower part usually yellow, greenish yellow at the apex, annulus prominent; inner surface of the perianth tube with 6 faint longitudinal ribs. *Stamens* 6, borne on thickened margin of the perianth tube; filaments curved downwards, connective broad, connate to form a hexagonal tube, sparsely silky-villous at base and outside the filament tube; anthers 1 mm long, straight or slightly curved, whitish. *Stigma* 3-lobed, lobes short, apex tufted with long hairs; style short, whitish, glandular hairy; ovary inferior, triangular, yellow to creamy-white, glabrous. *Fruit* a capsule, cup-shaped, dehiscing apically, brown, fleshy. *Seeds* ellipsoid.

Flowering & Fruiting — June to July.

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**Fig. 1** *Thismia sahyadrica* Sujanapal, Robi & Dantas. a. Habit; b. flower enlarged; c. outer view of tepals; d. inner view of tepals; e. lateral view of tepals with appendage; f. inner of pendulous stamens and annulus; g. anther with connective; h. gynoecium with short style and papillose stigma — Scale bars: a–b = 1 cm; c–h = 1 mm. — Drawing by E. Sanoj.

**Habitat & Ecology** — *Thismia sahyadrica* is a non-photosynthetic ephemeral herb, appearing briefly to flower and fruit after a period of heavy showers during the monsoon, only in the months of June and July. It is unclear whether they regenerate from seeds or stay dormant below-ground between periods of flowering. A total of 35 flowering individuals of *Thismia* were found on three locations within one square km. Representatives of the new taxon grow in humus-rich undisturbed forest soil in medium elevation tropical wet evergreen forest interspersed with small rocky boulders with rich lichen and moss cover. The terrain is undulating and sloped. Litter insects, molluscs, annelids, etc. are common. *Dysoxylum malabaricum* Bedd. ex C.DC. (*Meliaceae*) is a dominant tree in the upper stratum. *Syzygium gardneri* Thwaites (*Myrtaceae*) is also common. *Drypetes malabarica* (Bedd.) Airy Shaw, *Dimorphocalyx glabellus* Thwaites var. *lawianus* (Hook.f.) Chakrab. & N.P.Balakr. (*Euphorbiaceae*), *Dimocarpus longan* Lour. (*Sapindaceae*), *Ochlandra travancorica* (Bedd.) Benth. ex Gamble (*Poaceae*), and *Holigarna arnottiana* Hook.f. (*Anacardiaceae*) are the other major trees in the middle and lower stratum. Herbaceous and shrubby vegetation is very sparse. Light penetration through the tree canopy is very poor, probably due to the thick canopy. Seasonal rivulets are seen in the area, which finally drain to the Periyar river.

Major macrofungi identified from the habitat are *Coprinus disseminatus* (Pers.) Gray, *Lepiota clypeolaria* (Bull.) P.Kumm., *Leucoagaricus rubrotinctus* Singer, *Leucocoprinus cepistipes* (Sowerby) Pat., *Amanita angustilamellata* (Höhn.) Boedijn, *Marasmius haematocephalus* (Mont.) Fr., *Filoboletus manipularis* (Berk.) Singer, *Ramaria cokeri* R.H.Petersen, and *Ramaria* sp. Among these, *Ramaria* sp. is often found associated with the new species. Microfungi identified from the habitat are *Absidia* sp., *Aspergillus niger* Tiegh., *Cladosporium cladosporioides* (Fresen.) G.A.de Vries, *Fusarium oxysporum* Schldt., *Mucor racemosus* Fresen., *Penicillium* sp., *Rhizopus stolonifer* (Ehrenb.) Vuill., and *Trichoderma* sp.

Bryophytes recorded from the surface of rocks and bark of the trees in the habitat are *Frullania muscicola* Steph., *Aerobryum speciosum* (Dozy & Molk.) Dozy & Molk., *Meteoriopsis squarrosa* (Hook. ex Harv.) M.Fleisch., *Erythrodontium julaceum* (Hook. ex Schwägr.) Paris, *Entodon laetus* (Griff.) A.Jaeger, *Asterella khasiana* (Griff.) Grolle, *Targionia hypophylla* L., *Cephaloziella kiaeri* (Austin) S.W.Arnell, *Fossombronina cristula* Austin, *Anoetangium bicolor* Renauld & Cardot, *Bryum argenteum* Hedw., *Ptychostomum pseudotriquetrum* (Hedw.) J.R.Spence & H.P.Ramsay ex Holyoak & N.Pedersen, *Groutiella tomentosa* (Hornsch.) Wijk & Margad., and *Macromitrium sulcatum* (Hook.) Brid.

As the soil is an important component in the ecosystem, especially for the ephemeral flora, soil parameters were also analysed for the three locations. Generally, the soil belongs to the order inceptisols. The soil is loamy sand in texture (sand - 87 %, silt - 7 %, clay - 6 %). The pH of the soils were determined in 1 : 2.5 (soil : water) suspension and the soils were found to be strongly acidic, medium in organic carbon, low in available nitrogen, high in available phosphorus and medium in available potassium (Table 1).

**Table 1** Basic soil parameters in the habitats of *Thismia sahyadrica*.

Location No	pH	Organic Carbon (%)	Available Nitrogen (kg/ha)	Available Phosphorus (kg/ha)	Available Potassium (kg/ha)
1	5.36	1.26	206.45	62.63	148.61
2	5.39	1.31	184.61	54.82	110.57
3	5.31	1.05	235.09	63.59	130.27
<b>Mean</b>	<b>5.35</b>	<b>1.21</b>	<b>208.72</b>	<b>60.35</b>	<b>129.82</b>

Though the associated species and edaphic factors in the habitat were assessed, most of the available information on the ecology is anecdotal; the reproductive biology and life-cycle of the new species are poorly understood.

**Distribution & Phytogeography** — The new species is so far known only from the type locality at Neryamangalam forest in the Idukki district of Kerala, India. Phytogeographically, this area is part of the southern division of Western Ghats. Among the three subdivisions of southern Western Ghats (Nayar 1996), this location falls in the windward region of the Anamalai High Ranges, which is the central and broader ( $\pm 210$  km) subdivision situated immediately south of the Palghat Gap. The striking feature of the windward region of the Anamalai High Ranges is the high altitudinal gradient from 100–2695 m above sea level and formation of dense tropical evergreen forests as a major forest type dominated by *Dipterocarpus*, *Syzygium*, and *Cinnamomum* in the upper stratum with a wide range of species composition based on the elevation. The associated habitats in the region include moist deciduous forests, semi-evergreen forests and broad-leaved hill forests mainly along the medium and lower altitudes and shola forests - montane grasslands at higher elevations. Each major forest type in the area is composed of several edaphic types.

The family *Thismiaceae* is represented in the Western Ghats by *Haplothismia*, an extremely rare monotypic genus endemic to Parambikulam Wildlife Sanctuary (Sasidharan & Sujanalpal 2000). *Thismia sahyadrica* is the first record of the genus *Thismia* in the Western Ghats and together with a Sri Lankan endemic *T. gardneriana* Hook.f. ex Thwaites represents the only two species of *Thismia* known from the Indian subcontinent (Jonker 1938). The new species highlights the broad distribution of the genus. The biogeographic history of *Thismia*, however, is obscure. The genus is widespread in tropical America and Southeast Asia, but absent from Africa and Madagascar. Although the affinities of *T. sahyadrica* remain unclear, morphology suggests that the species is closely related to other Paleotropical species of *Thismia*. In that respect, the new species represents a range expansion of the genus in the Paleotropics (Map 1).

The Western Ghats – Sri Lanka biodiversity hotspot is among the eight hottest biodiversity hotspots on Earth, featuring exceptional concentrations of endemic species and experiencing exceptional loss of habitat (Myers et al. 2000). Apart from the newly reported species of *Thismia* in this region, out of nine other mycoheterotrophic taxa so far known from the Western Ghats – Sri Lanka hotspot, five were found nowhere else within the region and habitat (Hajra 1988, Govaerts et al. 2007, Nayar et al. 2014), indicating a high degree of endemism for mycoheterotrophic species in this region.

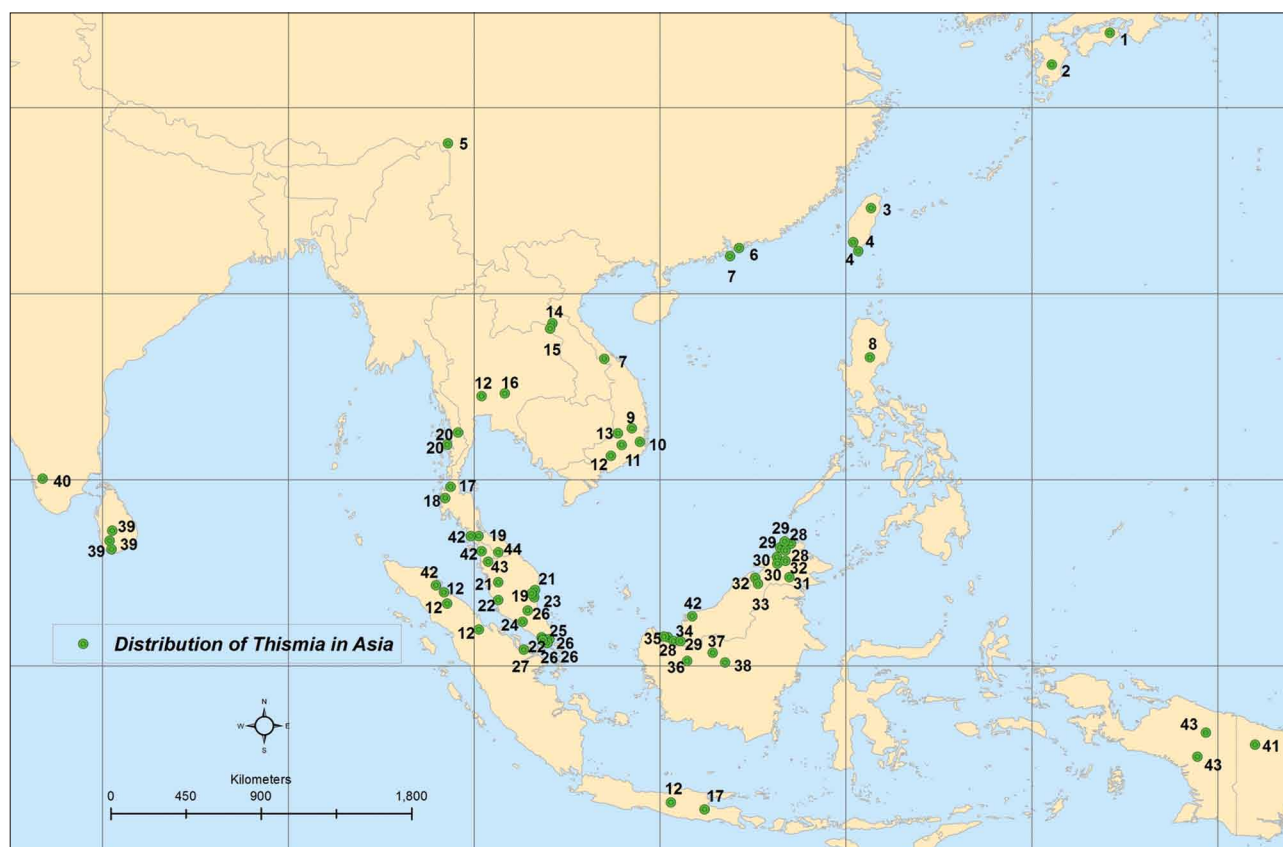
**Conservation status** — All the known occurrences of the new taxon are restricted to medium elevation evergreen forest and all are close to human settlements. This may lead to habitat loss. Most mycoheterotrophs cannot be cultivated (Merckx et al. 2013) which means that in-situ conservation is currently the only effective and practically viable method for the conservation of this species. Hence the locality needs to be protected from anthropogenic disturbances; also restrictions should be laid down for the road widening and other constructions in adjacent areas, as the State Highway is passing through these forest areas. These forests are only having the status of reserve forests, not of Protected Areas, hence special programmes should be formulated for the conservation of the species and its habitat. The current information on its distribution shows that the area of occupancy and extent of occurrence of the species both are less than 10 km<sup>2</sup>. Therefore, the species should be considered





**Fig. 2** *Thismia sahyadrica* Sujanapal, Robi & Dantas. a. Habitat; b–c. habit; d. young flowers; e. plants with flowers; f. flowers enlarged with pedicel and bract; g. outer view of tepals; h. inner and lateral view of tepals; i. hypanthium with lateral opening; j. longitudinal section of hypanthium together with annulus and stamen tube; k. stamens with connective; l. gynoecium with short style and papillose stigma. — Scale bars: g–h, j = 5 mm; i = 1 cm; k = 3 mm; l = 2 mm. — Photos by A.J. Robi.





**Map 1** Distribution of *Thismia* in Asia (Compiled from Govaerts et al. 2007, Larsen & Averyanov 2007, Chantanaorrapint 2008, 2012, Chiang & Hsieh 2011, Tsukaya & Okada 2012, Merckx et al. 2013, Dančák et al. 2013, Li & Bi 2013, Truong et al. 2014, Nuraliev et al. 2014, 2015, Mar & Saunders 2015, Hroneš et al. 2015, Chantanaorrapint & Sridith 2015, Chantanaorrapint et al. 2016).

1 - *Thismia abei* (Akasawa) Hatus.; 2 - *T. tuberculata* Hatus.; 3 - *T. huangii* P.Y.Jiang & T.H.Hsieh; 4 - *T. taiwanensis* Sheng Z.Yang, R.M.K.Saunders & C.J.Hsu; 5 - *T. gongshanensis* Hong Qing Li & Y.K. Bi; 6 - *T. hongkongensis* Mar & R.M.K.Saunders; 7 - *T. tentaculata* K. Larsen & Aver.; 8 - *T. gigantea* (Jonker) Hroneš; 9 - *T. mucronata* Nuraliev; 10 - *T. okhaensis* Luu, Tich, G.Tran & Dinh; 11 - *T. annamensis* K.Larsen & Aver.; 12 - *T. javanica* J.J.Sm.; 13 - *T. puberula* Nuraliev; 14 - *T. mirabilis* K.Larsen; 15 - *T. angustimitra* Chantanaorr.; 16 - *T. filiformis* Chantanaorr.; 17 - *T. clandestina* (Blume) Miq.; 18 - *T. nigricans* Chantanaorr. & Sridith; 19 - *T. alba* Holtum ex Jonker; 20 - *T. brunonis* Griff.; 21 - *T. arachnites* Ridl.; 22 - *T. fumida* Ridl.; 23 - *T. racemosa* Ridl.; 24 - *T. chrysops* Ridl.; 25 - *T. grandiflora* Ridl.; 26 - *T. aseroe* Becc.; 27 - *T. labiata* J.J.Sm.; 28 - *T. ophiuris* Becc.; 29 - *T. episcopalis* (Becc.) F.Muell.; 30 - *T. goodii* Kiew; 31 - *T. hexagona* var. *grandiflora* Tsukaya; 32 - *T. hexagona* Dančák, Hroneš, Kobrlová & Sochor; 33 - *T. brunneomitra* Hroneš; 34 - *T. bifida* M.Hotta; 35 - *T. neptunis* Becc.; 36 - *T. betung-kerihunensis* Tsukaya & H.Okada; 37 - *T. lauriana* Jarvie; 38 - *T. mullerensis* Tsukaya & H.Okada; 39 - *T. gardneriana* Hook.f. ex Thwaites; 40 - *T. sahyadrica* Sujanapal, Robi & Dantas; 41 - *T. appendiculata* Schltr.; 42 - *T. clavigera* (Becc.) F.Muell.; 43 - *T. crocea* (Becc.) J.J.Sm.; 44 - *T. claviformis* Chantanaorr. & J.Wai.

as Critically Endangered (CR) according to the IUCN Red List Categories and Criteria (IUCN 2012).

**Additional specimens examined (Paratype).** INDIA, Kerala, Idukki dist., Nerymangalam, Kulamankuzhikudi, A.J. Robi & M. Sumod 28096 (KFRI), c. 500 m, 26 June 2014.

**Taxonomic notes** — *Thismia sahyadrica* is unique in the genus by having a mitre with a single opening. Mitre-bearing species of *Thismia* are found in the sections *Pyramidalis*, *Rodwaya*, *Sarcosiphon*, *Glaziocharis*, *Geomitra*, and *Scaphiophora* (Merckx & Smets 2014). The relatively short, thick, unbranched roots of the new species show similarities with species in the sections *Sarcosiphon*, *Geomitra*, and *Scaphiophora*, which have short coralloid roots (except for *T. mirabilis* and *T. angustimitra*). On the other hand, both the single free and five fused tepals of *T. sahyadrica* have short filiform appendages, a characteristic that is only present in the section *Glaziocharis*. Therefore, until further molecular phylogenetic studies are undertaken the taxonomic affinities of *T. sahyadrica* remain obscure.

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