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A note on *Sapria himalayana* Griff. (Rafflesiaceae) from Jaintia Hills (Meghalaya, India)

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ABSTRACT A total of 19 flowers belonging to the genus *Sapria* Griff. (Rafflesiaceae) were discovered in a small forest tract on the Songket Hill, near the village of Tangnub, Meghalaya, India. The flowers, colored deep red with yellow warts, grew individually or in groups of three to five. They were in different stages of development even when growing on the same host plant. Further taxonomical determinations on a male specimen have shown that the flowers belong to *Sapria himalayana* Griff., a rare and endangered species included in the Red Data Book of the Botanical Survey of India. The population size of *S. himalayana* on the Songket Hill is small and may be affected by human activity.

KEY WORDS Endangered species; holoparasite; Meghalaya, India; *Sapria himalayana*.

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INTRODUCTION

Sapria Griff. is one of three genera belonging to the family of Rafflesiaceae, in which all members are holoparasites and grow on various species of *Tetrastigma* (Vitaceae) (Wu & Raven, 2003; Nikolov & Davis, 2017). At present, the genus *Sapria* contains four species: *S. himalayana* Griff., which has the most extensive growth range (Wu & Raven, 2003; Bendiksby et al., 2010), *S. poilanei* Gagnep. from Cambodia (Gagnepain et al., 1941), *S. ram* H. Bänziger & B. Hansen from Thailand (Bendiksby et al., 2010), and *S. myanmarensis* Nob. Tanaka, Nagam, Tagane & M.M. Aung from Myanmar (Tanaka et al., 2019). All species are dioecious, are narrowly host-specific and completely dependent on their host plant for their growth and nutrition, as they do not have any vegetative parts and chlorophyll (Davis & Wurdack, 2004). Their sexual reproduction is dependent on pollination by carrion flies and seed dispersion probably by rodents (Bendiksby et al., 2010; Nikolov & Davis, 2017).

Sapria himalayana was first described by the British botanist William Griffith (1844) from the evergreen forests of Mishmi Hills, Lohit district (Arunachal Pradesh, NE India) and is a rare species throughout its range from Northeastern India to Southwestern China, Thailand and Vietnam (Wu & Raven, 2003; Trần et al., 2019). It was also reported from Assam, Manipur, and Meghalaya (Bor, 1938; Arunachalam et al., 2004). However, recently it has been asserted (Borah & Ghosh, 2018; Ahmad et al., 2020) that all current locations of this plant in India might be in Arunachal Pradesh, where it is also best documented (Arunachalam et al., 2004; Hohl & Sebastian, 2014). The International Union for Conservation of Nature (IUCN) has included *S. himalayana* in the Red List of Threatened

Species as a rare and endangered species in India and at the global level.

Here we report the finding of *S. himalayana* in a forest on Songket hill, South east of Tangnub village during surface reconnaissance in a caving expedition carried out in the East Jaintia Hills District of Meghalaya, India (2–16 January 2020). On 7th January 2020, 19 *S. himalayana* individuals were sighted at one location and one of them, fully flowered, was collected for further study.

MATERIAL AND METHODS

Study area

Meghalaya is a state in North-Eastern India covering a geographical area of 22,429 km^2. The state is predominantly an elevated plateau crossed by deep steep valleys, situated between the Brahmaputra valley and the Bangladesh plains. The general climate in the region is monsoonal, with pronounced seasonal rainfall and temperature variations. Due to its position as an elevated barrier in the path of the Southwest monsoon winds from the Bay of Bengal, its Southernmost regions (e.g., Mawsynram, Cherapunjee), at the edge of the Shillong Plateau, are considered the rainiest places on Earth, with values of over 12 m/year (Khan et al., 1997; Prokop & Walanus, 2003). However, the amount of rainfall varies strongly across the state: in Shillong, the capital of Meghalaya, the values reach about 2.3 m/yr (Khan et al., 1997), whereas areas further north, towards the state of Assam, receive only 1.6 m/yr (Prokop & Walanus, 2003). The variations in altitude, humidity and temperature in Meghalaya have contributed to the rich floral diversity due to which it was designated as an Indo-Burmese Biodiversity hotspot. Out of ca. 3,331 plant species inventoried in the state, 1,236 are considered endemic (Khan et al., 1997).

The *S. himalayana* individuals were discovered in the region of the Tangnub village (Latitude 25°18’10’’ N, Longitude 92°30’00’’E, altitude 1100 m a.s.l.), ca. 20 km south-east of Khliehriat, East Jaintia Hills. The site is located on the western side of the Songket hill (Fig. 1), a northeast-facing spur of the Nongkhlieh Ridge, with a base of about 2 km long and 1.5 km wide. The crest is at 1240 m a.s.l., while the base is at 870 m asl. The higher parts, down to around ca. 950 m a.s.l., consist of

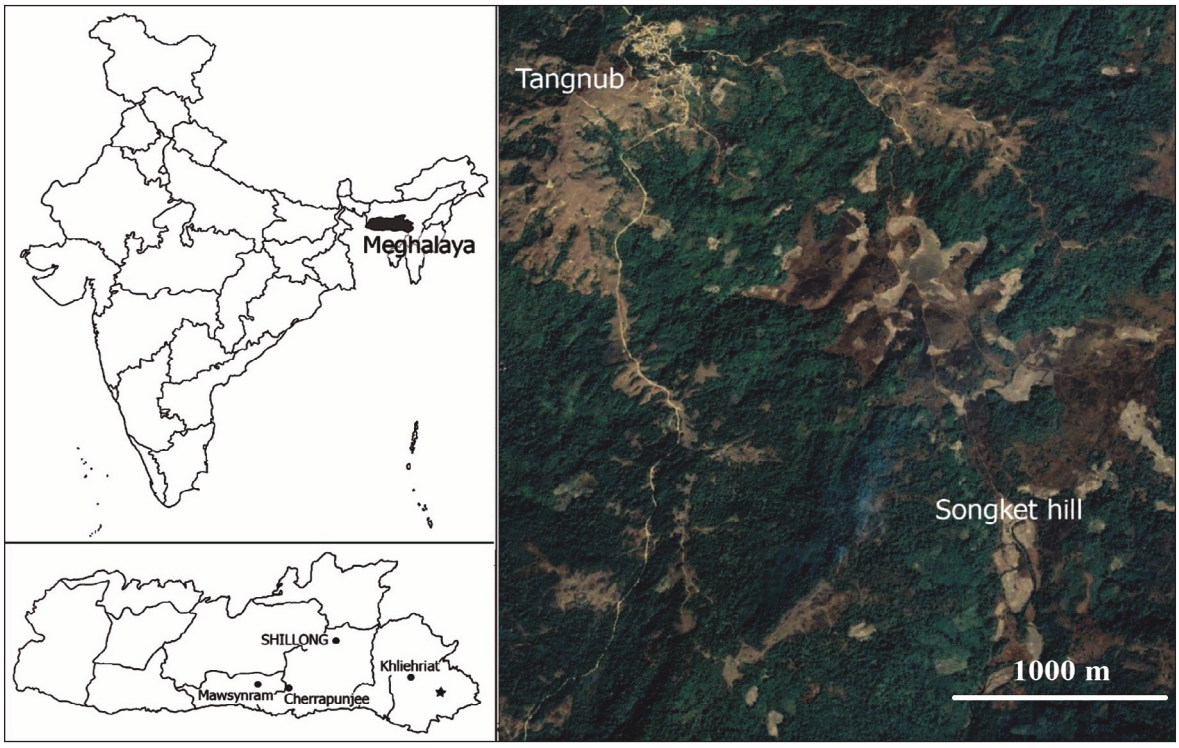

Figure 1. Location map of Songket Hill (star) in East Jaintia Hills, Meghalaya, NE India (d-maps.com). Tangnub - Songket Hill area current vegetation cover (jungle tracts and farming areas) (Google maps).

farms (meadow type) with clusters of trees and shrubs. From 950 a.s.l. to 870 a.s.l., the NE and SE of the hill are covered with a moderately dense forest. The farming type practiced by the people of Tangnub are shifting ("jhum") cultivation, rice cultivation and home gardens.

Geologically, the caprock (ca. 1200 m a.s.l. to 1000 m a.s.l.) consists of Upper Eocene inter-bedded shales and sandstones of the Kopili formation (Matsumaru & Sarma, 2010). The location where *S. himalayana* was found is situated near the contact of the sandstones with the middle to upper Eocene Prang Limestone (Matsumaru & Sarma, 2010). The area is characterized by large sinkholes and pinnacle karst, with short joint- and rift- controlled canyons, tectonically broken-up and partly eroded. The environment surrounding the spot where the *S. himalayana* grows is well shaded with trees, bamboo, ferns, and banana trees which contribute to the necromass of the soil in the canyons and between the limestone pinnacles. The soil temperature, recorded at 2:00 pm on the 24th of January 2020, was found to be 11 ± 1 ^{o}C, and the ambient temperature was 15.7 ± 2 ^{o}C. *S. himalayana* grows as isolated individuals or in groups of three to five, along with the host plant. All the individuals observed at Songket were growing at the ground surface, within an area of approximately 10–15 m^2. The host plants which support the growth of *S. himalayana* are lianas of the genus *Tetrastigma*. The species of the host plant could not be determined completely at this stage and more research is needed to understand the morphology and taxonomy of the host plant in its natural habitat.

Description and identification

Specimen examined: *Sapria himalayana* from India, Meghalaya, East Jaintia Hills: Songket hill near Tangnub village, collected by Pynshailang Syiemiong on the 7th of January 2020. The specimen has been identified and incorporated in the Assam herbarium, registration bearing Coll. no.-PS01, Accession no. 96582. *Sapria himalayana* is a root parasite, related to one of the largest flowers in the world, *Rafflesia arnoldii* of Malaya (Lawrence, 1960). It is well distinguished and identified from its saucer shape of the perigone lobe that spreads out and recurves, and the colour, which is deep red with yellow warts (Hansen, 1973; Meijer, 1997) (Figs. 2, 3).

Sapria himalayana usually grows just above the ground on liana roots, and being a holoparasite species, they derive their nutrients, fixed carbon, and nitrogen from the host plants to support their growth (Arunachalam et al., 2004). The first stage of their growth which we noticed is a globose formation, with white and pink bracts (Fig. 4). The growth of the flowers is not uniform: at the moment of discovery, three were in the globose stage, four others already reached their full growth, while in two others the perigone lobe was only partially open (Fig. 5); ten of them were already decaying (Figs. 6, 7). From our observations, flowering occurs from the end of December to January and according to Adhikari et al. (2003), the flowers are in bloom only for 2–3 days.

Morphologically, the *S. himalayana* Griffith from Meghalaya has a floral span of 90 mm in diameter, smaller than the *S. himalayana* f. *albovinosa* (110–165 mm in diameter) (Bänziger et al., 2000) and *S. myanmarensis* (100 mm) (Tanaka, 2019), but larger

Morphological parts of *Sapria himalayana*	Code	Measurement (mm)
Basal bracts	A	36
Perigone lobe	B	90
Flower Diameter	C	90
Height of cupule at flower base	C"	17
Circumference of perigone tube at lobe base	D	220
Circumference of perigone tube at top base	D"	275
Perigone lobe width	E	20
Perigone lobe length	F	30
Diameter of the whole diaphragm	H	60
Height of the flower	H"	120
Width of the diaphragm collar	I	22
Width of the diaphragm aperture	J	30
Ramenta length	K	7
Height of perigone tube	L	45
Flange of ridge on the inner surface	N	50
Column	Q	10
Height of disk	S	16
Diameter of crest of the disk	T	30
Depth on the center of the disk	U	7
Depth on the side of the disk	U"	9

Table 1. Morphological descriptions of Sapria himalayana Griff. (Rafflesiaceae) from Songket Hill, Meghalaya.

Figures 2–7. *Sapria himalayana* Griff. (male) from Songket Hill, fully flowered, in top view (Fig. 2) and lateral view (Fig. 3). Fig. 4: flower in globose stage. Fig. 5: partially opened flower in a clump on dug liana root. Fig. 6: partially opened flower in a clump with two senescent ones. Fig. 7: group of 5 senescent individuals (inset: view from top). Photos 2–4 by T. Tămaş, 5–7 by P. Syiemiong.

than either *S. poilanei* (65–120 mm) or *S. ram* (55–110 mm) (Bänziger & Hansen, 1997). The ramenta apices of *S. himalayana* from Songket Hill have a shallow recess (male flower), while the Vietnamese taxon is also bi-lobed or multi-lobed (especially in female specimens), or crateriform (i.e., with a shallow recess, especially in males) (Bänziger & Hansen, 1997). The aperture of the diaphragm and the diameter of the crest disk for the Meghalayan individual are similar in size (30±2 mm in diameter), whereas for *S. himalayana* f. *albovinosa,* the aperture of the diaphragm is 14–21 mm, smaller than its crest disk

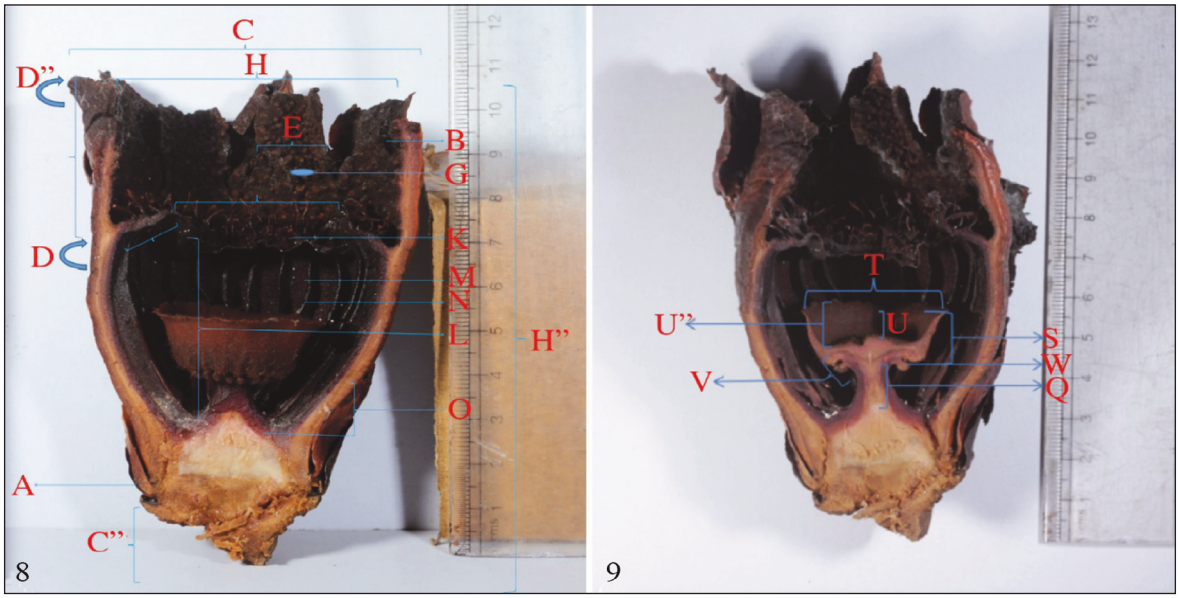

Figure 8. Longitudinal section of *Sapria himalayana* Griff. morphological parts with codes referred. A. Basal bracts, B. Perigone lobe, C. Flower diameter, C”. Height of cupule at flower base, D. circumference of perigone tube at lobe base, D”. Circumference of perigone tube at the top lobe, E. Perigone lobe width, F. Perigone lobe length, G. Wart, yellow spot on the inside of the lobe, H. Diameter of the whole diaphragm, H”. height of the flower, I. Width of the diaphragm collar, J. Width of diaphragm aperture, K. Ramenta length, L. height of perigone tube, M. Ridge on the inner surface of perigone tube, N. Flange of ridge on inner surface, O. Fusion area of perigone tube ridge, Q. Column, S. height of disk, T. Diameter of crest of the disk, U. Depth on the center of the disk, U”. Depth on the side of the disk, V. longitudinal strip of tissue bearing anther (in male).

(51–61 mm diameter) (Bänziger & Hansen, 1997). Other morphological descriptions of the *S. himalayana* from the Songket Hill are listed in detail in Table 1 and Fig. 8 with codes and measurements in millimeters (mm).

DISCUSSION AND CONCLUSIONS

Sapria himalayana is considered by various authors either as being on the brink of extinction due to habitat loss and human intervention (Arunachalam et al., 2004), endangered/threatened (Hohl & Sebastian, 2014), or “rare throughout its range and little understood” (Trần et al. 2019). In India, *Sapria* is considered rare (Nayar & Sastry, 1987) and the site where *S. himalayana* grows in Songket hill is facing disturbances from the locals who practice shifting cultivation, forest clearing, timber collection, firewood extraction and cattle grazing. The only other sighting of *Sapria* in Meghalaya in 2020 was on Nov. 21, 2020 in the Nokrek Biosphere Reserve, West Garo Hills District (Meghalaya Times, 2020), however the exact location was not disclosed to protect the flower from human interference. Whereas the West Garo Hills sighting of *Sapria* was in a Biosphere Reserve which receives a certain degree of protection, the existent threats to *S. himalayana* in Meghalaya are highly similar to the ones in the Namdapha National Park, Arunachal Pradesh (Arunachalam et al., 2004): the minute changes in the landscape and surroundings caused by those threats might create unfavourable effects for the microclimate of the area where *S. himalayana* grows. To conserve this threatened species, public awareness programs on protection of biodiversity should be organized for the local villagers, as well as regular monitoring from the State Forest Department and the Botanical Survey of India. The approach for the conservation and protection of *S. himalayana* should be ‘in situ’, by keeping its habitat in its natural condition, due to the difficulties related to the cultivation of such a host-specific parasite plant (Adhikari et al., 2003; Arunachalam et al., 2004). On the brighter side, the discovery of two new locations with flowering *Sapria* in Meghalaya within less than a year is a significant improvement on its status within a part of its limited range and may point to the existence of other undetected populations.

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