THE STATUS , ECOLOGY AND CONSERVATION OF SAPRIA HIMALAYANA GRIFF (RAFFLESIACEAE) IN THAILAND

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ABSTRACT

Sapria himalayana (Griff.) (Rafflesiaceae) is a parasitic plant, with spectacular red flowers about 20 cm across, which grows in the roots of lianas. The objectives of the study reported here were to determine the current status and distribution of *S. himalayana* in Thailand and to investigate its reproductive ecology to determine how best to conserve the species. I could confirm the continued survival of *S. himalayana* at one site in Chiang Mai Province and another in Mae Hong Sorn and received recent reports from Tak and Kanchanaburi. Host lianas were *Tetrastigma obovatum* (Laws.) Gagnep., *T. laoticum* Gagnep. and *T. cruciatum* Craib & Gagnep. (Vitaceae) in eveergreen forest at 1000-1450 m above sea level. After a developmental period of 100-123 days (99% c.l.), unisexual flowers (2.17 males per female) opened in September-April, with a peak (73.4%) in November-January. Flies may carry out pollination whilst seed dispersal may be effected by small rodents. Of 627 buds examined, 40% died before reaching maturity, mostly due to abortion. Mortality rates of malles and females were the same. *S. himalayana* is endangered with extinction. Sites where the plant grows should be better protected; collection or trade of the plant should be forbidden by law and attempts should be made to pollinate the flowers by hand and transfer seed to infect new hosts in the natural habitat.

การกระจาย สถานภาพและนิเวศวิทยาของ Sapria himalayana Griff. (Rafflesiaceae) ในประเทศไทย

Sapria himalayana (Griffith, 1845) วงศ์ Rafflesiaceae เป็นพืชเบียนดอกใหญ่สีแดง ขนาดเส้นผ่าศูนย์กลางถึง 20 เซนติเมตร ขึ้นอยู่ในรากของต้น lianas วัตถุประสงค์ของการศึกษานี้เพื่อการศึกษาสถานภาพและการกระจายของต้น S. himalayana ในประเทศไทย และศึกษานิเวศวิทยา การขยายพันธุ์เพื่อหาวิธีการอนุรักษ์พืชชนิดนี้ไว้

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พบพืชชนิดนี้ในเชียงใหม่ และแม่ฮ่องสอน รวมทั้งมีรายงานว่าพบที่ตากและกาญจนบุรี โดยจะขึ้นอยู่บนต้น lianas ชนิด Tetrastigma obovatum (Laws) Gagnep., T. laoticum Gagnep. และ T. cruciatum Craib & Gagnep ในวงศ์ Vitaceae ซึ่งพบในป่าดิบเขาที่ระดับความสูง 1000-1300 เมตร เหนือระดับน้ำทะเล ดอกของพืชนี้มีลักษณะเหมือนกันทั้งสองเพศ โดยมีอัตราส่วนดอกตัวผู้ต่อดอกตัวเมียเป็น 2.17 : 1 ดอกจะบานหลังจากการเจริญของดอก 99-122 วัน (ระดับความเชื่อมั่น 99%) ในช่วงเดือนกันยายนถึงเมษายน โดยบานมากที่สุดในเดือนพฤศจิกายน ถึงมกราคม (73.4%) แมลงวันจะเป็นตัวกระจายเกสร และ rodent ขนาดเล็กจะเป็นตัวกระจายเมล็ด จากการศึกษาตาดอก จำนวน 434 ตา พบว่า 40% จะตายไปก่อนที่จะเติบโตเต็มที่ สาเหตุส่วนใหญ่คือ แห้งตาย อัตราการตายของดอกตัวผู้และดอกตัวเมียก็เช่นเดียวกัน

ตามหลักเกณฑ์ของ IUCN Red Data Book S. himalayana เป็นพืชที่มีแนวโน้มสูญพันธุ์บริเวณที่พบพืชนี้สมควรที่จะได้รับการป้องกัน ควรมีกฎหมายห้ามเก็บและค้าพืชชนิดนี้ นอกจากนี้สมควรที่จะช่วยกันกระจายเกสรและเมล็ดไปยัง host ใหม่ในสภาพธรรมชาติ การที่นำพืชชนิดนี้มาเพาะเลี้ยงในสวนพฤกษศาสตร์ ยังไม่ประสบความสำเร็จ เนื่องจากการที่พืชนี้มีนิเวศวิทยาที่ซับซ้อน

INTRODUCTION

One of the most bizarre plant families must surely be the Rafflesiaceae. Not only does it include the world's largest flower (*Rafflesia arnoldii* R. Br., more than 1 m in diameter) but its species have evolved a specialized, parasitic way of life. They are incapable of photosynthesis and their vegetative tissus is reduced to microscopic filaments which absorb nutriment from the roots of host plants. In Thailand the family is represented by three species including *Sapria himalayana* Griff. The objectives of the study reported here were to determine the current status and distribution of *S. himalayana* in Thailand, investigate its reproductive ecology and determine suitable measures to conserve the species.

METHODS

The status and distribution of *S. himalayana* were determined from the literature, herbarium specimens and field surveys in Chiang Mai, Mae Hong Sorn and Ranong Provinces. At one site in Chiang Mai Province two colonies of *S. himalayana* were monitored intensively over 3

flowering seasons. At intervals of 1-2 weeks, the circumference of 627 labelled buds was measured at the widest point. Dates of bud opening or death and causes of mortality were recorded. Sex was determined after buds or flowers had died, by examining them for the presence of anthers. Insects emerging from flowers were collected for identification.

RESULTS AND DISCUSSION

S. himalayana was first described by W. Griffith (1845) from specimens he collected in 1836 from the Mishmee hills in the extreme east of Upper Assam where he claimed the species "occurred in abundance" at that time. Fig. 1 give some impression of the historical distribution of the species. The present day distribution has shrunk considerably due to loss of primary evergreen forest.

Most specimens in herbaria come from Thailand, where the species was first found in 1904 by Mackean and Hosseus in Chiang Mai Province. Their original specimens wer destroyed, but others from the same locality, collected by Dr. A.F.G. Kerr, were later described by HOSSEUS (1907) as new species, *Richthofenia siamensis* Hoss. Subsequently, however, this species was synonymised with *S. himalayana* STIRLING, 1939). Since then, 6 other localities for the species have been recorded in Thailand, all along the western border with Burma. During excursions in 1987-90 to several sites in Chiang mai, Mae Hong Sorn and Ranong Provinces, I could verify the survival of the species at only one site in Chiang Mai and another in Mae Hong Sorn. In Chiang Mai, 12 colonies, several kilometres apart, were found, whilst in Mae Hong Sorn, two very small colonies in close proximity were located. Therefore, from recent reports and my own observations, *S. himalayana* in Thailand is confined to the provinces of Chiang Mai, Mae Hong Sorn, Tak and Kanchanaburi (Fig. 1). Its continued existence in southern Thailand is uncertain.

All colonies found during the study parasitized the roots and lower stems of *Tetrastigma* spp : 5 on *T. cruciatum*, 5 on *T. laoticum* Gagnep. and 4 on *T. obovatum* Laws. All colonies grew in primary evergreen

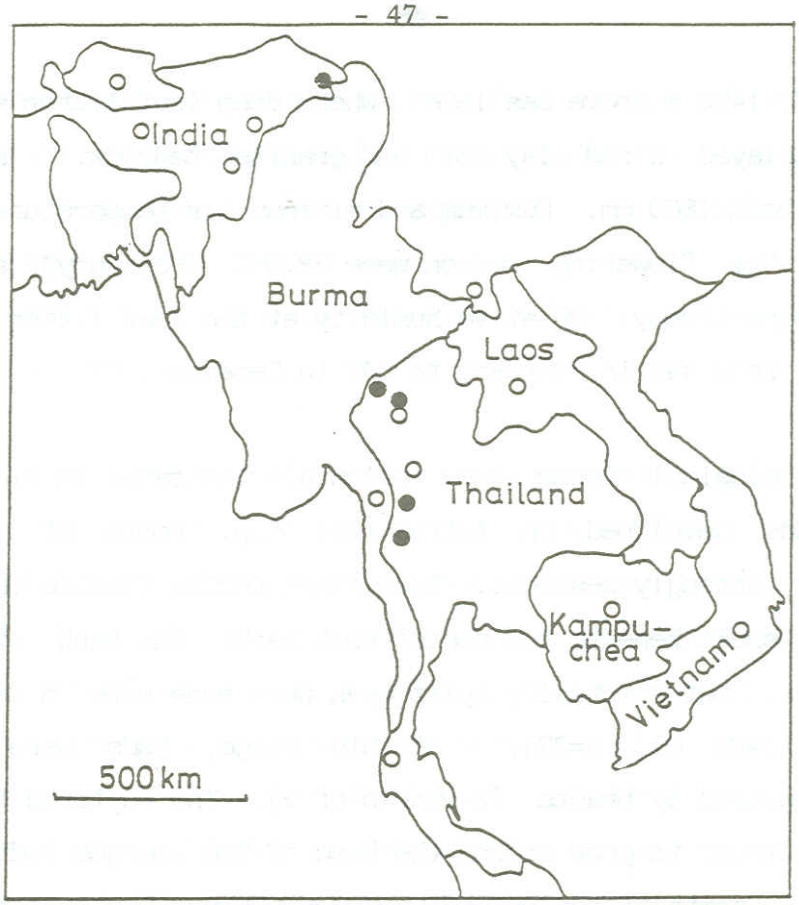
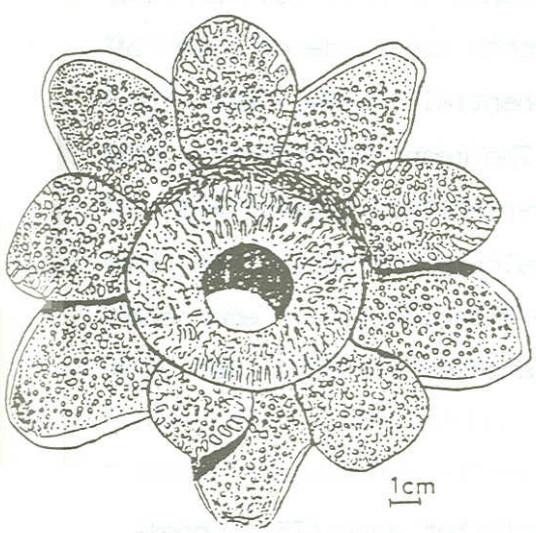


Figure 1. All known records of *Sapria himalayana*. Open circles pre-1970, solid circles post-1970.



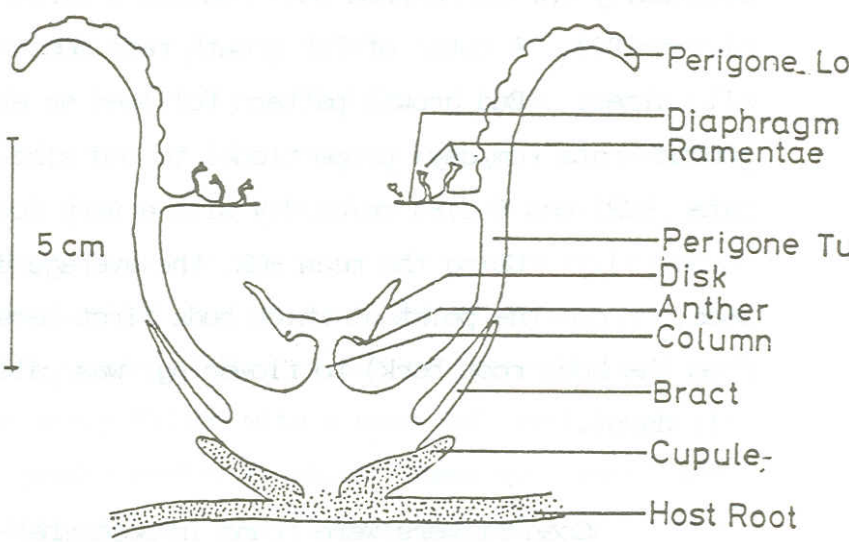


Figure 2. Top view and cross section through a male *Sapria himalayana* flower

forest at 1000-1450 m above sea level, where deep leaf litter and a dense root mat overlayed a red clay soil and granite bedrock. Mean annual rainfall was about 1800 mm. Maximum and minimum air temperatures at ground level during the flowering season were 33.0 C (February) and 11.5 C (December) respectively. Relative humidity at the leaf litter surface at mid-day ranged from 44% in February to 84% in December.

Morphological terms used below are indicated in Fig. 2. *S. himalayana* buds developed on *Tetrastigma* spp. roots of all sizes. Flowering was strongly seasonal. Buds first became visible in July, as they began to swell beneath the hosts' root bark. The bark stretched as the buds grew, but eventually split open when buds were 6.4-7.6 cm in circumference (99% cl, n=23). At this stage, buds were white and completely enclosed by bracts (2 whorls of 5). The ruptured bark of the host root continued to grow around the base of the emerged bud, forming a woody cupule. Growth of the bracts was much slower than that of the rest of the bud, so that when buds were 10.9-12.2 cm (99% cl, n=24) in circumference, the bracts were pushed apart, exposing the pale pink under surface of the outer whorl of perigone lobes. Bud growth rate then increased markedly. The perigone lobes turned a darker shade of pink, eventually unfolding when buds reached a circumference of 25.2-26.4 cm (99% cl, n=122). A total of 796 growth rate measurements were made on buds of all sizes. Bud growth pattern followed an exponential curve, with bud growth rate (cm/day) proportional to bud size. The mean relative growth rate (RGR) was 0.1184 cm/cm/day with a very low variability (99% cl = G = 0.00029). Using the mean RGR, the average developmental period of the buds, from the point at which buds first became visible (i.e. emergence from the host root bark) to flowering, was calculated as 111 days (99% cl = 11 days).

Open flowers were found in September-April but most (75%) opened in November-January. *S. himalayana* flowers are unisexual and both males and females were found emerging from the same host root system. Whether this indicated 2 or more dioecius individual *S. himalayana* plants of different sexes, infecting the same host or whether *S. himalayana* is in

fact monoecius could not be determined. The assertion that *S. himalayana* is dioecius and can be traced back to GRIFFITH (1845). How Griffith came to this conclusion, however, is not explained in his paper. Males always outnumbered females. The male:female ratio for open flowers in any month was never less than 2:1 and the ratio for all 379 open flowers examined during the study was 2.5:1.

As they opened, flowers emitted an odour similar to that of rotting meat, which persisted for 2-3 days. Male flowers produced pollen as a yellow fluid from 20 spherical anthers in a ring immediately below the disk (Fig.2). This presumably ensures that the pollinator picks up fairly large quantities of pollen, which would be required for the fertilization of a significant proportion of the many thousands of tiny ovules contained within the ovaries of females. The location of the stigmatic surface in female flowers has not yet been determined. Various insects, including carrion flies, which entered the flowers and may be responsible for pollination are currently being indentified. BANZIGER (pers. comm., 1987) reported that the matalic blue fly *Lucilia porphyrina* (Wlk.) entered *S. himalayana* flowers.

Within 3-4 days after opening, flowers darkened and eventually turned black. As flowers turned black, they shrank. The base of male flowers and their attachment to the host shrivelled rapidly and eventually they became detached from the host root. In female flowers, the perigone tube and lobes, diaphragm and disk shrivelled as in males, but the column, ovary and surrounding tissues at the base of the column remained alive. The base of the perigone tube swelled and remained white externally for about $2^{1/2}$ months after flower opening. This structure constituted the fruit of *S. himalayana*. The ovary filled with a mass of pinkish-yellow tissue, consisting of anastomosing septa, to which numerous seeds were attached. Over 3-6 months, this tissue slowly decomposed and the fruits eventually become detached from the host root. After detachment cupules shrank and became permanent scars on the host root.

No direct observations of seed dispersal were made. However, it was clear that seed dispersal could not occur unless the fruits were physically broken open. Indirect evidence suggested that rodents may perform this function. Up to 18% of fruits were attacked by rodents, which scraped out the ovary tissue, leaving behind remnants of the base of the perigone tube, still attached to the host root. This nearly always occurred $2\text{-}2^{1/2}$ months after flower opening. Why rodents should be attracted to the fruits during this fairly narrow time span could not be determined. The fruits were odourless and inconspicuous, often burried beneath fallen leaves. Trapping revealed the presence of several rat and squirrel species in the area. Judging from the size of teeth marks on the remains of the perigone tube, the most likely seed dispersers were *Rattus surifer* and *Rattus rattus*. Rat burrows were commonly observed amongst the roots of lianas and they might therefore be capable of depositing *S. himalayana* seeds on or near the roots of potential hosts.

About 40% of buds examined died before reaching maturity. Most mortality occurred early in the flowering season in October-November amongst younger buds. There was no difference in mortality rate between males and females. Abortion seemed to be the most common cause of death. Most buds showed no signs of physical damage or fungal infection. Only 4.6% of dead buds showed signs of attack by insects.

CONCLUSION

In Thailand I propose that *S. himalayana* is an "endangered" species according to International Union for the Conservation of Nature's Red Data Book criteria (IUCN, 1980), due to its rarity, continuing loss of habitat, vandalism of existing colonies, high degree of host specificity and low potential rate of reproduction and dispersal. Several colonies were destroyed by so-called "professional" botanists during the course of this study. *S. himalayana* from Thailand is more than adequately represented in herbaria and I therefore appeal to botanists not to collect any further specimens.

Several measures are needed to conserve the species. Attempts should be made to pollinate female flowers by hand, as natural cross-pollination between two distant colonies is probably a rare event in nature. Seed should then be transferred to suitable hosts at several separate locations to try to establish new colonies. Such work should be carried out *in situ* within protected areas, rather than in botanical gardens, since botanical gardens would not be able to reproduce the complicated host, habitat, pollination and seed dispersal mechanisms required to ensure survival of the species in the long term. Finally legislaltion should be passed to enable plants to be declared protected species so that destroying or trading in *S. himalayana* or other rare plant species could become a punishable offence.

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