

Taxonomy and conservation status of *Microchirita* (Gesneriaceae) in Peninsular Malaysia

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ABSTRACT. A revision of *Microchirita* (C.B. Clarke) Yin Z. Wang (Gesneriaceae) in Malaysia is presented as a precursory paper for the *Flora of Peninsular Malaysia* account. The taxonomic treatment includes a key for identification, detailed descriptions of the species, information on seed morphology (illustrated by Scanning Electron Microscopy micrographs), and a discussion on distributions, including maps, and the conservation status for each species.

Keywords. *Chirita*, limestone, seed morphology, SEM

Introduction

The genus *Microchirita* (C.B. Clarke) Yin Z. Wang was raised by Wang et al. (2011) from *Chirita* section *Microchirita* C.B. Clarke based on molecular phylogenetic studies by Möller et al. (2009) and Wang et al. (2011). This change of status was also supported by Weber et al. (2011). *Microchirita* comprises approximately 28 species in India (Western Ghats and NE India), southern China, Indochina, Myanmar, Thailand, Peninsular Malaysia, Borneo (Sarawak) and Indonesia (Sumatra, Java, Bali and Sumba). The highest concentration of species is in Thailand (Weber et al., 2011; Middleton & Triboun, 2013; Puglisi et al., 2016). Of the six taxa recognised in Peninsular Malaysia two are endemic, *Microchirita ruthiae* Rafidah and *M. sericea* (Ridl.) A. Weber & Rafidah (Rafidah, 2011). *Microchirita* species are herbs that usually grow in forest or on exposed rocks in the open or in light shade. In Malaysia, the genus is restricted to limestone areas (Henderson, 1939; Kiew, 2009).

In preparation for the *Flora of Peninsular Malaysia* account, complete descriptions of all Malaysian *Microchirita* species were prepared. The aim of the study was to examine morphological characters in detail, including ones that in previous descriptions were incompletely described, through the observation of living plants and herbarium specimens. These characters include colour, stigma form, hairs on corolla, and seeds. Furthermore, the distribution and the conservation status of each species is assessed. Recommendations have been made regarding their long-term protection.

A need for protection

Limestone karst hills and caves are an integral part of our natural heritage that have taken millions of years to form and, therefore, cannot be sustainably exploited. Limestone hills are especially rich in biodiversity which is often found in no other habitats. Therefore, national conservation action plans must urgently be implemented to protect these hills. National programmes should include long-term holistic strategies that balance the use of limestone hills and the preservation of their unique biodiversity. There are potential non-destructive uses of limestone hills for their caves, possible sustainable bird's nests harvesting, their value as scenic landscapes and monuments, their archaeological and cultural heritage, and their recreational value.

Actions: Threatened species require conservation action plans that include more intensive surveys, particularly for endemic species and threatened species. Species categorised under guidelines from IUCN (2012) as Critically Endangered (CR) or Data Deficient (DD) hold the greatest conservation concern due to a combination of extreme rarity and loss of habitat.

Legal status: Chua et al. (2009) suggested limestone hills should be included in the Permanent Forest Reserves network or that the protected status of Totally Protected Areas should be properly enforced. *Microchirita* species are restricted to limestone hills, so any disturbance to these limestone hills creates an impact on the included flora.

Buffer zone: In Peninsular Malaysia, apart from the limestone hills within Taman Negara, it is rare to find a hill with any surrounding forest left intact (Kiew, 1991). Karst hills are a unique habitat for several rare and endemic plants. In Peninsular Malaysia an estimated 1250 species are found on limestone (which is 22% of the Peninsular Malaysia flora), of which at least 125 species are endemic to limestone. *Microchirita* species mostly grow at the base of hills, especially the more widespread species such as *M. caliginosa*, and it is therefore important to have a buffer zone around these hills.

Awareness & education: To support the conservation of limestone hills, awareness of the threats to this habitat in the general public and by state authorities needs to be promoted.

Material and methods

Microchirita specimens were examined from the following herbaria: BK, BKF, BO, E, K, KEP, KLU, L, SAN, SAR, SING and UKMB (Thiers, continuously updated). Complete descriptions are based on herbarium specimens as well as observations on living material from field studies, together with materials cultivated in the FRIM

(Forest Research Institute Malaysia) nursery. Digital colour photographs were taken to illustrate morphology and habitat.

To examine the testa surface, seeds of *Microchirita* species were removed from fruits of herbarium specimens or from fresh material and were mounted using double-sided tape on aluminium stubs. They were then sputter coated with gold at 20 mA for 90 seconds. The specimens were then examined under a Scanning Electron Microscope, models FEI (Quantum 200) and JEOL (JSM-6400). Micrographs were made to record details of the seed at various magnifications.

To prepare distribution maps of a particular species/taxon, data from herbarium specimens were entered directly into BRAHMS (Botanical Research and Herbarium Management System) database software. The conservation status assessment for all species was made using the modified Malaysian Plant Red List Categories which is used solely for species growing in Malaysia (Chua & Saw, 2006). The Malaysian Rare (RA) category is an additional category to the IUCN Red List Categories (Chua, 2012) and refers to taxa that are rare but not necessarily in danger of extinction. A taxon data information sheet was completed for each species and the information was uploaded into the Malaysia Clearing House Mechanism website (<http://www.chm.frim.gov.my/>). The Extent of Occurrence (EOO) and Area of Occupancy (AOO) were calculated for each species using ArcView GIS 3.2a software. Distribution maps of all species are shown in Maps 1–7.

Conservation status and threats

In Malaysia, the limestone flora has repeatedly been recognised as critically endangered (Davis et al., 1995a, 1995b; Chua et al., 2009; Saw et al., 2009; Kiew et al., 2011) and has been identified as one of the Important Plant Areas (IPAs) (Kiew et al., 2011). In Peninsular Malaysia, limestone karst hills are mostly concentrated in the central and northern states and most hills lie on state land that has no legal protection (Chua et al., 2009). According to Kiew (1991), the limestone flora is particularly vulnerable because it occupies such a small area (0.4% of the land area of Peninsular Malaysia), and is threatened by quarrying and mining, land clearance for agricultural practices, burning, flooding by hydroelectric dams, temple building and damage associated with recreational activities. Price (2001) stated that in 1975, a total of 62 limestone hills were quarried (3 in Perlis, 8 in Kedah, 32 in Perak, 3 in Selangor, 7 in Pahang and 6 in Kelantan). However by 2013, there were 66 active quarries in Perak (Ramli et al., 2014) alone. In Sarawak, the major threats to the vegetation of limestone hills include farming activities, which can lead to the burning of limestone vegetation, quarrying and the collection of plants for sale.

The current critical threats to *Microchirita* species are mostly from quarrying and mining of the limestone, mostly for cement, thereby destroying the habitat and the vegetation. Endemic species are the most vulnerable to extinction. Other threats to the plant populations are land clearance around the foothills, mostly for agriculture leading to changes in microclimate and increased risk of fire, particularly in Kelantan

and Pahang, and also from direct human disturbance.

Microchirita species are not economically valuable but rather have value as flagship species of threatened limestone habitats because they are found nowhere else. Table 1 summarises the conservation status of each species of *Microchirita* in Malaysia. Two taxa are categorised as Least Concern (LC), one as Near Threatened (NT), one as Vulnerable (VU) and two as Endangered (EN). None of the *Microchirita* species in Malaysia are categorised as Extinct (EX). The two taxa that are categorised as LC occur within the network of Totally Protected Areas (in Taman Negara) and have no known current threats. Of the three threatened taxa, the two Endangered taxa, *Microchirita ruthiae* (found only in Kelantan) and *M. sericea* (found only in Perak, Perlis and Kedah), are endemic to Peninsular Malaysia and the hills where they grow are not legally protected and are threatened by quarrying. The Vulnerable taxon, *Microchirita rupestris* (Ridl.) A.Weber & Rafidah, is categorised as Vulnerable in Malaysia whereas globally it should be considered Least Concern (Middleton, pers. comm.). Further details are under each species.

Table 1. Conservation status of *Microchirita* species in Peninsular Malaysia.

Species	No. of hills	IUCN Category
<i>Microchirita caliginosa</i> (C.B.Clarke) Yin Z.Wang	24	Least Concern
<i>Microchirita involucrata</i> (Craib) Yin Z.Wang	18	Least Concern
<i>Microchirita rupestris</i> (Ridl.) A.Weber & Rafidah	7	Vulnerable
<i>Microchirita ruthiae</i> Rafidah	6	Endangered
<i>Microchirita sericea</i> (Ridl.) A.Weber & Rafidah	5	Endangered
<i>Microchirita viola</i> (Ridl.) A.Weber & Rafidah	6	Near Threatened

Notes on selected habitat and morphological characters

In Peninsular Malaysia, as elsewhere, *Microchirita* species are morphologically very similar, especially when sterile. Nevertheless, there are a few characters that separate the species even though vegetative and reproductive characters can be variable. Observations in the field, together with photos, are important in recording diagnostic characters that cannot be seen or are difficult to see in dried herbarium specimens.

Microchirita caliginosa (C.B.Clarke) Yin Z.Wang and *M. involucrata* (Craib) Yin Z.Wang are frequently found at the base of hills where there is a thin soil layer. On this soil *Microchirita caliginosa* and *M. involucrata* always produce carpets of seedlings that grow rapidly. *Microchirita sericea*, *M. rupestris*, *M. viola* (Ridl.) A.Weber & Rafidah and *M. ruthiae*, however, inhabit rock crevices and cracks in the limestone, sometimes in wet conditions. *Microchirita* species often have a short lifespan or are annual with most species living for less than six months to one year (pers. obs.). What would appear to be perennial plants have been observed, however,

in *Microchirita ruthiae* and *M. sericea*. Observations of the developmental stages (buds, flowering and fruiting stages) shows that *Microchirita* species produce flowers at a very early stage when they have only one or two leaves, then flower continuously throughout their short life (pers. obs.). *Microchirita caliginosa* and *M. involucrata*, and occasionally *M. rupestris*, are monopodial.

In general, the hair type of the lamina surface is different in each *Microchirita* species. The type of hairs (whether pubescent, strigose or sericeous) and the density (sparse or dense) vary across the species. It varies from sparsely pubescent (*M. involucrata*), to moderately densely pubescent (*M. ruthiae*) to densely pubescent (*M. caliginosa*), while *M. rupestris* and *M. viola* have sparsely strigose hairs. Furthermore, *Microchirita sericea* has densely sericeous hairs. The colour of the upper surface of the fresh lamina varies from yellowish green, whitish green to dark green, while the lower surfaces of *Microchirita viola* and *M. caliginosa* are sometimes reddish to reddish-green. This character is useful in the field.

Some species have epiphyllous or crested inflorescences (*Microchirita ruthiae*) or they have cymose inflorescences (*M. involucrata* and *M. rupestris*). The individual inflorescences of *Microchirita* are always up to 6-flowered or rarely more.

Ridley (1905, 1908, 1923) relied on bract characters in his keys to *Microchirita* species, thus treating this character as diagnostic. Two species of *Microchirita* have conspicuous bracts: *M. rupestris* (saucer-shaped bract) and *M. involucrata* (foliose bract) (Fig. 1).

There are differences in the size and indumentum of the calyx lobes but the differences are small. In general, the indumentum of the calyx of *Microchirita caliginosa* and *M. ruthiae* is similar in their glandular and eglandular hairs. *Microchirita rupestris* and *M. viola* have ciliate hairs while *M. sericea* has densely sericeous hairs.

The shape of the corolla tube varies from slightly curved to more strongly curved downwards. The length of the corolla tube ranges from 1.4–5.5 cm and the width from 2–4 mm. The colour of the corolla tube varies from cream, yellowish, pale purple to dark purple, to occasionally whitish. The throat colour for all *Microchirita* species is yellow or whitish, except for *M. involucrata* that usually possesses a dark red throat.

The glandular hairs in the throat of the corolla in some species are translucent or glistening-translucent, bead-like hairs except for *M. rupestris* that has a cluster of hairs (not bead-like) around the corolla mouth. *Microchirita viola* differs from the other species in having conspicuously attractive golden yellow, glandular bead-like hairs that can be seen from the corolla mouth.

In general, the corolla lobes are usually unequal in all *Microchirita* species, and the lowest lobe is the largest. *Microchirita viola* is distinct from all the other species by having the median lower lobe much longer than the other two lobes. The width of the lobes was measured from lobe to lobe (across). The width of the *Microchirita sericea* corolla reaches to 3 cm across while the rest are less than 2.5 cm wide and most range from 1.2 to 2 cm. The colour of the lobes is always much darker than that of the corolla tube and varies from whitish, pale blue, pale purple to deep purple or violet. The lobes may be striped or almost plain-coloured (Fig. 2). *Microchirita viola* and *M. sericea* have conspicuously striped lobes while the others possess faint stripes.

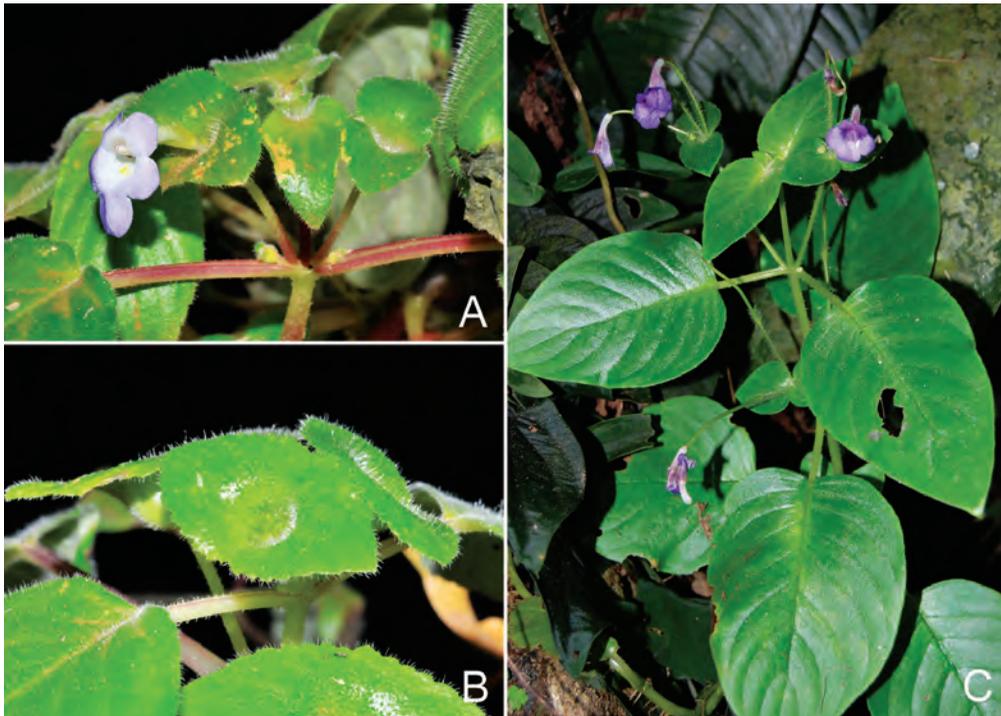


Fig. 1. Conspicuous bracts in Malaysian *Microchirita*. **A, B.** *Microchirita rupestris* (Ridl.) A. Weber & Rafidah. **C.** *Microchirita involucrata* (Craib) Yin Z. Wang. (Photos: A.R. Rafidah)

In Peninsular Malaysia, flower colour is of great importance in separating the species even though this character is lost on dried specimens. Flower colour is constant, only a few have occasional white flowers in purple populations. Photographs of the flowers are therefore crucial.

Microchirita species have two stamens and the filaments are usually curved and geniculate with the exception of *M. involucrata* and *M. ruthiae* that have straight filaments. The anthers are generally fused apically or joined. However, the anthers of *Microchirita ruthiae* are free and not joined together.

Two types of hairs, glandular or eglandular, are found on the ovary and style in *Microchirita* species. *Microchirita caliginosa* and *M. ruthiae* have both types of hairs, while the others consistently only have eglandular hairs. In fresh flowers, stigma colour varies from white, whitish green, pale purple to deep purple, independently of the colour of the style or the corolla. The stigmas are shallowly bilobed or deeply bilobed and covered with papillate trichomes. Unequal stigma lobes are seen in *Microchirita involucrata*.

The seed shape in *Microchirita* species ranges from narrowly ellipsoid through ellipsoid to broadly ellipsoid or broadly ovoid (Table 2). Species with a seed length:width ratio of 3:1 (seen clearly in *Microchirita viola*) are described as narrowly ellipsoid, which distinguishes it from the other species. Those with a ratio 2:1, such as

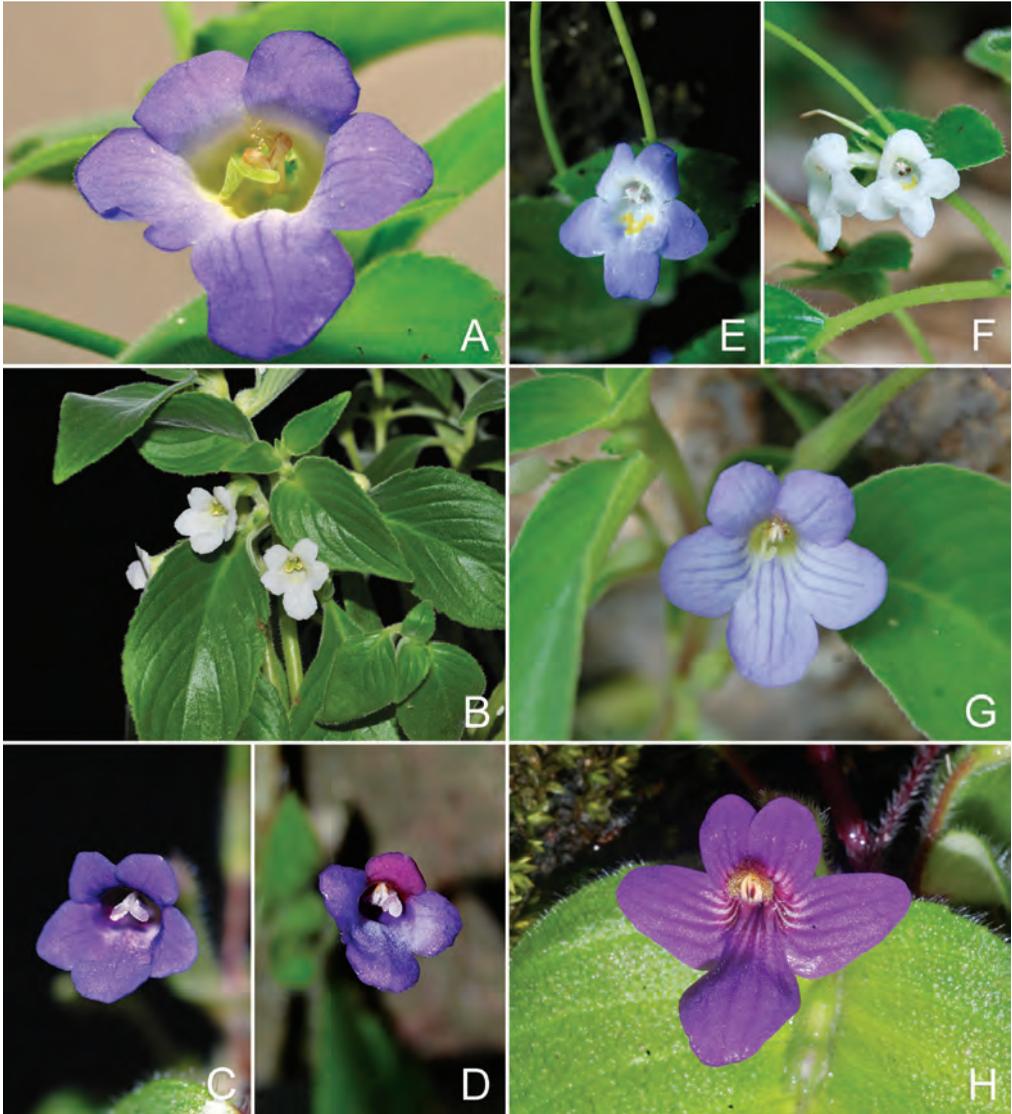


Fig. 2. Corolla shape, colour and pattern. **A.** *Microchirita caliginosa* (C.B.Clarke) Yin Z.Wang. **B.** *M. ruthiae* Rafidah. **C, D.** *M. involucrata* (Craib) Yin Z.Wang. **E, F.** *M. rupestris* (Ridl.) A.Weber & Rafidah. **G.** *M. sericea* (Ridl.) A.Weber & Rafidah. **H.** *M. viola* (Ridl.) A.Weber & Rafidah. (Photos: A.R. Rafidah & K. Imin)

Microchirita caliginosa, *M. involucrata*, *M. sericea* and *M. ruthiae*, have a narrowly ellipsoid to broadly ellipsoid or broadly ovoid shape. The cell edges of *Microchirita* species also vary from weakly elevated (*Microchirita viola* and *M. sericea*) to elevated (*M. caliginosa* and *M. ruthiae*) to strongly elevated (*M. involucrata* and *M. rupestris*).

Table 2. Summary of seed characters in *Microchirita* species.

Characters	<i>M. caliginosa</i>	<i>M. involuocrata</i>	<i>M. rupestris</i>	<i>M. sericea</i>	<i>M. viola</i>	<i>M. ruthiae</i>
Shape	Ellipsoid to narrowly ellipsoid	Narrowly ellipsoid to broadly ellipsoid	Ellipsoid	Broadly ellipsoid	Narrowly ellipsoid	Broadly ovoid or ellipsoid
Length (µm)	435–550	315–380	324–385	300–380	600–710	286–406
Width (µm)	100–230	120–250	170–220	120–250	200–280	190–245
l/w-ratio (approx.)	2–4:1	1½–2:1	1¼–2:1	2:1	3:1	2:1
Cell shape	Polygonate	Polygonate	Polygonate	Polygonate	Polygonate	Polygonate
Cell orientation	Straight	Straight	Straight	Straight	Straight	Straight
Cell edges	Elevated	Strongly elevated	Strongly elevated	Weakly elevated	Very weakly elevated	Elevated
Cell pattern	Reticulate	Strongly reticulate	Strongly reticulate	Weakly reticulate	Very weakly reticulate	Reticulate
Surface patterns	Papillate, canalliculate	Papillate to canalliculate	Canalliculate	Papillate	Papillate	Papillate

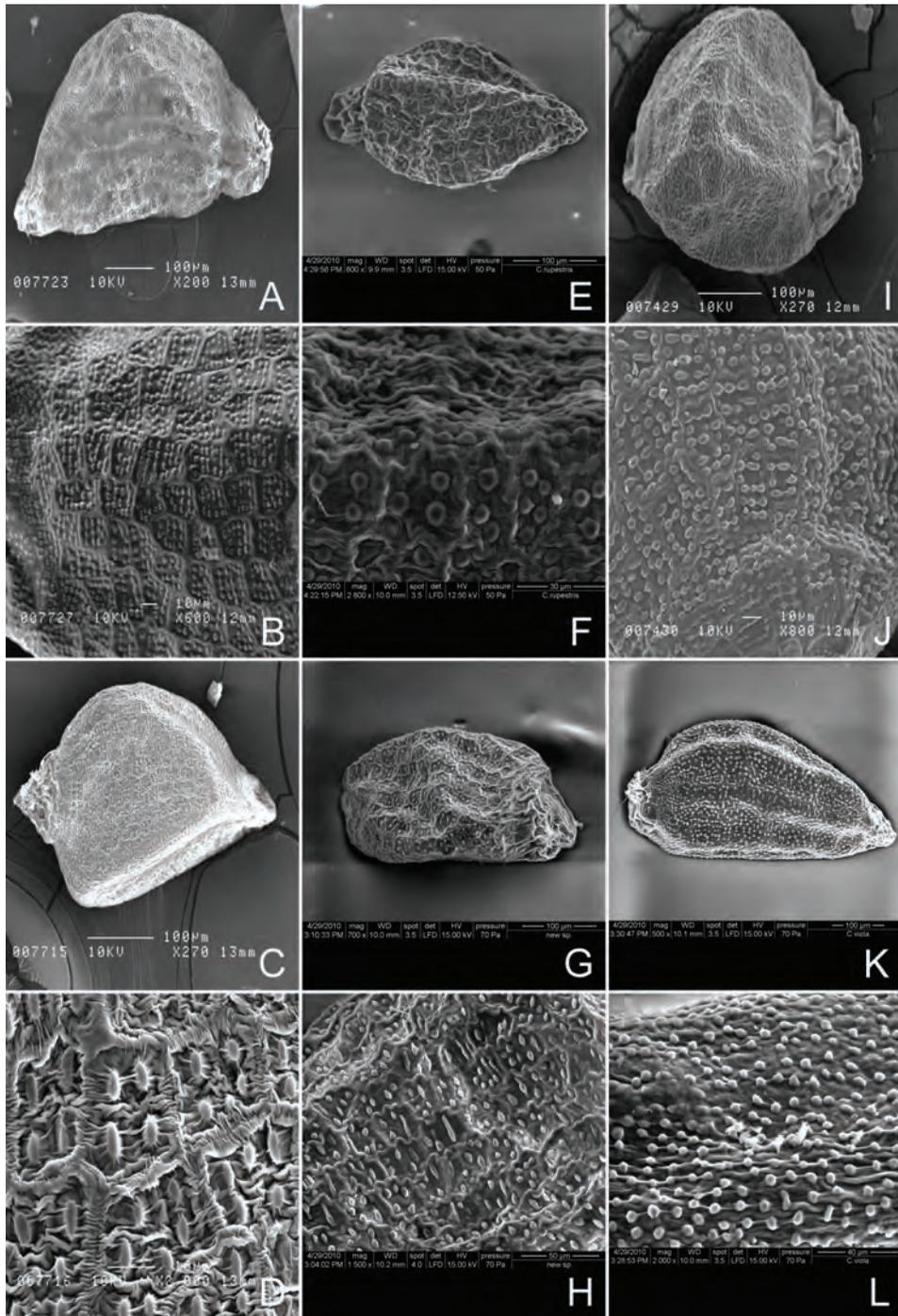


Fig. 3. SEM micrographs of seeds of *Microchirita* showing seed shape, size and surface pattern. **A, B.** *M. caliginosa* (C.B.Clarke) Yin Z.Wang. **C, D.** *M. involucrata* (Craib) Yin Z.Wang. **E, F.** *M. rupestris* (Ridl.) A.Weber & Rafidah. **G, H.** *M. ruthiae* Rafidah. **I, J.** *M. sericea* (Ridl.) A.Weber & Rafidah. **K, L.** *M. viola* (Ridl.) A.Weber & Rafidah. (Photos: A.R. Rafidah)

The surface pattern of the seed is consistent in all species, that is, it is either papillate or canaliculate (Fig. 3/Table 2). All *Microchirita* seeds have bumps or knobs within a thick square (up to 10 bumps), except *M. viola* which does not form squares and the bumps are arranged continuously in lines, while *M. sericea* forms weak squares. This character is useful for distinguishing between species.

Taxonomic treatment

Microchirita (C.B.Clarke) Yin Z.Wang, J. Syst. Evol. 49: 59 (2011); Weber et al., Taxon 60: 778 (2011). – *Chirita* sect. *Microchirita* C.B.Clarke in A.DC. & C.DC., Monogr. Phan. 5(1): 127 (1883); Wood, Notes Roy. Bot. Gard. Edinburgh 33: 134 (1974). – *Roettlera* sect. *Microchirita* (C.B.Clarke) Fritsch in Engl. & Prant, Nat. Pflanzenfam. 4(3B): 148 (1895). – *Didymocarpus* sect. *Microchirita* (C.B.Clarke) Chun, Sunyatsenia 6: 290 (1946). – TYPE: *Microchirita hamosa* (R.Br.) Yin Z.Wang, lectotype designated by Burt (1954).

Short-lived or rarely perennial, caulescent (erect or creeping) herbaceous plants; stem branched or unbranched, sometimes slightly woody, often fleshy, indumentum of white or silvery soft, glandular hairs. **Leaves** opposite, whorled or decussate; petiole long or short, winged or not; lamina variable in shape, ranging from narrowly elliptic to ovate, base sometimes unequal, margin entire or serrate. **Inflorescences** axillary, epiphyllous, crested or cymose, one- to many-flowered; bracts free, cup-shaped, leaf-like or caducous. **Flowers**: **calyx** pentamerous, free to base, appressed in the fruit; **corolla** bilaterally symmetrical, tubular to broadly funnel-shaped with 5 lobes, upper lip 2-lobed, lower lip 3-lobed, lobes rounded; **stamens** 2, filaments adnate to the corolla, anthers fused either apically or joined by a ligature, rarely free, anther-thecae divergent, staminodes 2 or very rarely 3; **nectary** rim entire, cleft or lobed; **carpels** two, rarely with one carpel sterile, style one, straight, stigma bilobed. **Fruit** a slender capsule, plagiocarpic, dehiscence on both sides. **Seeds** numerous, tiny.

Distribution. Approximately 28 species in India (Western Ghats and NE India), China, Indo-China, Myanmar, Thailand, Peninsular Malaysia, Borneo (Sarawak) and Indonesia (Java, Sumatra, Bali, and Sumba) with centre of diversity in Thailand. In Malaysia, six species are recorded.

Habitat and ecology. In Peninsular Malaysia restricted to limestone hills. In wet, light to moderately shady places at cliff bases, on cliff walls in crevices and cracks, or at cave entrances.

Key to *Microchirita* species in Malaysia

- 1a. Lamina narrowly elliptic or elliptic with widest point of lamina at the middle ... 2
 1b. Lamina ovate, obovate, lanceolate or ovate with widest point of lamina below or above the middle..... 4
- 2a. Margin serrate 4. *M. ruthiae*
 2b. Margin serrulate 3
- 3a. Stem erect; leaf lower surface pale green to yellowish green, sometimes reddish green, base narrowly cuneate 1. *M. caliginosa*
 3b. Stem creeping; leaf lower surface very pale green or whitish green, base attenuate or sometimes cordate 5. *M. sericea*
- 4a. Inflorescences cymose, bracts present 5
 4b. Inflorescences epiphyllous and crested, bracts absent (or minute) 6
- 5a. Bracts connate-perfoliate into cup-like arrangement 3. *M. rupestris*
 5b. Bracts not fused at base, leaf-like 2. *M. involucrata*
- 6a. Corolla tube pale violet, lobes with conspicuous dark purple stripes; glandular hairs golden yellow, apically swollen in a cluster above the anther 6. *M. viola*
 6b. Corolla tube white or cream, pale yellow or pale purple, lobes conspicuously striped or plain; glandular bead-like hairs translucent or glistening yellow or brown 7
- 7a. Corolla tube white; anthers free 4. *M. ruthiae*
 7b. Corolla tube cream, pale yellow or pale purple; anthers fused apically or joined by apical ligature 5. *M. sericea*

1. *Microchirita caliginosa* (C.B.Clarke) Yin Z.Wang, J. Syst. Evol. 49: 60 (2011). – *Chirita caliginosa* C.B.Clarke in A.DC. & C.DC., Monogr. Phan. 5(1): 122 (1883); Clarke in Hooker, Fl. Brit. India 4: 360 (1884); Ridley, J. Linn. Soc., Bot. 32: 516 (1896); Ridley, J. Straits Branch Roy. Asiat. Soc. 44: 58 (1905); Ridley, Fl. Malay Penins. 2: 524 (1923); Wood, Notes Roy. Bot. Gard. Edinburgh 33: 186 (1974). – *Roettlera caliginosa* (C.B.Clarke) Kuntze, Revis. Gen. Pl. 2: 476 (1891). – TYPE: Malaysia, Peninsular Malaysia, Kuala Lumpur [Klang], 1891, *Kehding in Beccari* 73 (holotype FI [FI013109], digital image seen). (Fig. 2A, 3A–B, 4, 5)

Chirita parvula Ridl., J. Fed. Malay States Mus. 10: 149 (1920); Ridley, Fl. Malay Penins. 2: 524 (1923). – TYPE: Malaysia, Peninsular Malaysia, Pahang, Kota Tongkat, 10th mile Benta-Kuantan road, June 1917, *Evans s.n.* (holotype K [K000450490]).

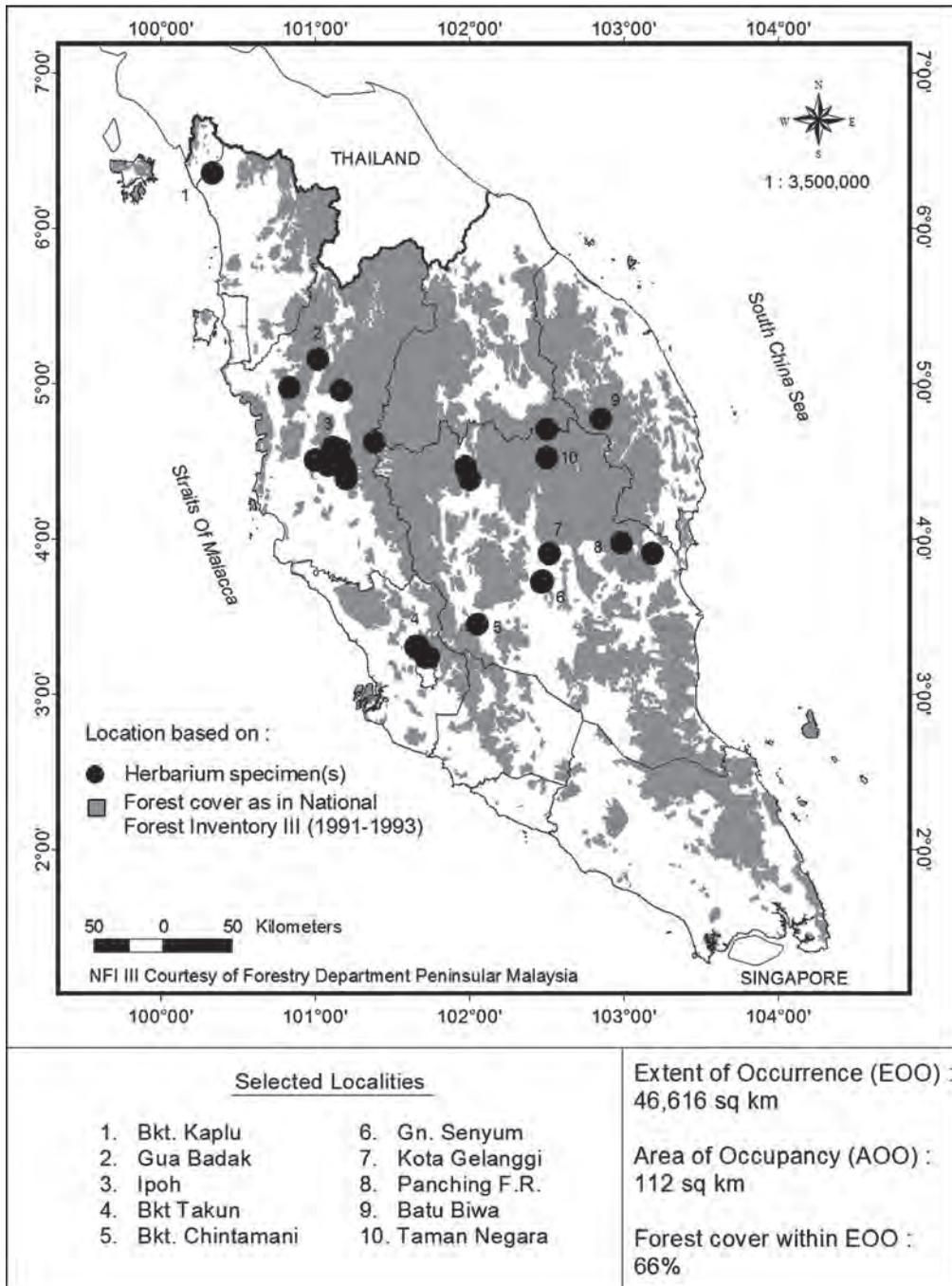


Fig. 4. Distribution of *Microchirita caliginosa* (C.B.Clarke) Yin Z.Wang in Peninsular Malaysia.

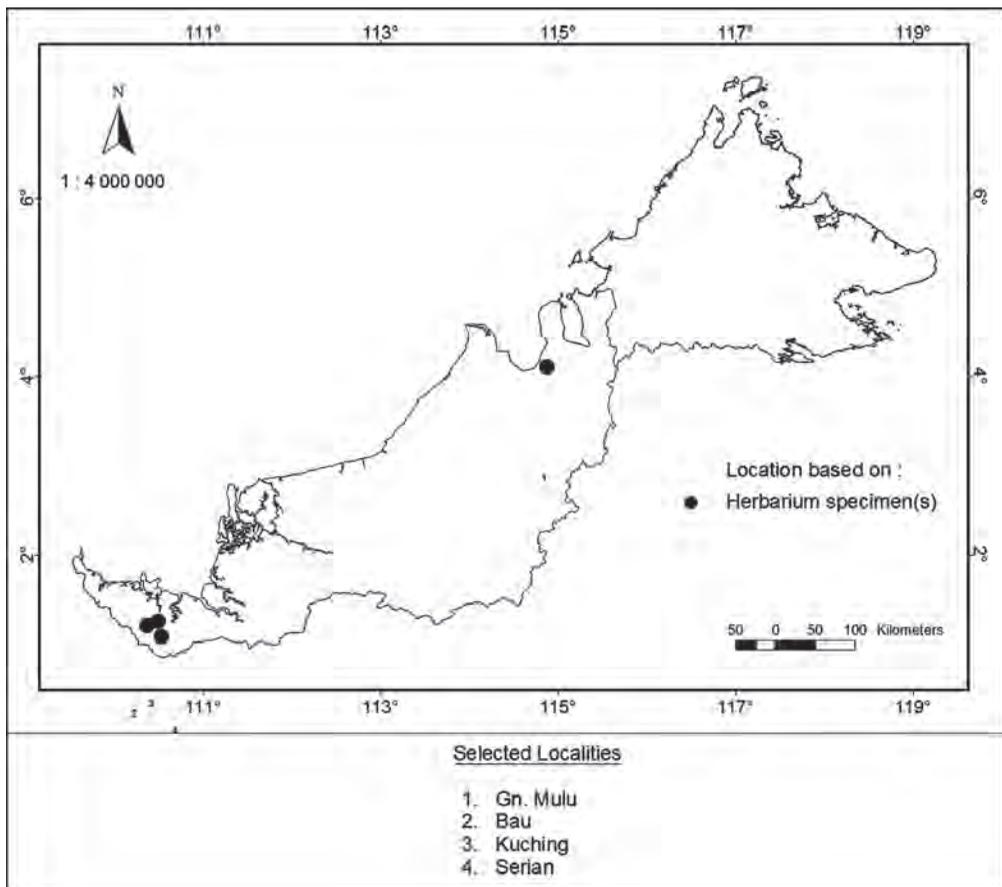


Fig. 5. Distribution of *Microchirita caliginosa* (C.B.Clarke) Yin Z.Wang in Sarawak.

Chirita fusca C.B.Clarke in A.DC. & C.DC., Monogr. Phan. 5(1): 129 (1883). – *Roettlera fusca* (C.B.Clarke) Kuntze, Revis. Gen. Pl. 2: 476 (1891). – TYPE. Malaysia, Sarawak, June 1896, *Lobb* (holotype K [000858415]).

Branching, monopodial, herbaceous, short-lived plant. **Stems** brown to pale red or pale maroon, succulent, erect, flowering at 1 cm tall, erect up to 60 cm, 2–7 mm diameter, shortly decumbent at the base, hairs pubescent or strigose, rarely glabrous, internodes to 10 cm long. **Leaves** opposite, decussate, lowermost solitary (resulting from one of a pair dying); petioles green sometimes maroon, 2–6 cm long, hairs glandular and eglandular; lamina narrowly elliptic or elliptic, 6–15.5 × 2.5–7 cm, yellowish green to dark green above, pale green or greyish green or sometimes reddish beneath, soft when fresh, papery when dry, densely pubescent, base narrowly cuneate, unequal, margin serrulate, apex acuminate; midrib sunken above, prominent beneath, pubescent beneath, lateral veins 5–10 pairs on each side of the midrib, intercostal veins reticulate. **Inflorescences** epiphyllous, to 6-flowered; bracts absent; pedicels pale green,

sometimes greenish maroon, shortly fused to the petiole, to 1.5 cm long, sparsely glandular hairy. **Calyx** green, clasping the corolla tube, lobes narrowly triangular or very narrowly ovate, 10–12 mm long, 8–10 mm wide, margin ciliate, outer surface glandular and eglandular hairy. **Corolla** very sparsely hairy outside and inside, tube usually cream or yellowish, sometimes whitish or pale purple, 2.4–5.5 cm long, slightly curved, 2–4 mm wide at the base, inside throat dark yellow to pale yellow, glandular hairs in the mouth of the tube above the anthers translucent pale yellow; upper lobes elliptic, not spreading, 4–5.5 × 5–6 mm, lower lateral lobes elliptic, 5–6 × 4–6 mm, lower central lobe elliptic, slightly elongated, recurved or not, 6–8 × 5–10 mm. **Stamens**: filaments cream or white, inserted at 8–10 mm from the base of the corolla, 3–6.5 mm long, slightly curved or geniculate, glabrous; anthers pale yellow, pale brown or whitish, at base with long white deflexed hairs, anther thecae divergent, 2–3 mm long; staminodes 2 (rarely 3), cream or green, vestigial, inserted at 9 mm from the base of the corolla tube, 2–7 mm long, glabrous. **Nectary** pale yellow or cream, a shallowly lobed ring, to 1 mm high. **Pistil** pale green; ovary 1.8–2.5 cm long, 1 mm wide at the base, narrowing to 0.5 mm below the stigma, hairs glandular and eglandular; style 6–28 mm long; stigma deeply 2-lobed, to 3 mm long, above with very fine papillose hairs, beneath with very sparsely glandular hairs; ovules cream, less than 1 mm long. **Capsules** green, cylindrical, slender, slightly curved towards tip, to 8 cm long, 1.3–1.8 mm diameter, sparsely hairy; calyx persistent, green, hairy. **Seeds** yellowish cream to brownish, 435–550 × 100–230 µm, ellipsoid to narrowly ellipsoid, surface papillate or canaliculate.

Distribution. Endemic to Malaysia: Peninsular Malaysia (Kedah, Pahang, Perak, Selangor and Terengganu) and Sarawak (Kuching Division).

Habitat and ecology. Damp places on limestone karst hills, limestone cliffs, crevices and on open limestone rocks, on thin soil or on guano in caves or cave mouths, around the base or at the foot of limestone hills and at the base of shaded rocks. Altitude to 240 m.

Provisional IUCN conservation status. Least Concern (LC). Populations are widespread within the network of Totally Protected Areas in Taman Negara (the National Park), both in Pahang and Terengganu.

Additional specimens examined. PENINSULAR MALAYSIA: **Kedah:** Kodiang, Bkt. Kaplu, 6 Nov 2009, *Rafidah FRI 64417* (KEP); *ibidem*, 27 May 2010, *Rafidah FRI 64545* (KEP). **Pahang:** Bkt. Charas, 15 Oct 1931, *Henderson 25233* (SING); *ibidem*, 26 Nov 1984, *Kiew RK 1557* (KEP); *ibidem*, 1 Apr 2008, *Rafidah FRI 55717* (KEP); Bkt. Chintamani, 4 Oct 1931, *Henderson SFN 25033* (SING, BK); Gn. Jebak Puyuh, 10 Feb 1986, *Kiew RK 2158* (KEP); *ibidem*, 10 Feb 1986, *Kiew RK s.n.* (KEP); Gn. Senyum, 30 Jul 1929, *Henderson s.n.* (SING); *ibidem*, 28 Nov 1984, *Kiew RK 1587* (KEP); *ibidem*, 2 Apr 2008, *Rafidah FRI 55721* (KEP); Gua Bama, 3 Apr 2008, *Rafidah FRI 55726* (KEP); Gua Cermin R.F., 31 Mar 2008, *Rafidah FRI 55713* (KEP); *ibidem*, 31 Mar 2008, *Rafidah FRI 55714* (KEP); Gua Kechil, 30 Jul 2009, *Rafidah FRI 64379* (KEP); Kota Glanggi, 4 Aug 1929, *Henderson SFN 22419* (SING); *ibidem*, 2

Apr 2008, *Rafidah FRI 55724* (KEP); Panching, 26 Nov 1984, *Kiew RK 1571* (KEP); Panching F.R., 15 Oct 1931, *Henderson SFN 25223* (SING); Taman Negara, Batu Subuh, 5 Oct 1984, *Dawn RK 1470* (KEP); Taman Negara, Kuala Keniyam, 29 Sep 1982, *Kiew RK 1202* (KEP). **Perak:** Batu Kurau, Dec 1884, *Scortechini 1582* (SING); Ipoh, 17 Jul 1917, *Burkill 2558* (SING); *ibidem*, s.d., *Gordon GS 435* (KLU); *ibidem*, Feb 1904, Ridley s.n. (SING); Gopeng, 8 Mar 1993, *Davison GD 4* (KEP); Gn. Lanno, 16 Apr 1925, *Mills 15061* (SING); Gn. Mesah, 20 Apr 1962, *Burt B1665* (SING); *ibidem*, May 1902, *Curtis s.n.* (SING); Gn. Pipit, 23 Apr 1987, *Kiew RK 2524* (KEP); Gn. Rapat, 21 Jul 2009, *Rafidah FRI 64347* (KEP); *ibidem*, 9 Mar 1931, *Samsuri SA 560* (KLU, SING); Kinta, Aug 1898, *Curtis 3109* (SING); *ibidem*, Jan 1885, *King's collector 7028* (SING); *ibidem*, 1885, King's collector 937 (SING); Kuala Dipang F.R., Feb 1890, *Curtis 2359* (SING); *ibidem*, 1898, Ridley s.n. (SING); Lenggong, Gua Badak, 28 Oct 2008, *Imin FRI 63212* (KEP); *ibidem*, Jul 1909, Ridley s.n. (SING); Sg. Siput, 21 May 1985, *Anthony's SA 842* (KEP); Sg. Siput Utara, 7 Jan 2015, *Rafidah FRI 82007* (KEP). **Selangor:** Batu Caves, 18 Oct 1983, *Anthony's SA 379* (KEP); *ibidem*, 19 Nov 1916, *Burkill 2253* (SING); *ibidem*, s.d., *Chung 331* (KLU), s.d., *Chung 390* (KLU); *ibidem*, Feb 1890, *Curtis 2359* (SING); *ibidem*, May 1902, *Curtis s.n.* (SING); *ibidem*, s.d., *Ding Hou 715* (KEP); *ibidem*, 23 Jan 1966, *Hardial 477* (SING); *ibidem*, 1889, Kelsall s.n. (SING); *ibidem*, 1 May 1981, *Kiew RK 1023* (KEP); *ibidem*, *Mohd. Kasim 391* (KLU); *ibidem*, 14 Oct 1966, *Ng FRI 1629* (KEP, SING); *ibidem*, 23 Jun 1889, *Ridley s.n.* (SING); *ibidem*, 4 Nov 1953, *Sinclair SFN 40066* (KEP, SING); *ibidem*, 29 Nov 1959, *Smith KEP 85205* (KEP); *ibidem*, s.d., *Yap SK 26* (KLU); Bkt. Anak Takun, 27 Apr 2006, *Phoon FRI 51570* (KEP, SING); *ibidem*, 3 May 2005, *Sam FRI 50118* (KEP); Kanching F.R., 10 Jul 1995, *Julia JS 26* (KEP); Bkt. Takun, 3 Nov 1937, *Mohd. Nur 34389* (SING); *ibidem*, 9 Mar 1988, *Saw FRI 36215* (SING); *ibidem*, 20 Nov 1962, *Sinclair 10732* (SING); *ibidem*, Nov 1969, *Stone 8934* (KLU); *ibidem*, 21 Sep 1969, *Stone 8794* (SING); *ibidem*, 24 Jun 1933, *Symington FMS 30796* (KEP); *ibidem*, 8 May 1935, *Symington 39598* (KEP); Kanching, 16 Mar 1935, *Symington FMS 37431* (KEP). **Terengganu:** Taman Negara, Batu Biwa, 25 Oct 1986, *Kiew RK 2339* (KEP, SING); *ibidem*, 22 Oct 1986, *Kiew RK 2284* (SING).

Notes. This is overall the most common species in Malaysia but is less common further north (Kedah mainland and Kelantan) where it is then replaced by *Microchirita involucrata*. Where the distribution of these two species overlaps, they can occasionally be found on the same hill, e.g. Gua Bama, Pahang. It is absent from Langkawi, Kedah. It is the only species to occur in Borneo (Sarawak). Specimens for Sarawak are listed in Kiew (2004). *Microchirita caliginosa* always produces carpets of seedlings that grow very quickly. One unusual *Microchirita caliginosa* population was found in Bukit Kaplu, Kedah, where the stem and lower lamina surface was reddish and the corolla was much smaller compared with the usual *M. caliginosa*.

2. *Microchirita involucrata* (Craib) Yin Z.Wang, J. Syst. Evol. 49: 60 (2011) (“*involucrate*”). – *Chirita involucrata* Craib, Gard. Chron., Ser. 3, 83: 140 (1928); Wood, Notes Roy. Bot. Gard. Edinburgh 33: 199 (1974). – TYPE: “Cult. Hort. Bot. Abdn, 17/xi/27 from seed collected in Surat on Kaw Tao by A.F.G. Kerr, 30/xii/26” (lectotype ABD, specimen with appended protologue, designated here by Carmen Puglisi; isolectotype ABD). (Fig. 2C–D, 3C–D, 6)

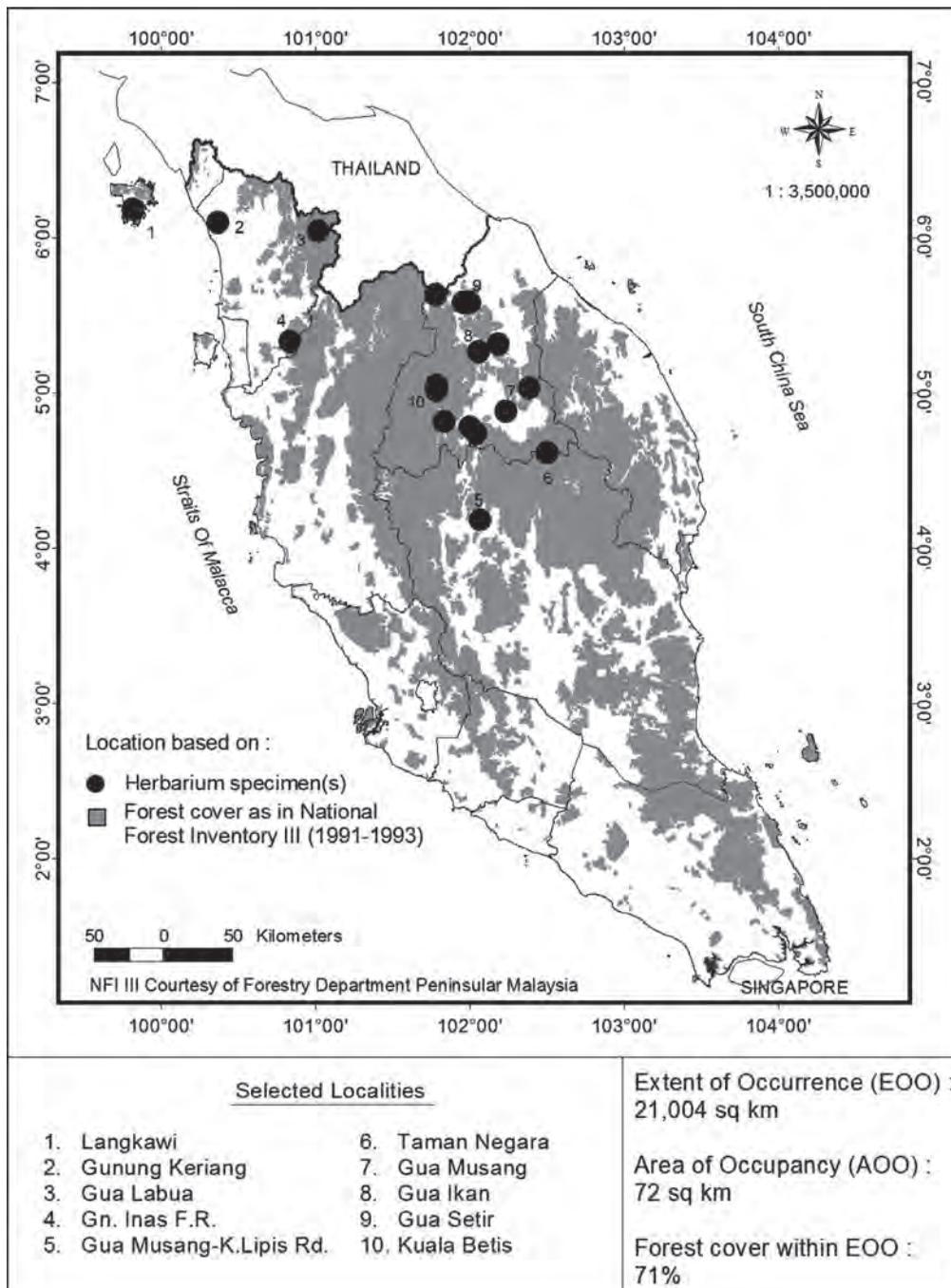


Fig. 6. Distribution of *Microchirita involucrata* (Craib) Yin Z.Wang in Peninsular Malaysia.

Branching, monopodial, herbaceous, short-lived plant. **Stems** pale green, reddish green or purplish, succulent, to 36 cm tall, 4–7 mm diameter, slightly pubescent, sometimes or rarely glabrous, internodes to 11 cm long. **Leaves** decussate; petioles green, sometimes maroon, 2–10 cm long, pubescent; lamina ovate to broadly ovate, 5.5–11 × 3.5–7 cm, yellowish green to dark green above, pale green or whitish green beneath, soft when fresh, chartaceous when dry, sparsely pubescent, base rounded or subcordate, unequal, margin serrulate, apex acute; midrib sunken above, prominent beneath, pubescent beneath, lateral veins 6–8 pairs on each side of the midrib, intercostal veins reticulate. **Inflorescences** axillary, cymose, to 6-flowered; peduncles, bracts and pedicels sparsely glandular hairy; peduncle 1.8–3 cm long, not fused to petiole; bracts dark green, opposite, in pairs, leaf-like, 10–20 × 9–15 mm; pedicels pale green, sometimes greenish maroon or downy, shortly fused to the petiole, 1–2 cm long, sparsely glandular hairy. **Calyx** pale green, clasping the tube, lobes narrowly triangular or very narrowly ovate, 5–6 mm long, 1–2 mm wide, margin ciliate, outer surface glandular and eglandular hairy. **Corolla** very sparsely hairy outside, corolla tube usually lilac or pale purple, sometimes dark purple, 1.4–2 cm long, slightly curved, 2–3 mm wide at the base, throat dark red; lobes plain or very faintly striped, upper lobe sometimes dark or violet blue, the lower lobes dark pink or dark purple, upper lobes triangular, not spreading, 3–3.5 × 5–6 mm, lower lateral lobes elliptic, 5–6 × 4–5 mm, lower central lobe elliptic, 5–6 × 8–9 mm. **Stamens**: filaments white, inserted at 6–10 mm from the base of the corolla, c. 6 mm long, straight, glabrous; anthers purplish white or dark purple; anther-thecae divergent, 1–2 mm long; staminodes 2, white, vestigial, inserted at 6–7 mm from the base of the corolla tube, 4–5 mm long, hairy, sometimes glabrous. **Nectary** cream or pale yellow, entirely cylindrical, to 1 mm long. **Pistil** whitish green; ovary 5–9 mm long, 1.5 mm wide at the base, narrowing to 0.5 mm below the stigma, glabrous; style to 6 mm long; stigma pale brown or whitish purple, shallowly bilobed, 1–2 mm long, slightly bent backwards when mature, with very fine papillose hairs above; ovules cream, less than 1 mm long. **Capsule** pale to dark green, to 5.5 cm long, 1–2.5 mm wide, slightly curved, erect or horizontal, glabrous, slightly hairy towards tip; calyx persistent, green, hairy. **Seeds** yellowish cream to brown, many, 315–380 × 120–250 µm, narrowly ellipsoid to broadly ellipsoid, surface canaliculate, each testa cell or square with up to 6 knobs or bumps.

Distribution. Peninsular Thailand, Cambodia, southern Vietnam and Malaysia (Kedah, Kelantan and Pahang).

Habitat and ecology. Growing in limestone crevices and shady places. On Langkawi, Kedah, on limestone hills by the sea and, inland, at the base of limestone cliffs or on rich damp soil around cave mouths.

Provisional IUCN conservation status. Least Concern (LC). Populations occur in Taman Negara (The National Park) and it is the most common species found in the northern and eastern part of Malay Peninsula.

Additional specimens examined. PENINSULAR MALAYSIA. **Kedah:** Gn. Inas F.R., 30 Oct 2007, *Imin FRI 58583* (KEP); Gn. Keriang, 6 Nov 2009, *Rafidah FRI 64418* (KEP); *ibidem*, 1898, Ridley s.n. (SING); Langkawi, Sep 1924, *Burkill 1493* (SING); *ibidem*, 1978, *Keng 79* (SING); Langkawi, P. Buyong, 3 Nov 2009, *Rafidah FRI 64395* (KEP); Langkawi, P. Jerkom, 17 Nov 1941, *Corner s.n.* (SING); Langkawi, P. Langgun, Feb 1989, Tay 155 (SING); Langkawi, P. Timun, 3 Nov 2009, *Rafidah FRI 64394* (KEP); Ulu Muda F.R., Gua Labua, 4 Mar 2008, *Rafidah FRI 55687* (KEP). **Kelantan:** Elephant Cave, 15 May 1990, *Kiew RK 2948* (KEP); Gn. Reng, 14 Jan 2010, *Rafidah FRI 64448* (KEP); Gua Batu Boh, 4 Mar 2008, *Chew FRI 58699* (KEP); *ibidem*, 3 Aug 1962, UNESCO 268 (SING); Gua Ikan, 14 May 1990, *Kiew RK 2940* (SING); Gua Setir, 19 May 1990, *Kiew RK 3038* (SING); *ibidem*, 12 Jan 2010, *Rafidah FRI 64426* (KEP); Kuala Betis, 15 Feb 2003, *Kiew RK 5253A* (SING); Batu Papan F.R., 9 May 1990, *Kiew RK 2885* (SING); Gua Batu Boh, Gua Chawan, 14 Mar 2000, *Kiew RK 4195* (SING); Sg. Jenera, 10 May 1990, *Kiew RK 2896* (KEP); Sg. Keteh, Gua Ninik, 18 Feb 1924, *Nur 12130* (SING); Sg. Nenggiri, P. Raba, 12 May 1990, *Kiew RK 2920* (SING). **Pahang:** Kuala Lipis, 27 Apr 1996, *Kiew RK 3913* (KEP); Gua Bama, 25 Aug 2008, *Mohd Hairul FRI 60062* (KEP); *ibidem*, 3 Apr 2008, *Rafidah FRI 55728* (KEP); Gua Tipus, Oct 1927, Henderson SFN 19403 (SING); Taman Negara, Batu Kanok, 9 Oct 1984, *Kiew RK 1505* (SING); Taman Negara, Batu Subuh, 5 Oct 1984, *Dawn RK 1472* (KEP); *ibidem*, 5 Oct 1984, *Dawn RK 1474* (KEP); *ibidem*, 8 Oct 1984, *Kiew RK 1491* (KEP); Taman Negara, Batu Kepayang, 3 Oct 1984, *Kiew RK 1424* (KEP); Taman Negara, Bkt. Batu Luas, 2 Oct 1984, *Kiew RK 1404* (KEP); *ibidem*, 11 Oct 1984, *Kiew RK 1537* (KEP). THAILAND. 1901, *Curtis 3221* (SING); Kau Hoa Kwai, Tassateng, *Seidenfaden 2134* (SING).

Notes. *Microchirita involucrata* is most common in the northern and eastern part of the Malay Peninsula, especially in Kelantan, where it replaces *M. caliginosa*. Unusual plants with whitish flowers and 4 stamens were recorded from Gunung Reng, Kelantan.

3. *Microchirita rupestris* (Ridl.) A. Weber & Rafidah, *Taxon* 60: 779 (2011). – *Chirita rupestris* Ridl., J. Straits Branch Roy. Asiat. Soc. 44: 60 (1905); Ridley, J. Asiat. Soc. Bengal 74: 766 (1908); Craib, *Curtis's Bot. Mag.* 136: t. 8333 (1910); Ridley, Fl. Malay Penins. 2: 525 (1923); Henderson, Malay. Wild Fls., Dicots. 349 (1959); Wood, Notes Roy. Bot. Gard. Edinburgh 33: 201 (1974). – TYPE: Malaysia, Peninsular Malaysia, Kedah, Langkawi, November 1889, *Curtis 2120* (lectotype SING [SING0042989], designated here by Carmen Puglisi; isolectotype SING [SING0042990]). (Fig. 2E–F, 3E–F, 7)

Chirita glasgovii Ridl., J. Straits Branch Roy. Asiat. Soc. 44: 60 (1905); Ridley, J. Asiat. Soc. Bengal 74: 766 (1908); Ridley, Fl. Malay Penins. 2: 526 (1923). – TYPE: Malaysia, Peninsular Malaysia, Perak, Waterloo Estate, December 1897, *Robertson-Glasgow s.n.* (holotype SING).

Erect, monopodial, herbaceous, short-lived plant, axillary branches sometimes present. **Stems** greenish purple or pale green, to 25 cm tall, 5 mm diameter, starting to flower when 2-leaved, slightly curved at the root base, finely hairy; internodes not swollen, 5.5–8 cm long. **Leaves** decussate; petiole green sometimes reddish green, to 6 cm long,

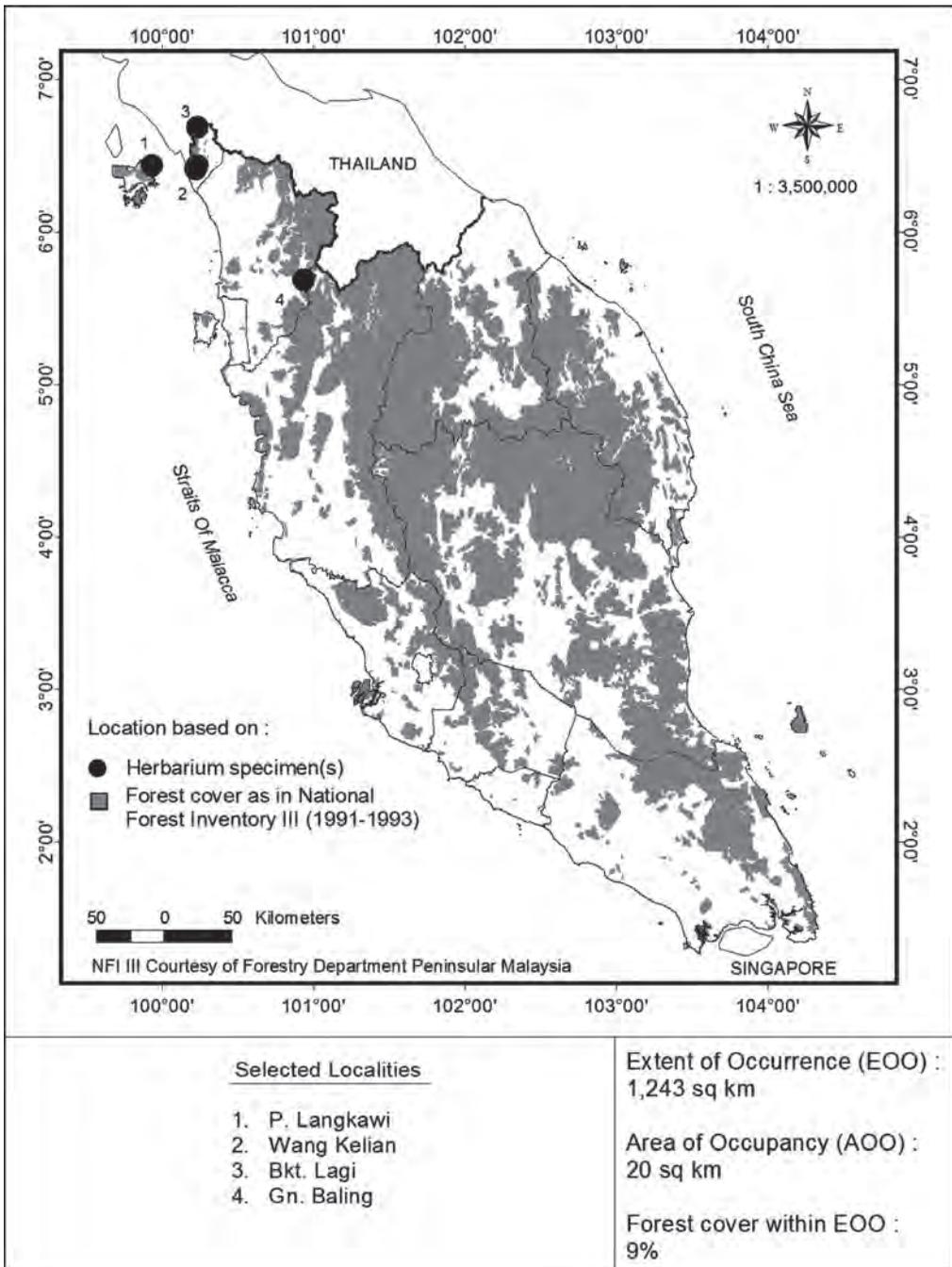


Fig. 7. Distribution of *Microchirita rupestris* (Ridl.) A. Weber & Rafidah in Peninsular Malaysia.

shortly hairy; lamina ovate, sometimes obovate or lanceolate, 8–14 × 4.5–6.6 cm, yellowish green to dark green above, pale green to whitish green beneath, coriaceous when fresh and dried, sparsely strigose hairy on both surfaces, base oblique, unequal, margin shallowly serrate, apex acute; midrib sunken above, prominent beneath, lateral veins 6–8 pairs on each side of the midrib, intercostal veins reticulate. **Inflorescence** axillary, branched cyme, with up to 6 flowers; peduncles, bracts and pedicels with pubescent hairs; peduncles reddish green or pale green, to 5 cm long, not adnate to petiole; bracts dark green above, pale green or whitish green beneath, 1.2–3.5 × 1.2–3 cm, connate-perfoliate, margin serrate; pedicels green, to 1 cm long. **Calyx** pale green, clasping the tube, lobes narrowly triangular, 8–11 mm long, 7–11 mm wide, outer surface ciliate, inner surface glabrous. **Corolla** sparsely hairy outside with a cluster of hairs in the mouth of the tube above the anthers, hairs not bead-like, tube lilac, pale purple or white outside, throat whitish, 1.5–2.8 cm long, curved downwards; lobes faintly striped, dark purple, bluish purple, lilac or white, with 2 yellow patches on the lower lobes, upper lobe sometimes dark or violet blue, the lower lobes dark pink or dark purple, upper lobes elliptic, not spreading, 4–5 × 5–6 mm, lower lateral lobes elliptic, 5–6 × 4–5 mm, lower central lobe elliptic, 5–6 × 8–10 mm. **Stamens**: filaments slightly geniculate at the point of attachment, whitish with black-brown spots at the knees, inserted at 6–10 mm from the base of the corolla, 4–5.5 mm long; anthers cream with a purple mark, anther-thecae divergent, 2–3 mm long, with reflexed hairs to 2 mm long on the lower surface; staminodes 2, brown, inserted at 6 mm above the base of the corolla, less than 4 mm long, glabrous. **Nectary** pale green, a complete ring, up to 1.1 mm deep. **Pistil** light green; ovary 9–10 mm long, 0.5 mm wide at the base, narrowing to 0.2 mm below the stigma, hairs glandular; style to 4 mm long; stigma deeply 2-lobed, 2 mm long, very fine glandular hairy (abaxial), slightly papillose (adaxial); ovules cream, less than 1 mm long. **Capsule** green, to 8 cm long, slender, erect; calyx persistent, pale to dark green, hairy. **Seeds** yellowish cream, 324–385 × 170–220 µm, ellipsoid, papillate or canaliculate.

Distribution. Southern, western and northern Thailand, Peninsular Malaysia (Kedah, Perak and Perlis).

Habitat and ecology. On limestone cliffs or rock faces. On Langkawi on limestone by the sea and, inland, at cave mouths or on rich damp or thinner soil layers at base of limestone cliffs.

Provisional IUCN conservation status. Vulnerable VU B1ab(iii) in Peninsular Malaysia. In Peninsular Malaysia *Microchirita rupestris* has a patchy distribution in Kedah (Gunung Baling and some parts of Langkawi), Perak (Waterloo Estate) and Perlis, but none lie within the network of Totally Protected Areas. It is vulnerable because it inhabits limestone cliffs and rock faces, cave mouths, rich damp soil at the base of limestone hills, or, in Langkawi, commonly on limestone by the sea that is sensitive to disturbance. Although limestone is quarried on the main island of

Langkawi, populations of this species are safe from quarrying on the smaller islands. However, there also other threats, such as from environmental destruction caused by tourism infrastructure and other development activities. The major threats on Gunung Baling are also from quarrying. In neighbouring Thailand this species is common and widespread (Middleton, pers. comm.).

Additional specimens examined. PENINSULAR MALAYSIA: **Kedah:** Gn. Baling, 25 Nov 1941, *Corner s.n.* (SING); ibidem, 1 Nov 2008, Imin FRI 63180 (KEP); Gn. Keriang, 6 Nov 2009, Rafidah FRI 64419 (KEP); Langkawi, Nov 1941, *Corner s.n.* (SING); ibidem, 1979, Stone 14294 (KLU); Langkawi, Gua Cerita, 4 Nov 2009, Rafidah FRI 64399 (KEP); Langkawi, P. Langgun, 4 Nov 2009, *Rafidah FRI 64397* (KEP); ibidem, 6 Nov 2009, *Rafidah FRI 64419* (KEP); ibidem, Feb 1989, *Tay 149* (SING); Langkawi, Selat Panchor Air, Ahmad Saktian Langgang C120 (KLU). **Perlis:** Bkt. Lagi, 16 Nov 1929, *Henderson SFN 22816* (SING); ibidem, 16 Nov 1929, *Henderson SFN 22848* (SING); Gua Cenderawasih, 25 Nov 1929, *Haniff 7559* (SING); ibidem, 9 Jan 2007, Phoon FRI 53210 (KEP, SING); Wang Kelian, 29 Nov 2000, *Kiew RK 5149* (KEP, SING).

Notes. *Microchirita rupestris* is not commonly found in Malaysia and has a narrow distribution, being found only west of the Main Range. The population from Gunung Baling, Kedah, was recorded with whitish flowers. *Chirita glasgovii* Ridl. is based on material collected at Waterloo, Perak but the type material is not distinct from *Microchirita rupestris*. An attempt was made to re-collect the species from a limestone area close to the type locality to confirm this decision but this was unsuccessful.

4. *Microchirita ruthiae* Rafidah, *Nordic J. Bot.* 31: 612 (2013). – TYPE: Peninsular Malaysia, Kelantan, Jeli, Gunung Reng, 24 October 2009, *Rafidah FRI 64385* (holotype KEP; isotypes E, SING). (Fig. 2B–H, 3G–H, 8)

Caulescent, herbaceous, branched plant. **Stems** pale green or whitish green, flowering at c. 10 cm tall, erect or sub-erect to 30 cm, 6–8 mm diam., sparsely to densely hairy, internodes 3.5–6.5 cm long, hairs eglandular, whitish. **Leaves** opposite, decussate; petiole pale green, 5–15 mm long, hairs eglandular; lamina ovate or elliptic, 6.5–14.5 × 6–6.5 cm, dark green, yellowish green above, pale green to whitish beneath, thinly coriaceous, pubescent, base cuneate, sometimes unequal, margin serrate, apex acute; midrib sunken above, prominent beneath, lateral veins 6–7 pairs on each side of the midrib, hairy, intercostal veins reticulate. **Inflorescence** epiphyllous (axillary), 1–4-flowered, flowering from petiole base; bracts absent; pedicels very pale green, shortly fused to the petiole, to 5–15 mm long, glandular hairy. **Calyx** pale green at base, dark green towards tip, clasping the corolla tube, lobes 8–10 mm long, 1–2 mm wide, apex acute, margin entire, hairy, outer surface glandular and eglandular hairy. **Corolla** tube very sparsely hairy outside, whitish, pale green, or sometimes dull purple, 2–2.5 cm long, slightly curved, throat very pale green to whitish green, glandular hairs above the anthers, glistening; lobes faintly striped, whitish, sometimes very pale

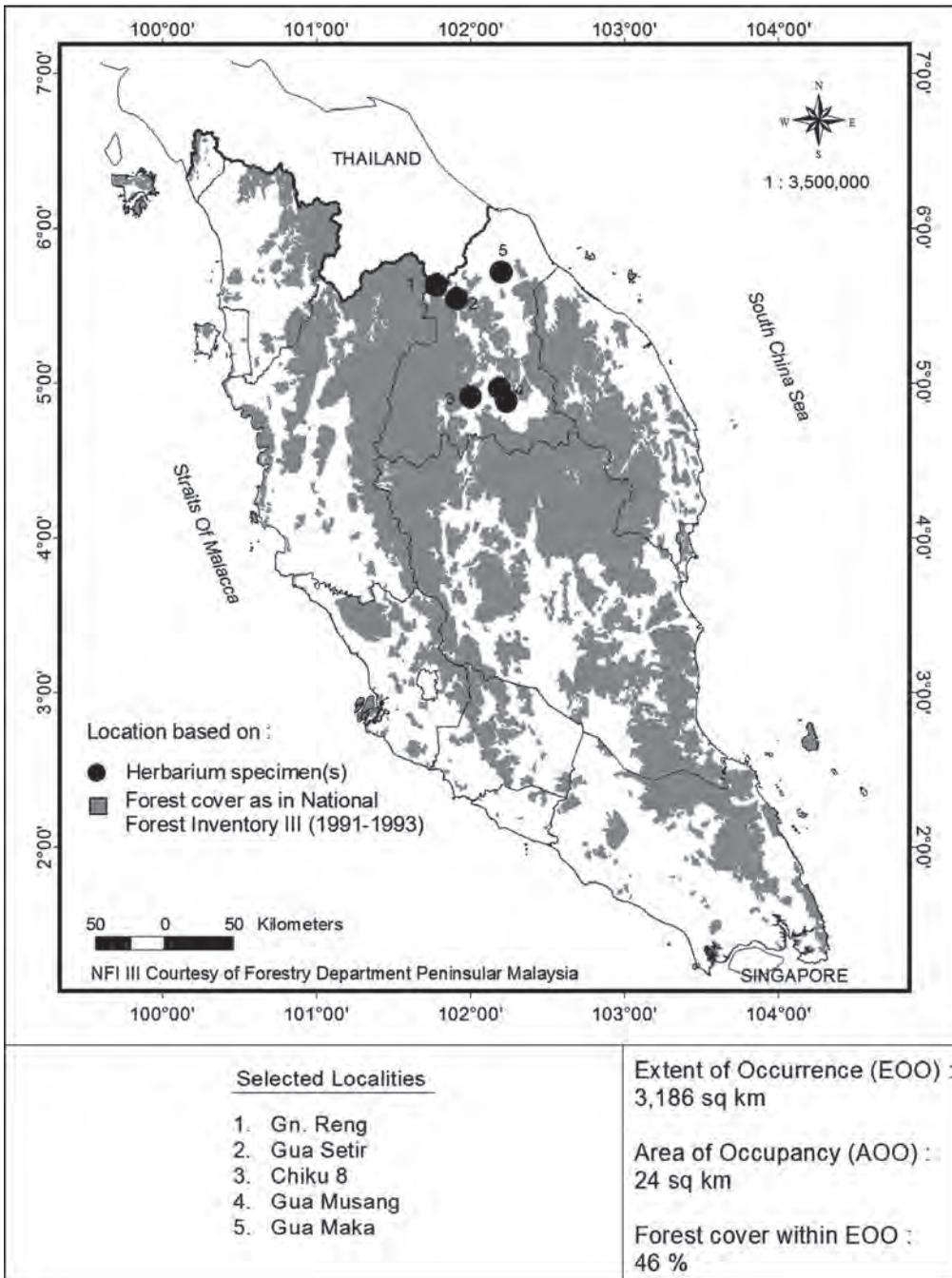


Fig. 8. Distribution of *Microchirita ruthiae* Rafidah in Peninsular Malaysia.

purple, upper lobes rounded, spreading, slightly cleft at apex of each lobe, 4–5 × 5–7 mm, lower lateral lobes rounded, 4–5 × 5–7 mm, lower central lobe elliptic, elongated, 6–8 × 8–10 mm. **Stamens**: filaments pale green, inserted at 6–8 mm from the base of the corolla, 3–4 mm long, straight, glabrous; anther-thecae divergent, 1–2 mm long, yellow, not joined, with long reflexed hairs on the lower surface; staminodes 2 (rarely 3), pale green, inserted at 6 mm from the base of the corolla tube, 1.5–2 mm long. **Nectary** pale yellow or cream, less than 1 mm deep. **Pistil** pale green; ovary 1–1.4 cm long, c. 1.5 mm wide at the base, narrowing to 0.5 mm below the stigma, glandular and eglandular hairy; style 6–8 mm long; stigma deeply 2-lobed, c. 2 mm long, 4 mm wide, inserted between the anthers, very fine densely papillose hairy; ovules cream, less than 1 mm long. **Capsule** green, 3–5.5 cm long, 2–3 mm wide, slender, erect, densely hairy; calyx persistent, pale green, hairy. **Seeds** yellowish cream, 325–440 × 190–220 µm, broadly ovate or elliptic, slightly elongate with papillate surface.

Distribution. Endemic in Peninsular Malaysia: Kelantan.

Habitat and ecology. On limestone cliffs, crevices or soil pockets at base of limestone. Some plants grow in places directly exposed to sunlight but most grow in shaded habitats.

Provisional IUCN conservation status. Endangered EN B1ab(iii). None of the six Kelantan limestone hills where this species is found lie within the network of Totally Protected Areas. The species is prone to disturbance because it grows on limestone cliffs, in crevices or in soil pockets at the base of hills and the surrounding areas are plantations with associated disturbance and microclimate changes. On Gunung Reng it is additionally disturbed by recreational activities. None of these localities is protected by a buffer zone.

Additional specimens examined. PENINSULAR MALAYSIA: **Kelantan**: Chiku 8, 24 May 1990, *Kiew RK 3112* (KEP, SING); Gua Musang, Batu Serai, 17 May 1990, *Kiew RK 2996* (SING); Gn. Reng, 18 May 1990, *Kiew RK 2008* (KEP); ibidem, 14 Jan 2010, Rafidah FRI 64448 (KEP); ibidem, 7 Aug 1984, *Weber UPM 3453* (KEP); Gua Maka, 19 May 1990, *Kiew RK 3022* (KEP); Gua Setir, 13 Jan 2010, Rafidah FRI 64441 (KEP).

Notes. *Microchirita ruthiae* occurs only east of the Main Range. Sterile material of *Microchirita ruthiae* superficially looks similar to *M. sericea*.

5. *Microchirita sericea* (Ridl.) A. Weber & Rafidah, *Taxon* 60: 779 (2011). – *Chirita sericea* Ridl., *J. Straits Branch Roy. Asiat. Soc.* 43: 59 (1905); Ridley, *J. Asiat. Soc. Bengal* 74: 764 (1908); Ridley, *Fl. Malay Penins.* 2: 525 (1923); Wood, *Notes Roy. Bot. Gard. Edinburgh* 33: 187 (1974). – TYPE: Malaysia, Peninsular Malaysia, Perak, Ipoh, August 1898, *Curtis 3131* (lectotype SING [SING0042991], designated here; isolectotype SING [SING0042992]). (Fig. 2H, 3I–J, 9)

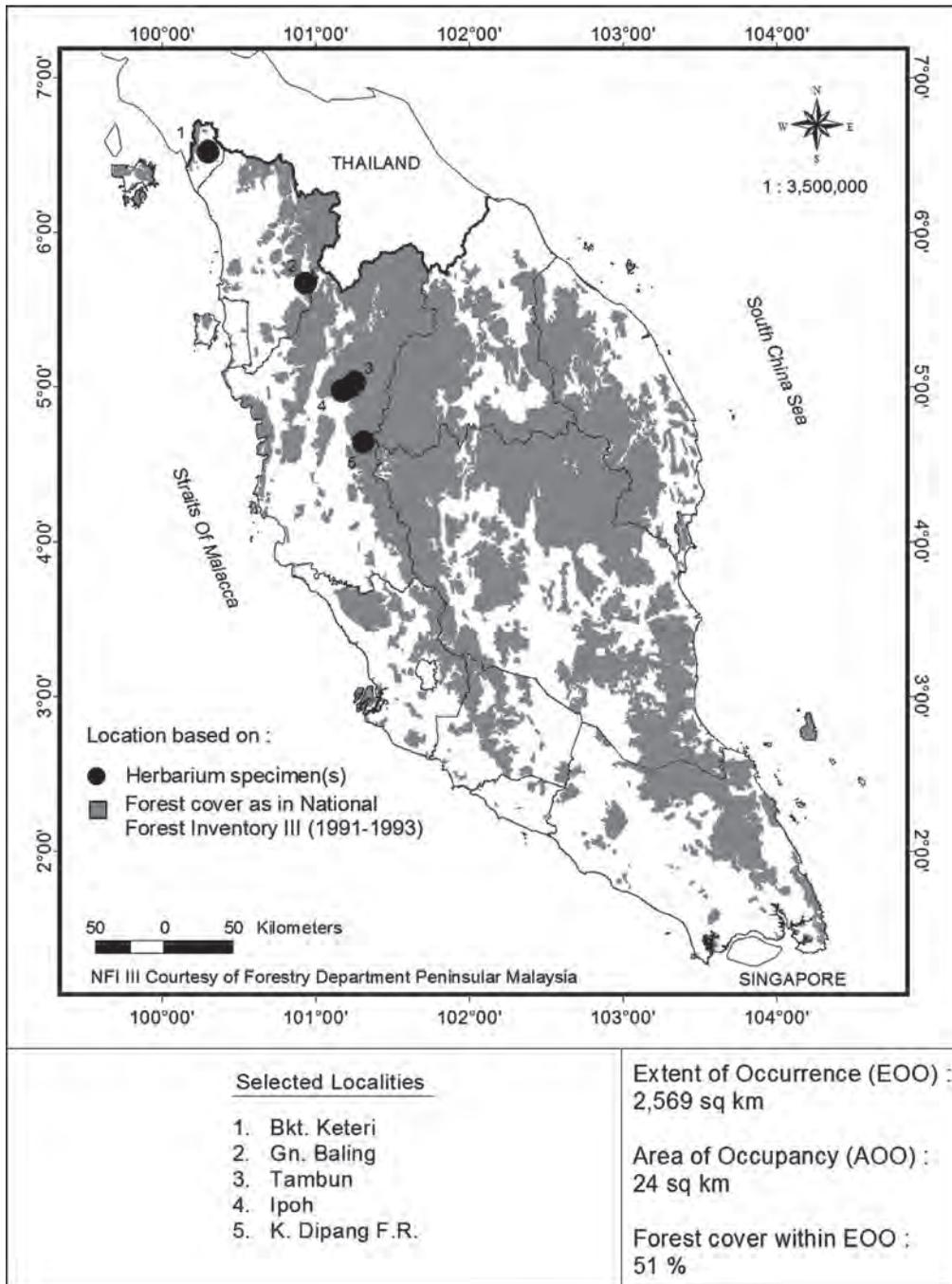


Fig. 9. Distribution of *Microchirita sericea* (Ridl.) A. Weber & Rafidah in Peninsular Malaysia.

Chirita sericea var. *scortechinii* Ridl., J. Straits Branch Roy. Asiat. Soc. 43: 59 (1905). – TYPE: Peninsular Malaysia, Perak, 1884, *Scortechini 112b* (lectotype K, designated by Wood (1974); isolectotype SING).

Herbaceous, apparently perennial plant. Stems, leaves and inflorescence densely hairy with eglandular white or downy hairs. **Stems** woody, pale green, sometimes reddish green, creeping to 30 cm long, internodes to 5.5 cm long. **Leaves** opposite; petiole pale green, to 2.2 cm long; lamina narrowly elliptic or narrowly ovate, 4–11 × 1–4 cm, pale green above, very pale green or whitish green beneath, coriaceous when fresh and dry, densely sericeous hairs on both surfaces, base attenuate, or sometimes cordate or unequal, margin serrulate, apex acuminate or acute; midrib sunken above, prominent beneath, lateral veins 5–10 pairs on each side of the midrib, intercostal veins reticulate. **Inflorescences** epiphyllous, 1–4-flowered; bracts absent; pedicels pale green, shortly fused to the short petiole, 2–3 cm long. **Calyx** pale green, clasping the corolla tube, lobes narrowly triangular, 16–20 mm long, 2–3 mm wide, outer surface densely hairy. **Corolla** hairy outside, tube pale blue, lilac or white, to 2.6 cm long, narrowly tubular, slightly curved, not pouched, throat yellow, glandular hairs translucent brown, positioned above the anthers; lobes conspicuously striped, upper lobes rounded, not spreading, 3.5–5 × 5–6 mm, lower lateral lobes elliptic, 5–6 × 5–7 mm, lower central lobe elliptic, elongated, 6.5–8 × 8–10 mm. **Stamens**: filaments brown, inserted 1.1–1.4 cm from the base of the corolla, 4–8 mm long, slightly geniculate proximally; anthers very pale green, sometimes brown, anther-thecae divergent, 2–3 mm long, fused apically, with reflexed hairs on the lower surface; staminodes 2, cream, inserted 1.1–1.4 cm from the base of the corolla tube, to 2 mm long. **Nectary** pale green or cream, 2–3 mm long, margin entire. **Pistil** pale green, densely eglandular hairy; ovary 15–20 × 1–2 mm; style 1–1.2 cm long; stigma slightly 2-lobed, heart-shaped, to 2 mm long, abaxially velvety, adaxial with very fine papillose hairs. **Capsule** whitish green, to 7 cm long, cylindrical slender, slightly curved; calyx persistent, green, hairy. **Seeds** yellowish cream, many in one row, 300–380 × 120–250 µm, broadly elliptic, rounded, surface papillate or canaliculate.

Distribution. Endemic to Peninsular Malaysia (Perak, Perlis and Kedah).

Habitat & ecology. On limestone cliffs or rocks, in dry places at the foot of limestone cliffs, often under overhangs or near caves.

Provisional IUCN conservation status. Endangered EN B1ab(iii). This species does not grow within the network of Totally Protected Areas and has a narrow distribution. The populations are restricted to a few hills in Perak, i.e. Kuala Dipang, Ipoh limestone and one record from Gunung Baling, Kedah. The last collection from Gunung Baling was made in 1941 and recent field trips did not re-locate it from that area. Part of Gunung Baling is currently disturbed by quarrying activity. In Perak, no karst hill is protected and many hills are actively being quarried or the flora is being degraded by resort or recreational development or through activities related to temples (Kiew et al., 2011).

Additional specimens examined. PENINSULAR MALAYSIA: **Kedah:** Gn. Baling, 25 Nov 1941, *Corner s.n.* (SING). **Perak:** Gn. Rapat, 21 Jul 2009, *Rafidah FRI 64347* (KEP); ibidem, 26 May 2010, *Rafidah FRI 64544* (KEP); Gn. Tasek, Perak Tong Temple, 21 Jul 2009, *Rafidah FRI 64348* (KEP); ibidem, 23 Oct 1958, *Sinclair 9844* (SING); Ipoh, 4 Jul 1917, *Burkill 2552* (SING); ibidem, Aug 1898, *Corner s.n.* (KEP); ibidem, Feb 1904, *Ridley 11952* (SING); ibidem, Feb 1904, *Ridley s.n.* (KEP); ibidem, 18 Aug 1986, *Weber UPM 4167* (KEP); ibidem, 18 Aug 1986, *Weber s.n.* (KEP); Kuala Dipang F.R., 1898, *Ridley s.n.* (SING); Tambun, 10 Sep 1920, *Burkill 6284* (SING); Sg. Siput Utara, 29 Jan 2015, *Rafidah FRI 82017* (KEP). **Perlis:** Bkt. Keteri, 28 Nov 2013, *Rafidah FRI 75880* (KEP).

Notes. *Microchirita sericea* occurs west of the Main Range, replacing *M. rupestris* in the south.

6. *Microchirita viola* (Ridl.) A. Weber & Rafidah, *Taxon* 60: 779 (2011). – *Chirita viola* Ridl., *J. Linn. Soc., Bot.* 32: 516 (1896); *Ridley, J. Straits Branch Roy. Asiat. Soc.* 43: 58 (1905); *Ridley, Fl. Malay Penins.* 2: 525 (1923); *Henderson, Malay. Wild Fls., Dicots.* 350 (1959); *Wood, Notes Roy. Bot. Gard. Edinburgh* 33: 190 (1974). – TYPE: Malaysia, Peninsular Malaysia, Kedah, Langkawi, Sep 1890, *Curtis 2570* (lectotype SING [SING0042993], designated here; isoelectotypes SING [SING0042994, SING0042995]). (Fig. 2H, 3K–L, 10)

Chirita hamosa auct. non R.Br.: *Wood, Notes Roy. Bot. Gard. Edinburgh* 33: 191 (1974), *pro parte.*

Short-lived, caulescent, branching herbs. **Stems** reddish or pale green, beginning to flower at the one-leaf stage, to 30 cm tall, 5–7 mm diam., internodes swollen, to 10 cm long, finely hairy. **Leaves** opposite, decussate; petiole pale green, sometimes reddish, to 6 mm long, with glandular hairs; lamina ovate, sometimes orbicular, 3–8.5 × 2–5.5 cm, yellowish green to pale green above, whitish green or reddish beneath, coriaceous when fresh and dry, sparsely strigose hairy on both surfaces, base slightly cordate or rounded, margin serrate, apex acute; midrib sunken above, prominent beneath, lateral veins 6–16 pairs on each side of the midrib, intercostal veins reticulate. **Inflorescence** crested epiphyllous, up to 3 2-paired flowers; bracts absent; pedicels fused to the petioles, green or reddish, to 1 cm long, glandular and eglandular hairy. **Calyx** green or reddish green, lobes narrowly ovate, 7–10 mm long, c. 1 mm wide, outer surface ciliate, inner surface glabrous. **Corolla** tube pale violet, sparsely hairy outside, 2–2.2 cm long, curved downwards, throat very pale purple, glandular bead-like golden yellow hairs, to 1.5 mm long, apically swollen in a cluster in the throat above the anthers; lobes violet, each with conspicuous dark purple stripes, upper lobes rounded, slightly imbricate, not spreading, 4–5 × 3.5–5 mm, lower lateral lobes elliptic, spreading, 5–6 × 4.5–6 mm, lower central lobe elliptic, elongated, curved downwards, 6.5–10 × 4.5–6 mm. **Stamens:** filaments white, sometimes reddish at base, inserted at 5–8 mm from the base of the corolla, 1.8–2 mm long, slightly geniculate at the point of attachment;

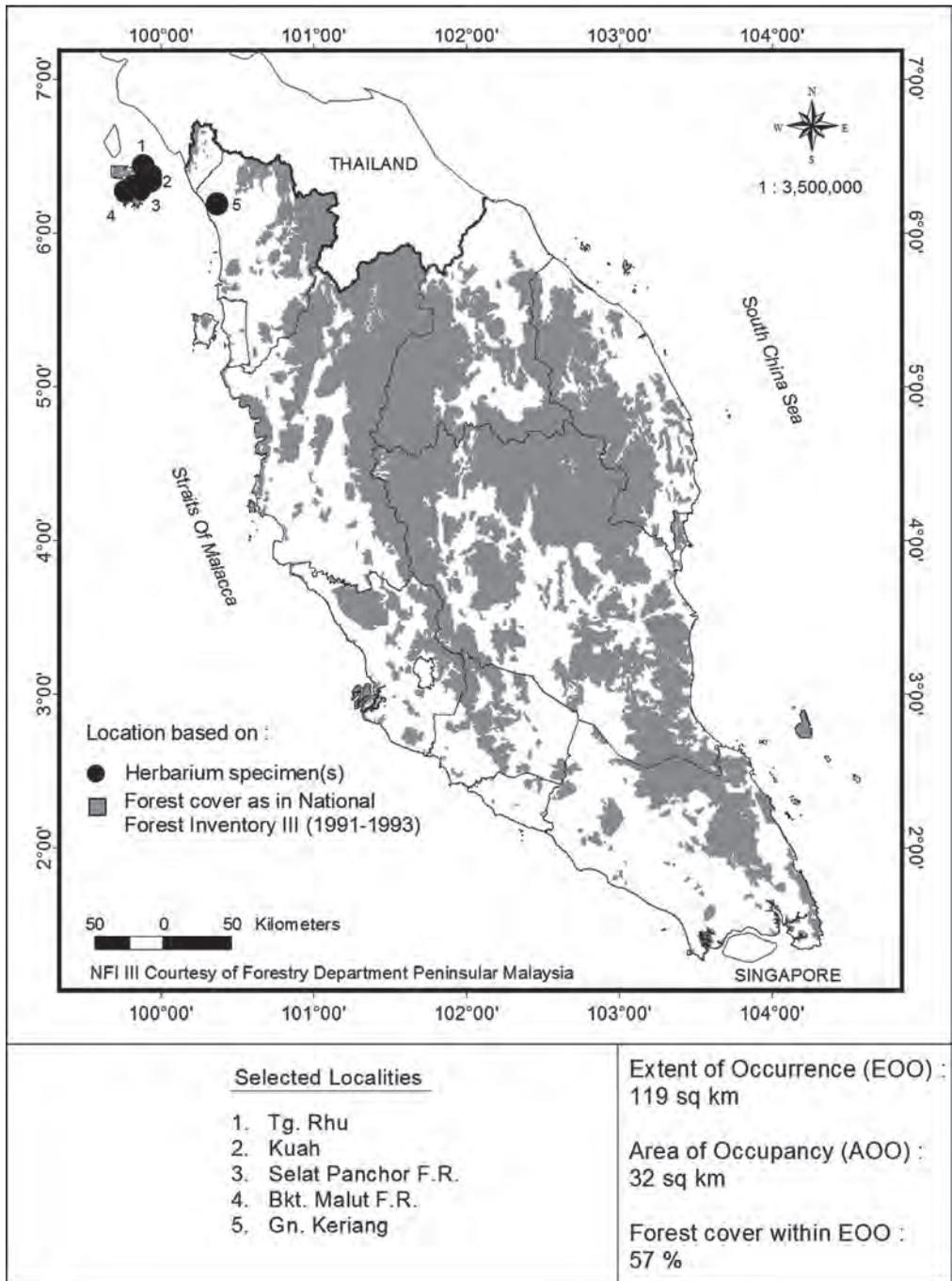


Fig. 10. Distribution of *Microchirita viola* (Ridl.) A. Weber & Rafidah in Peninsular Malaysia.

anthers pale yellow with purple markings, anther-thecae joined apically, 1.5–1.7 mm long; staminodes 2 or 3, unequal in size, white, inserted 5–8 mm above the base of the corolla, 1.3–2.2 mm long. *Nectary* cream, to 1.1 mm long. *Pistil* very pale green; ovary 4–5 mm long, 0.5 mm wide at the base, narrowing to 2 mm below the stigma, eglandular hairy; style to 4 mm long; stigma pale yellow, shallowly 2-lobed, c. 2 mm long, very fine glandular hairy; ovules cream, less than 1 mm long. *Capsule* pale green or reddish green, to 5 cm long, cylindrical and slender, sparsely hairy, sometimes glabrous; calyx persistent, reddish green, hairy. *Seeds* yellowish cream, many in one row, 600–710 × 200–280 µm, very narrowly ellipsoid, surface rounded papillate.

Distribution. Peninsular Thailand and Peninsular Malaysia (Kedah: Langkawi and Gunung Keriang).

Habitat and ecology. On limestone cliffs or crevices with a thin soil layer or, on Langkawi, on limestone rocks near the sea.

Provisional IUCN conservation status. Near Threatened (NT). The species is common on Langkawi Island, much of which is protected. Its Near Threatened status is based on its localised and patchy distribution on Langkawi Island. The species flowers abundantly from October to December in the wettest period. Previously it was recorded in Gunung Keriang on the Kedah mainland but it has not been recollected in spite of recent botanical collecting there.

Additional specimens examined. PENINSULAR MALAYSIA: **Kedah:** Gn. Keriang, Feb 1890, *Allen s.n.* (SING); Langkawi, 20 Nov 1941, *Corner s.n.* (SING); Langkawi, Ayer Hangat, *Chung 505* (KLU); Langkawi, Bkt. Malut F.R., 4 Nov 1968, Keng 80 (SING); Langkawi, Batu Puteh, Aug 1941, Nauen 38120 (SING); Langkawi, Kuah, 8 Nov 1968, *Chung RC 7* (KEP); *ibidem*, 5 Nov 2009, *Rafidah FRI 64407* (KEP); *ibidem*, 1979, Stone 14349 (KLU); Langkawi, P. Langgun, 4 Nov 2009, *Rafidah FRI 64398* (KEP); Langkawi, P. Timun, 1926, *Holtum 17433* (SING); Langkawi, Selat Panchor F.R., 19 Nov 1941, *Corner 37832* (SING); *ibidem*, 21 Nov 1934, *Henderson SFN 28931* (SING); *ibidem*, Nov 1934, *Henderson SFN 29185* (SING); *ibidem*, 3 Nov 2009, *Rafidah FRI 64388* (KEP); Langkawi, Tg. Rhu, 21 Nov 1993, *Anthonyamy SA 1144* (KEP, SING); Langkawi, Tg. Sawah, 22 Nov 1941, *Corner s.n.* (SING); Langkawi, Tg. Terai, 13 Nov 1941, *Corner s.n.* (SING).

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References

- Burtt, B.L. (1954). Studies in the Gesneriaceae of the world: Types and lectotypes of certain genera and groups of lower rank. *Notes Roy. Bot. Gard. Edinburgh* 21: 193–208.
- Chua, L.S.L. (2012). Conservation. In: Kiew, R., Chung, R.C.K., Saw, L.G. & Soepadmo, E. (eds) *Flora of Peninsular Malaysia Series II*, vol. 3, pp.3–10. Kepong: Forest Research Institute Malaysia.
- Chua, L.S.L. & Saw, L.G. (2006). *Malaysia Plant Red List: Guide for contributors*. Kepong: Forest Research Institute Malaysia.
- Chua, L.S.L., Kiew, R. & Chan, Y.M. (2009). Assessing conservation status of Peninsular Malaysian Begonias. *Blumea* 54: 94–98.
- Davis, S.D., Heywood, V.H. & Hamilton, A.C. (1995a). In: Davis, S.D., Heywood, V.H. & Hamilton, A.C. (eds) Limestone flora of Peninsular Malaysia. In: *Centres of Plant Diversity, a Guide and Strategy for Their Conservation*, vol. 2. Asia. Australasia and the Pacific, pp. 303–307. U.K., Cambridge: IUCN Publication Unit.
- Davis, S.D., Heywood, V.H. & Hamilton, A.C. (1995b). In: Davis, S.D., Heywood, V.H. & Hamilton, A.C. (eds) Limestone flora of Borneo. In: *Centres of Plant Diversity, a Guide and Strategy for Their Conservation*, vol. 2. Asia. Australasia and the Pacific, pp. 332–336. U.K., Cambridge: IUCN Publication Unit.
- Henderson, M.R. (1939). The flora of limestone hills of the Malay Peninsula. *J. Malayan Branch Roy. Asiat. Soc.* 17: 13–87.
- IUCN (2012). *The IUCN Red List Categories and Criteria*. Version 3.1 (2nd edition). Gland: IUCN Species Survival Commission, IUCN.
- Kiew, R. (1991). The Limestone Flora. In: Kiew (ed) *The State of Nature Conservation in Malaysia*, pp. 42–50. Kuala Lumpur: Malayan Nature Society.
- Kiew, R. (2004). The limestone flora of Sarawak. In: Yong, H.S., Ng, F.S.P. & Lee, E.Y.E. (eds) *Sarawak Bau limestone biodiversity*, pp. 79–89. *Sarawak Mus. J.* 59(80), Special issue 6. Kuching: Sarawak Museum Department.
- Kiew, R. (2009). The natural history of Malaysian Gesneriaceae. *Malayan Nat. J.* 61(3): 257–265.
- Kiew, R., Ummul-Nazrah, A.R. & Chua, L.S.L. (2011). Conservation status of *Paraboea* species (Gesneriaceae) in Malaysia. *Gard. Bull. Singapore* 63(1&2): 433–450.
- Middleton, D.J. & Triboun, P. (2013). New species of *Microchirita* (Gesneriaceae) from Thailand. *Thai Forest Bull., Bot.* 41: 13–22.
- Möller, M., Pfosser, M., Jandg, C.G., Mayer, V., Clark, A., Hollingsworth, M.L., Barfuss, M.J.H., Wang, Y.Z., Kiehn, M. & Weber, A. (2009). A preliminary phylogeny of the ‘Didymocarpoid Gesneriaceae’ based on three molecular data sets: Incongruence with available tribal classifications. *Amer. J. Bot.* 96(5): 989–1010.
- Price, L. (2001). *Caves and karst of Peninsular Malaysia*. Kuala Lumpur: Gua Publications.
- Puglisi, C., Middleton, D.J., & Suddee, S. (2016). Four new species of *Microchirita* (Gesneriaceae) from Thailand. *Kew Bull.* 71: 2–7.

- Rafidah, A.R. (2011). *Revision of Chirita (Gesneriaceae) for Peninsular Malaysia*. Unpublished MSc thesis, University of Malaya, Kuala Lumpur, Malaysia.
- Ramli, M.O. & Meor Abdul Rahman, M.T. (2014). Estimation of Sub-Surface Limestone Reserve Under Idle Ex-Mining Land in Perak. In: Taib, N.I. (ed) *Proceedings of the National Geoscience Conference 2014*, pp. 183–192. Kuala Lumpur: Geological Society of Malaysia.
- Ridley, H.N. (1905). The Gesneraceae of the Malay Peninsula. *J. Straits Branch Roy. Asiat. Soc.* 43: 1–92.
- Ridley, H.N. (1908). Gesneriaceae. In: King, G. & Gamble, J.S. (eds) *Materials for a Flora of the Malayan Peninsula*. *J. Asiat. Soc. Bengal* 74: 729–908.
- Ridley, H.N. (1923). Gesneriaceae. In: *The Flora of the Malay Peninsula*, vol. 2: 495–505. London: L. Reeve & Co.
- Saw, L.G., Chua, L.S.L. & Abdul Rahim, N. (2009). *Malaysia National Strategy for Plant Conservation*. Malaysia: Ministry of Natural Resources and the Environment & Forest Research Institute Malaysia.
- Thiers, B. (continuously updated). Index Herbariorum: A global directory of public herbaria and associated staff. New York Botanical Garden's Virtual Herbarium. <http://sweetgum.nybg.org/science/ih/>. Accessed 22 Nov. 2016.
- Wang, Y.Z., Mao, R.B., Liu, Y., Li, J.M., Dong, Y., Li, Z.Y. & Smith, J.F. (2011). Phylogenetic reconstruction of *Chirita* and allies (Gesneriaceae) with taxonomic treatments. *J. Syst. Evol.* 49, 1: 50–64.
- Weber, A., Middleton, D.J., Forrest, A., Kiew, R., Lim, C.L., Rafidah, A.R., Yao, T.L. & Möller, M. (2011). Molecular systematics and remodeling of *Chirita* and associated genera (Gesneriaceae). *Taxon* 60: 767–790.
- Wood, D. (1974) A revision of *Chirita* (Gesneriaceae). *Notes Roy. Bot. Gard. Edinburgh* 33: 123–205.

Appendix 1. Specimens Examined. Specimens are arranged by collector (with first initial, when known) in alphabetical order, followed by collector's number in numerical order (s.n. = without number), followed by the taxon number in the text.

- Ahmad Saktian Langgang 120 (3); Allen, M. s.n. (6); Anthonysamy, S. 379 (1), 842 (1), 1144 (6).
- Burkill, I.H. 1493 (2), 2253 (1), 2552 (5), 2558 (1), 6284 (5); Burt, B.L. 1665 (1).
- Chew, M.Y. 58699 (2); Chin, S.C. 331 (1), 390 (1), 505 (6), 2121 (6); Chung, R.C.K. 7 (6); Corner, E.J.H. 37832 (6), s.n. (2), s.n. (3), s.n. (5), s.n. (6); Curtis, C. 2120 (3), 2359 (1), 2570 (6), 3109 (1), 3131 (5), 3221 (2), s.n. (1).
- Davison, G.W.H. 4 (1); Dawn, J. 1470 (1), 1472 (2), 1474 (2); Ding, H. 715 (1).
- Evans. s.n. (1).
- Gordon, H.S. 435 (1).
- Hardial, S. 477 (1); Henderson, M.R. 19403 (2), 22419 (1), 22816 (3), 22848 (3), 25033 (1), 25223 (1), 25233 (1), 28931 (6), 29185 (6), s.n. (1); Holttum, R.E. 17433 (6).
- Imin, K. 58583 (2), 63180 (3), 63212 (1), 71983 (2).
- Julia, S. 26 (1).
- Kamarul Hisham, M. 67229 (1); Kehding in Beccari 73 (1); Kelsall, H. s.n. (1); Keng, H. 79 (2), 80 (6); Kiew, R. 1023 (1), 1202 (1), 1404 (2), 1424 (2), 1491 (2), 1505 (2), 1537 (2), 1557 (1), 1571 (1), 1587 (1), 2008 (4), 2158 (1), 2284 (1), 2339 (1), 2524 (1), 2885

(2), 2896 (2), 2920 (2), 2940 (2), 2948 (2), 2996 (4), 3022 (4), 3038 (2), 3112 (4), 3913 (2), 4915 (2), 5149 (3), 5253A (2), 65514 (1), 70496A (1), 70509 (1), *s.n.* (1); *King's collector*. 937 (1), 5028 (1), 7028 (1).

Lobb (1).

Maxwell, J.F. 78-131 (1); *Mills, G.R.* 15061 (1); *Mohd Hairul, M.A.* 54065 (3), 60062 (2), 72402 (3), 72449 (2); *Mohd. Haniff.* 7559 (3); *Mohd. Kasim, R.* 391 (1); *Mohd. Nur* 12130 (2), 34389 (1).

Nauen, J.C. 38120 (6); *Ng, F.S.P.* 1629 (1).

Phoon, S.N. 51570 (1), 53210 (3).

Rafidah, A.R. 55687 (2), 55713 (1), 55714 (1), 55717 (1), 55721 (1), 55724 (1), 55726 (1), 55728 (2), 64314 (2), 64319 (2), 64346 (5), 64347 (1), 64348 (5), 64349 (5), 64379 (1), 64385 (4), 64388 (6), 64394 (2), 64395 (2), 64397 (3), 64398 (6), 64399 (3), 64407 (6), 64417 (1), 64418 (2), 64419 (3), 64426 (2), 64441 (4), 64447 (2), 64544 (5), 64545 (1), 64582 (1), 64606 (1), 64638 (1), 82008 (1), 82017 (4); *Ridley, H.N.* 11952 (5), *s.n.* (1), *s.n.* (2), *s.n.* (5); *Robertson-Glasgow s.n.*(3).

Sam, Y.Y. 50118 (1); *Samsuri, A.* 560 (1); *Saw, L.G.* 36215 (1); *Scortechini, B.* 112b (5), 1582 (1); *Sinclair, J.* 9844 (5), 10732 (1), 40066 (1); *Smith, J.W.* 85205 (1); *Stone, B.C.* 8934 (1), 8794 (1), 14294 (3), 14349 (6); *Syahida-Emiza, S.* 66733 (1); *Symington, C.F.* 30796 (1), 37431 (1), 39598 (1).

Tay, E.P. 149 (3), 155 (2).

UNESCO. 268 (2).

Weber, A. 3453 (4), 4167 (5), 840807 (4).

Yap, S.K. 26 (1).

