

# *Orophea sichaikhani* (Annonaceae), a new species from southern Thailand, with a key to the species of *Orophea* in Thailand and notes on some species

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**Background and aims** – Recent botanical expeditions in Ranong Province, southern Thailand yielded unidentifiable collections of *Orophea* subgenus *Sphaerocarpon* (Annonaceae). To elucidate the taxonomic status of these collections, detailed morphological examinations and comparisons with morphologically similar species are made.

**Material and methods** – This study followed standard practices of herbarium taxonomy. Specimens of *Orophea* spp. in BKF, CMUB, L, and QBG herbaria were studied. Digitised type specimens deposited in BM, E, G, K, and L herbaria were accessed. A stereo microscope was used for morphological observations and measurements.

**Key results** – A new species *Orophea sichaikhani* is described and illustrated. The Peninsular Malaysian *O. hastata* and *O. kingiana* are the species most similar to the new species. *Orophea sichaikhani* is different from *O. hastata* in several traits: indumentum on ovaries and young twigs; length of pedicels, inner petals, and inner petal claw; and inner petal colour and tip. The new species differs from *O. kingiana* by having dissimilar colour and tip of inner petals; lower number of stamens and carpels per flower; and glabrous ovaries. Additionally, a key to the species of *Orophea* in Thailand and notes on certain species are provided.

**Keywords** – Annonaceae; Miliuseae; morphology; new species; *Orophea*; subgenus *Sphaerocarpon*; systematics; taxonomy; southern Thailand.

## INTRODUCTION

Annonaceae are a large pantropical angiosperm family with 108 genera and ca 2430 species (Chatrou et al. 2018). The genus *Winitia* Chaowasku is herein accepted, whereas the genus *Boutiquea* Le Thomas is not, following Guo et al. (2017). Two additional genera have been subsequently established: *Polyalthiopsis* Chaowasku (Chaowasku et al. 2018b) and *Leoheo* Chaowasku (Chaowasku et al. 2018a).

The genus *Orophea* Blume, along with 24 other genera, constitutes the Miliuseae, the largest tribe of subfamily Malmeoideae (Chatrou et al. 2012; Chaowasku et al. 2014, 2020; Guo et al. 2017). The monophyly of the genus has

been demonstrated (Guo et al. 2017), but its sister group remains obscure (Chaowasku et al. 2014, 2020; Guo et al. 2017). *Orophea* is principally recognised by the combination of (1) dissimilar petal whorls, the inner one being clawed towards the base and generally connivent at anthesis, (2) a reduced number of stamens and carpels per flower, and (3) loosely arranged stamens with a minute connective apex not covering the thecae (Keßler 1988; Leonardía & Keßler 2001). In addition, glands of various shapes are generally present on the adaxial surface of the inner petals (Keßler 1988; Leonardía & Keßler 2001). The genus, with ca 61 species (Turner 2018), is distributed from the Indian subcontinent through mainland Asia to the Southeast Asian islands; the

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Moluccas mark the eastern boundary of the genus (Keßler 1988). Two subgenera have been differentiated: subgenus *Orophea* with ellipsoid-cylindrical to cylindrical monocarps, which are moniliform when containing multiple seeds, and subgenus *Sphaerocarpon* Kessler with globose (rarely shortly oblongate) monocarps (Keßler 1988; Leonardia & Keßler 2001). Each subgenus has been shown to be monophyletic, but this is only based on a limited number of species per subgenus (Guo et al. 2017). However, when more species in each subgenus are added in a molecular phylogeny, each subgenus remains monophyletic with strong support (Anissara Damthongdee et al. unpubl. res.).

In the course of revising the genus for the flora of Thailand, unidentifiable specimens of *Orophea* subgenus *Sphaerocarpon* from Ranong Province, southern Thailand were collected. Comparisons with the morphologically most similar species reveal that these collections represent a new species, which is herein described. Furthermore, a key to the species of *Orophea* in Thailand and a discussion on additional species with doubtful identification (i.e. *O. enterocarpa* Maingay ex Hook.f. vs *O. fusca* Craib and *O. kerrii* Kessler vs *O. siamensis* Craib) are given.

## MATERIAL AND METHODS

Practices of standard herbarium taxonomy were conducted. Specimens studied were from BKF, CMUB, L, and QBG herbaria. Descriptions (and drawings) of *Orophea* spp. in the following publications were consulted: Hooker & Thomson (1872), King (1892), Craib (1922, 1925), Sinclair (1955), Keßler (1988, 1990), and Leonardia & Keßler (2001). Type specimens of relevant names were accessed via online platforms of BM, E, G, K, and L herbaria. The indumentum terminology of Hewson (1988) was followed. The word “circa (ca)” indicates a single observation/measurement. Measurements of flowers and a monocarp of the new species are based on fluid-preserved materials, whereas measurements of flowers of other *Orophea* spp. are based on rehydrated materials. Petal colours in the description are based on field notes.

## TAXONOMIC TREATMENT

***Orophea sichaikhanii*** Damth., Aongyong & Chaowasku, **sp. nov.** (figs 1–3) – Type: THAILAND • Ranong Province, Kraburi District, Tambon Pakchan, Ban Khlong Ngoen; ca 400 m; 17 Nov. 2018; fl.; *Sichaikhan* 6; holotype: CMUB; isotypes: BKF, QBG.

**Diagnosis** – *Orophea sichaikhanii* belongs to subgenus *Sphaerocarpon*, owing to the possession of a ± reticulate tertiary venation and a globose monocarp. By possessing similar leaf shape and size, inner petal shape, and nectary glands (number and shape) on the inner petal adaxial side, the Peninsular Malaysian *O. hastata* King and *O. kingiana* Leonardia & Kessler are morphologically most similar to the new species. *Orophea sichaikhanii* differs from *O. hastata* by having glabrous to subglabrous young twigs (vs sparsely to densely hairy), longer pedicels (10.5–15 mm vs ca 2 mm) and inner petals (11.5–13.5 mm vs 8–9 mm), shorter inner petal claw (1.5–2 mm vs ca 4 mm), dissimilar colour

of inner petals (greenish yellow, tip yellow vs dark red with dark yellow point), and glabrous ovaries (vs sparsely hairy). Compared to *O. kingiana*, the new species is also different in several features: inner petal colour (greenish yellow, tip yellow vs dark red), number of stamens (9 vs 12) and carpels (11 or 14 vs 18) per flower, and indumentum on ovaries (absent vs sparse). In addition, the inner petal tip (both surfaces) of *O. sichaikhanii* is smooth, while it is slightly warty in *O. hastata* and *O. kingiana*.

**Description** – **Treelets** ca 2.5 m tall. **Young twigs** glabrous to subglabrous. **Petioles** 5–8 mm, grooved on upper surface, glabrous on both surfaces; **leaves** subcoriaceous, elliptic, larger blades 8.7–21.5 × 3.5–9 cm, base cuneate to broadly cuneate, apex caudate-acuminate (acumen usually 15–20 mm long), seldom ± acute, glabrous to subglabrous on lower surface, glabrous on upper surface; **midribs** raised on lower surface (less so towards apex), puberulous with appressed hairs, slightly sunken (flatter towards apex) on upper surface, glabrous; **secondary veins** 8–10 per side, apical end of adjacent ones usually not joining into loops, rather prominent on lower surface, angle with midrib 35–40° (at middle part of leaf blade); **tertiary veins** reticulate, seldom reticulate-percurrent. **Inflorescences** 3- to 5-flowered, axillary or in axils of fallen leaves; flower buds ovoid; peduncles 3–8 mm long, glabrous; rachis up to 13 mm long, glabrous, bracts present; pedicels 10.5–15 mm long, glabrous, each bearing a single triangular bract, placed at a bit higher than midpoint of pedicels. **Sepals** connate at base, broadly ovate-triangular, 1.6–2.1 × 1.6–2 mm, adaxial side glabrous, abaxial side subglabrous, margin puberulous-tomentose with erect and appressed hairs. **Outer petals** broadly ovate, 3–5 × 3–4.5 mm, greenish yellow, glabrous on both surfaces, margin puberulous-tomentose with erect and appressed hairs; **inner petals** ± elongated rhombic, 11.5–13.5 × 4–5 mm, 2–2.5 mm thick (at midpoint of blade), connivent at anthesis, greenish yellow, tips (ca 1/3 of blade) yellow and separated at anthesis, smooth on both surfaces, apex obtuse, claw 1.5–2 mm long, adaxial side of inner petals glabrous on claw and lower half of blade, tomentose with erect and appressed hairs on midline of upper half of blade only, abaxial side subglabrous, margin puberulous with erect and appressed hairs, nectary glands on adaxial side located on lower half of blade, paired slits. **Stamens** 9 per flower, 1–1.5 mm long, connective apex obtuse. **Carpels** 11 or 14 per flower, 1–1.5 mm long, stigmas globose, ovaries glabrous, ovules 2 per ovary, lateral, uniseriate. **Torus** ± hemispherical, pilose-villous. **Fruit** only 1 monocarp found, globose, ca 14 mm in diameter, smooth and glabrous, base contracted into a stipe ca 3.5 mm long, smooth and glabrous, fruiting pedicel ca 17 mm long; **seed** not observed.

**Distribution (including conservation status), phenology, and ecology** – Critically Endangered: CR B2ab(iii). *Orophea sichaikhanii* is so far only known from Ranong Province, southern Thailand. According to a recent expedition to Ban Khlong Ngoen forest area (ca 7 km northeast of Ban Khlong Ngoen School) with a distance of ca 5 km travelled, around 20 individuals were observed; based on our observations we assume that the AOO of the species is below 10 km<sup>2</sup>. The species occurs in a single location, which has been considerably disturbed by agricultural expansion. In



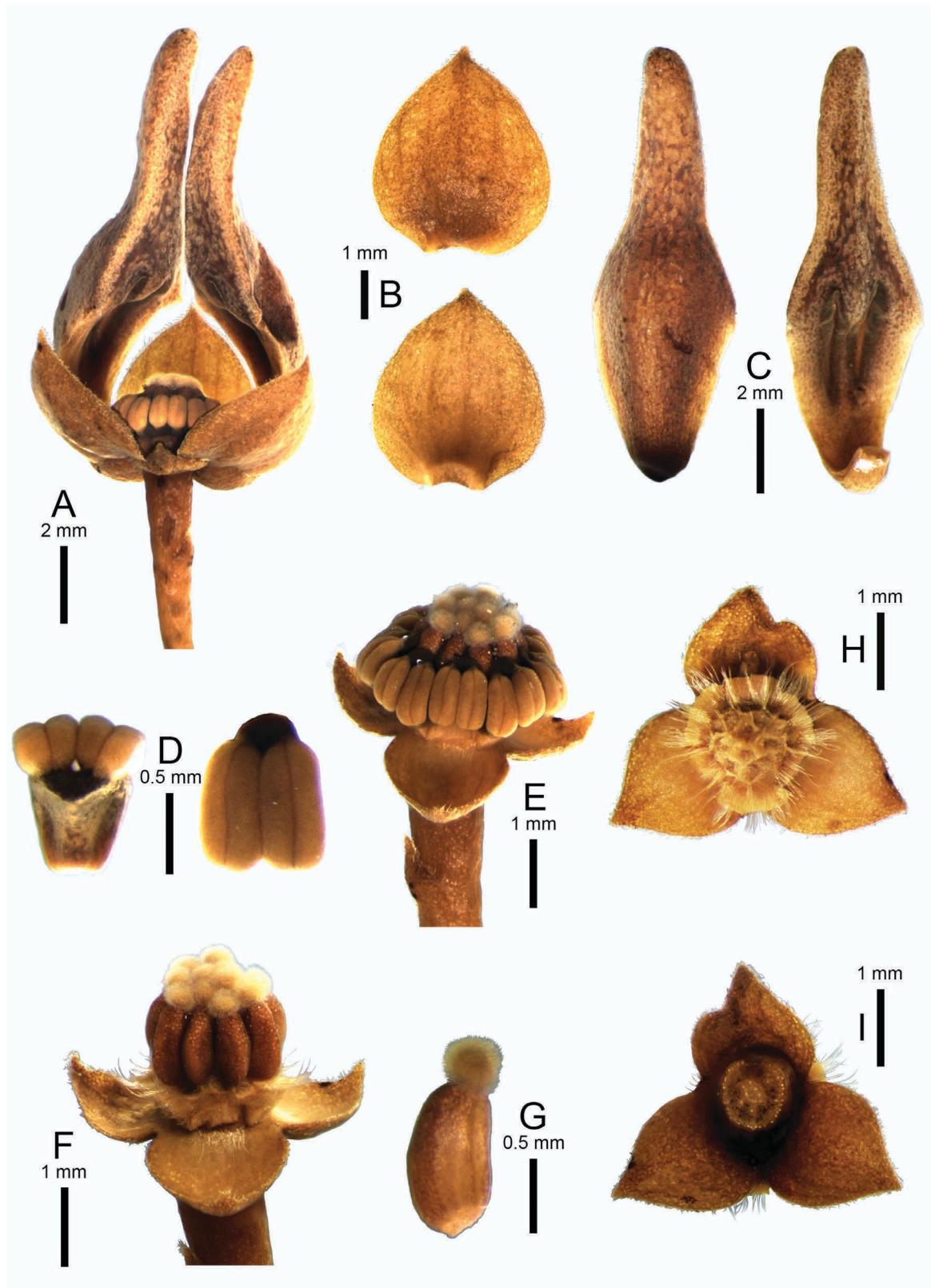
Figure 1 – Holotype of *Orophea sichaikhani* at CMUB (Sichaikhan 6).

addition, other human activities such as mushroom or fruit foraging may cause damage to individuals. Although the new species may also occur in nearby protected forests (e.g. Prince of Chumphon Wildlife Sanctuary, South Side), it is under threat because deforestation in the Ban Khlong Ngoen

forest area, particularly for plantations, happens nearly every single day (Geerawit Sichaikhan pers. comm.). On the basis of this information, we assess the species as critically endangered based on IUCN (2012) criterion “CR B2ab(iii)”. The flowering material was collected in November, whereas



**Figure 2** – *Orophea sichaikhani*. **A.** Inflorescence and flowers. **B.** Infructescence and globose monocarp. **C.** Twig, showing upper leaf surface. **D.** Twig, showing lower leaf surface. Photographs by Kithisak Aongyong (A) and Geerawit Sichaikhan (B–D).



**Figure 3** – Flower and floral organs of *Orophea sichaikhani*. **A.** Flower with one inner petal removed. **B.** Outer petal: adaxial (below) and abaxial (above) sides. **C.** Inner petal: adaxial side (right), showing glands (paired slits), and abaxial side (left). **D.** Stamen: adaxial (left) and abaxial (right) sides. **E.** Flower with petals removed. **F.** Flower with petals and stamens removed. **G.** Carpel, showing glabrous ovary and globose stigma. **H.** Flower with petals, stamens, and carpels removed, showing torus and adaxial side of sepals. **I.** Same as (H), but showing abaxial side of sepals. All from *Sichaikhan 6* (CMUB).

# Key to the species of *Orophea* in Thailand

1. Tertiary leaf venation generally percurrent; monocarps ellipsoid-cylindrical to cylindrical, moniliform when multi-seeded (= subgenus *Orophea*) ..... 2
- 1'. Tertiary leaf venation generally reticulate; monocarps globose (rarely shortly oblongate) (= subgenus *Sphaerocarpon*)..... 4
2. Outer petals 3–5 mm long..... *O. cuneiformis* King
- 2'. Outer petals  $\geq$  8 mm long..... 3
3. Young twigs densely hairy; upper surface of leaf blade sparsely hairy; inner petal blade  $\pm$  rhombic to  $\pm$  broadly elliptic, nectary glands on adaxial side single,  $\pm$  sub-circular, covering  $\pm$  80 percent of blade, raised and sunken in middle, ovule 1 per ovary..... *O. brandisii* Hook.f. & Thomson
- 3'. Young twigs subglabrous to sparsely hairy; upper surface of leaf blade glabrous; inner petal blade  $\pm$  trullate, nectary glands on adaxial side single or paired,  $\pm$  transversely elliptic, only at base of blade, slightly sunken, edge slightly raised and sinuate, ovules 2–6 per ovary ..... *O. fusca* Craib
4. Stamens 6 per flower..... 5
- 4'. Stamens  $\geq$  9 per flower..... 7
5. Young twigs densely hairy; base of leaf blade subcordate to cordate; inner petal blade  $\pm$  sub-circular ..... *O. hirsuta* King
- 5'. Young twigs sparsely hairy; base of leaf blade cuneate, broadly cuneate, or obtuse; inner petal blade  $\pm$  rhombic ..... 6
6. Base of leaf blade symmetrical; peduncles ca 1 mm long; inner petals ca 10 mm long..... *O. siamensis* Craib
- 6'. Base of leaf blade slightly asymmetrical (usually at the very base); peduncles 5–15.5(–17.5) mm long; inner petals 4.5–7(–8) mm long ..... *O. polycarpa* A.DC.
7. Inner petals 6–8 mm long,  $\pm$  red-pink, tip (ca 1/3 of blade) yellow, nectary glands on adaxial side of blade single,  $\pm$  horseshoe-shaped, stamens 12 per flower..... *O. kerrii* Kessler
- 7'. Inner petals 11.5–13.5 mm long, greenish yellow, tip (ca 1/3 of blade) yellow, nectary glands on adaxial side of blade paired slits, stamens 9 per flower..... *O. sichaikhanii* Damth., Aongyong & Chaowasku

the fruiting material was collected in July. The new species occurs in fragmented evergreen forests close to plantations, usually on hill slopes, sometimes near streams, at an elevation of 200 to 400 m.

**Etymology** – This species is named after Geerawit Sichaikhan, who collected the specimens. He is an electrical engineer, but has a strong interest in plant diversity, especially in the area where he was born and has lived (Ban Khlong Ngoen).

**Additional specimen examined** – THAILAND • Ranong Province, Kraburi District, Tambon Pakchan, Ban Khlong Ngoen; ca 200 m; 6 Jul. 2020; fr.; *Sichaikhan* 7; CMUB.

## DISCUSSION

The new species is most morphologically similar to two particular species endemic to Peninsular Malaysia: *Orophea hastata* and *O. kingiana*, based on resemblances in the shape and size of leaves (figs 1, 2C, D), as well as the inner petal shape (fig. 3C) (King 1892; Leonardía & Keßler 2001). Furthermore, the three species share similar nectary glands

on an adaxial side of the inner petals (as paired slits; fig. 3C (right); Leonardía & Keßler 2001). The morphological features distinguishing the three species are shown in table 1. Keßler (1988) and Leonardía & Keßler (2001) reported that the number of stamens and carpels per flower of *Orophea* is divisible by three, but our carpel counts (11 or 14) on three flowers of *O. sichaikhanii* and the stamen and/or carpel counts of King (1892) on some species of *Orophea* do not agree well with such a finding. Floral ontogenetic studies on various species of *Orophea*, including *O. sichaikhanii*, may shed light on the origin of this incongruence.

Although *O. sichaikhanii* and *O. malayana* Kessler belong to the same subgenus and exhibit  $\pm$  green flowers, they differ in many aspects (e.g. leaf blade texture, petiole length, inner petal size and shape, arrangement of inner petal glands, and number of stamens and carpels per flower; Keßler 1990) and are therefore unlikely to be confused. Although *O. malayana* has been claimed to occur in Thailand (Leonardía & Keßler 2001), it is absent from Thailand based on re-investigations by the first author.

**Table 1** – Morphological comparisons between *Orophea sichaikhani*, *Orophea hastata*, and *Orophea kingiana*.

	<i>O. sichaikhani</i>	<i>O. hastata</i>	<i>O. kingiana</i>
<b>Indumentum on young twigs</b>	absent or almost absent	sparse to dense	almost absent to sparse
<b>Pedicle length (mm)</b>	10.5–15	ca 2	7–10
<b>Inner petal length (mm)</b>	11.5–13.5	8–9	8–12(–13.5)
<b>Length of inner petal claw (mm)</b>	1.5–2	ca 4	1–1.5
<b>Inner petal tip (both surfaces)</b>	smooth	slightly warty	slightly warty
<b>Inner petal colour</b>	greenish yellow, tip (ca 1/3 of blade) yellow	dark red with dark yellow point	dark red
<b>Number of stamens per flower</b>	9	9 or 10	12
<b>Number of carpels per flower</b>	11 or 14	10 or 12	18
<b>Indumentum on ovaries</b>	absent	sparse	sparse

*Orophea enterocarpa* was reported to occur in Thailand (e.g. Keßler 1988; Chalermglin 2001; Gardner et al. 2015). However, comparisons of the lectotype and protologue of *O. enterocarpa* (Hooker & Thomson 1872) with the type specimens, protologue (Craib 1925), and several other collections of *O. fusca* (see appendix) led to the conclusion that the plant identified in Gardner et al. (2015: 140) as *O. enterocarpa* represents *O. fusca*, whereas the plant identified in Chalermglin (2001: 248–249) as *O. enterocarpa* possibly represents an undescribed species. Therefore, *O. enterocarpa* is excluded from the flora of Thailand and is considered to only occur in Peninsular Malaysia. It has smaller petals (both whorls: outer petals  $5 \times 3.5\text{--}4\text{ mm}$  vs  $9\text{--}13.5 \times 7\text{--}11\text{ mm}$ , inner petals  $8\text{--}10 \times 3\text{--}4\text{ mm}$  vs  $13.5\text{--}17.5 \times 4\text{--}6\text{ mm}$ , inner petal claw  $3.5\text{--}4.5\text{ mm}$  long vs  $8\text{--}10\text{ mm}$  long; fig. 4) than *O. fusca*. It is worth noting that Turner (2018) also lists the two species as distinct from each other.

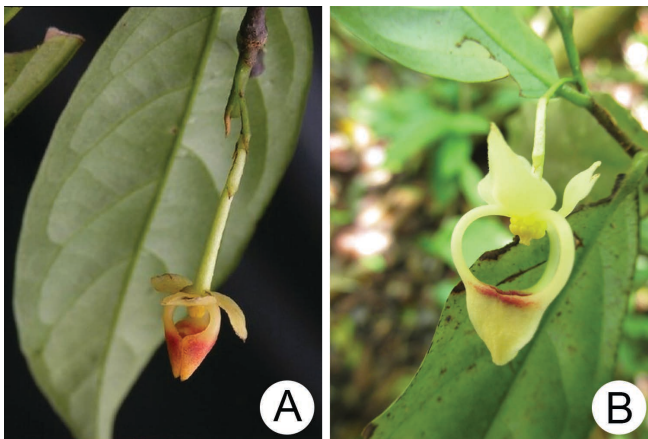
According to Leonardía & Keßler (2001), *Orophea siamensis* occurs in southern Thailand and Nan Province of northern Thailand. Study of the type specimens and protologue of *O. siamensis* (Craib 1922), and specimens (including the type) of *O. kerrii* (see appendix) showed that *O. siamensis* is endemic to Nan Province of northern

Thailand. The specimens from southern Thailand identified as *O. siamensis* by Leonardía & Keßler (2001) represent *O. kerrii*, which is endemic to southern Thailand. The two species can be mainly distinguished by the number of stamens per flower (12 in *O. kerrii* vs 6 in *O. siamensis*) and the inner petal length (6–8 mm in *O. kerrii* vs ca 10 mm in *O. siamensis*). *Orophea siamensis* is a very poorly known species, with only one collection (type specimens) available, necessitating recollections to shed light on its affinity.

It is worthwhile to mention that the northern part of southern Thailand is likely to be a centre of endemism for Annonaceae in Thailand, since, besides *O. sichaikhani*, there are a number of species that are not found elsewhere outside this region, e.g. *Artabotrys longipetalus* J.Chen & Eiadthong (Chen & Eiadthong 2020), *Meiogyne gardneri* D.M.Johnson (Johnson et al. 2019), *Miliusa intermedia* Chaowasku & Kessler and *Miliusa nakhonsiana* Chaowasku & Kessler (Chaowasku & Keßler 2013), *Mitrephora chulabhorniana* Damth., Aongyong & Chaowasku (Damthongdee et al. 2019), *Mitrephora monocarpa* R.M.K.Saunders & Chalermglin (Saunders & Chalermglin 2019), *Neo-uvaria telopea* Chaowasku (Chaowasku et al. 2011), *Pseuduvaria fragrans* Y.C.F.Su, Chaowasku & R.M.K.Saunders (Su et al. 2010), *P. khaosokensis* Yoosukkee & Chaowasku (Yoosukkee et al. 2020), *Trivalvaria stenopetala* Chaowasku & D.M.Johnson (Johnson et al. 2021), and *Winitia thailandana* Chaowasku & Aongyong (Chaowasku et al. 2020).

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**Figure 4** – A. Inflorescence and flower of *Orophea enterocarpa*. B. Inflorescence and flower of *Orophea fusca*. Photographs by Kamarudin Mat-Salleh (A) and Anissara Damthongdee (B).

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APPENDIX

**Additional specimens of *Orophea fusca* examined** – THAILAND – **Krabi** • Khao Pra-Bang Kram; 26 Feb. 2002; fl.; *Chamchumroon et al. VC1333*; BKF • Khao Pra-Bang Kram; 4 Apr. 1988; fl.; *Niyomdham & Ueachirakan 1748*; BKF, L. – **Nakhon Si Thammarat** • Kiriwong, Khao Plai Chai; 27 Aug. 1953; fl.; *Plernchit 675*; BKF. – **Narathiwat** • Bacho; 21 Dec. 1968; fl., fr.; *Phengnaren 25*; BKF. – **Trang** • Khao Chong; 13 Apr. 1969; fl., fr.; *Phusomsaeng 136*; BKF, L. – **Yala** • Gau Long; fl., fr.; *P.N. + S.S. 343*; BKF.

**Additional specimens of *Orophea kerrii* examined** – THAILAND – **Krabi** • Khao Phanom Bencha National Park, headquarters, 'Dog-slide Trail'; 8°14'N, 98°55'E; 8 Dec. 2004; fl.; *Gardner & Tippayasri ST1225*; BKF, L. • Khao Phanom Bencha National Park, trail near headquarters; 8°14'N, 98°55'E; 16 Jul. 2000; fr.; *Middleton et al. 490*; BKF • Khao Phanom Bencha National Park, Huai Tai Falls; 8°14'N, 98°55'E; 9 May 2002; fl., fr.; *Pooma et al. 3644*; BKF, L. – **Nakhon Si Thammarat** • Khao Luang; 25 Mar. 1962; fl.; *Plernchit 1862*; BKF • Khao Luang National Park, SE side of Khao Luang Mountain, between Kiriwong Village and summit; 8°29'N, 98°45'E; 7 Mar. 2006; fl., fr.; *Gardner ST2452*; BKF. – **Phangnga** • Takuapa, Sri Phangnga National Park, Ton Deng Waterfall; 21 Feb. 2002; fl.; *Chamchumroon et al. VC1303*; BKF • Takuapa, Sri Phangnga National Park, road to Tamnang Waterfall; 8°59'76"N, 98°27'95"E; 24 Apr. 2005; fl., fr.; *Pooma et al. 5224*; BKF, L. – **Ranong** • Khlong Kam Puang; ca 9°15'N, 98°20'E; 26 Apr. 1973; fl.; *Geesink & Santisuk 4930*; BKF, L. – **Trang** • Khao Chong; 14 Jan. 1966; fl.; *Boonnab 292*; BKF • Khao Chong; ca 7°40'N, 99°45'E; 14 Jun. 1974; fr.; *Geesink et al. 7215*; BKF, L. • Khao Chong; 10 Mar. 1985; *Maxwell 85-275*; BKF, L. • Khao Chong, road upriver on left bank past entrance to Blue Trail; 2 Feb. 1985; fl.; *Newman 34*; BKF • Khao Chong, 16-hectare plot; 7°33'N, 99°48'E; Feb. 2001; fl.; *Sinbumroong & Davies 181*; BKF.

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