Songklanakarin J. Sci. Technol.
41 (4), 788-794, Jul. – Aug. 2019

http://www.sjst.psu.ac.th

Original Article

The genus *Codariocalyx* Hassk. (Leguminosae-Papilionoideae) in Thailand: taxonomy and anatomy of leaf and stem

Witsanu Saisorn and Pranom Chantaranothai*

Center of Excellence on Biodiversity, Department of Biology, Faculty of Science, Khon Kaen University, Mueang, Khon Kaen, 40002 Thailand

Received: 21 November 2017; Revised: 20 March 2018; Accepted: 26 March 2018

Abstract

The genus *Codariocalyx* Hassk. in Thailand is revised. Three species viz. *C. gyroides* (Roxb. ex Link) X.Y.Zhu, *C. microphyllus* (Thunb.) H.Ohashi and *C. motorius* (Houtt.) H.Ohashi are recognized. A key, descriptions, photographs, distribution maps, ecological and phenological data and vernacular names are provided. The anatomy of the leaf and stem are also presented.

Keywords: anatomy, Desmodieae, Fabaceae, taxonomic revision

1. Introduction

The genus *Codariocalyx* Hassk. was described by Hasskarl (1842), to accommodate four species: *C. capitatus* Hassk., *C. conicus* Hassk., *C. gyrans* (L.f.) Hassk., and *C. gyroides* (Roxb. ex Link) X.Y.Zhu. In The Plant List (http://www.theplantlist.org), *C. capitatus* is listed as an unresolved name and *C. conicus* as a synonym of *C. gyroides*. *Desmodium microphyllum* (Thunb.) DC., which appears as an accepted name in The Plant List, was transferred to *Codariocalyx* by Ohashi (2004). At present, the genus consists of three species: *C. gyroides*, *C. microphyllus* (Thunb.) H.Ohashi, and *C. motorius* (Houtt.) H.Ohashi (synonym *C. gyrans* (L.f.) Hassk.). It is distributed in Asia and *C. microphyllus* also reaches Australia (Ohashi, 1973; Ohashi, 2004; Pedley, 1999). The most distinctive characteristic of the genus is its arillate seed. Here we provide, for the first time a report on the taxonomic information of the genus for Thailand.

*Corresponding author
Email address: chantaranothai@gmail.com

2. Materials and Methods

Our taxonomic study was based on herbarium specimens from AAU, ABD, BCU, BK, BKF, BM, BO, C, CMU, CMUB, E, FOF, G, HN, HNU, K, KEP, KKU, KYO, L, NHL, P, PSU, QBG, SING, TI and online type specimens from BRI, G, PE, R and S. Herbarium acronyms are followed Thiers (2016). Living plants of all three species were observed in various parts of Thailand and herbarium material was collected. The anatomical characters of the leaves and stems from eight populations of all three species were examined. The leaf epidermis was prepared by scraping with a razor blade and a paintbrush. The samples were stained with 1% safranin O for 20−30 mins, dehydrated with 70% and 95% twice of absolute ethanol for 5 mins each, then immersed in xylene to absolute ethanol (1:1) and pure xylene for 5 and 10−15 mins, respectively. Sample slides were mounted in DePeX. Petiole, leaf blade and stem cross-sections were embedded in paraffin before sectioning. The sections were stained with 1% safranin O and fast green for 30 mins and 15 secs, respectively, and mounted in DePeX. Samples were examined and photographed with an Olympus CH30 light microscope.

3. Results and Discussion

3.1 Taxonomic treatment

Codariocalyx Hassk., Flora 25(2, Beibl. 3): 48. 1842 (*'Codoriocalyx'*), *ortho. cons*.

Desmodium Desv. sect. *Pleurolobium* DC. subsect. *Gyrantia* DC., Prodr. 2: 326. 1825, p.p., excl. sp.cit. *D. timoriense* DC.

Desmodium Desv. subg. *Pleurolobium* Baker in Hook.f., Fl. Brit. Ind. 2: 174. 1876.

Erect or prostrate herbs. *Leaves* spirally arranged, uni- and trifoliolate; stipules 2, free. *Leaflets* stipellate and petiolulate; lamina subcoriaceous; venation pinnately netted, margins entire, lateral veins not reaching the leaf margins. *Inflorescence* pseudo-racemose or panicle-like, terminal or axillary. *Primary bract* 1, caducous, ovate, prominently veined. *Secondary bracts* absent. *Flowers* papilionaceous, 3–10 mm long, in 1–2-flowered fascicles; bracteole absent; pedicels pilose, densely puberulent to pubescent, with or without uncinate hairs. *Calyx* light green, orange or reddish green, campanulate; tube glabrous to densely pubescent; teeth 5. *Petals* 5, yellow-orange to dark orange, whitish purple, or greenish purple; standard 1, clawed, not auriculate; wings 2, free, clawed, auriculate; keels 2, connate, clawed, papillose-auriculate. *Stamens* 10, diadelphous, vexillary stamen completely free; other stamens connate; anthers dorsifixed, longitudinally dehiscent. *Ovary* oblong, laterally compressed, with 3–9 ovules; stigma minutely capitate. *Pods* smooth or reticulate-patterned, dehiscent along lower suture, sessile or stipitate, constricted between seeds; articles not detached from each other when dry; calyx persistent, not accrescent. *Seeds* reniform, with well-developed aril.

Three species distributed in the Himalayas, India, Sri Lanka, China, Taiwan, Japan, Myanmar, Indo-China, Malesia and one species extending to Australia. All species are indigenous in Thailand.

Key to the species

1. Terminal leaflets 0.4–1.5 by 0.2–0.7 cm. Pedicels pilose, with uncinate hairs. Pods reticulate-patterned **2. C. microphyllus**

1. Terminal leaflets 1–8.5 by 0.5–4.5 cm. Pedicels puberulent or densely pubescent, without uncinate hairs. Pods smooth

2. Terminal leaflet obovate to elliptic, lower surface densely appressed and whitish sericeous. Flowers 9–10 mm long. Pedicels 3.5–6 mm long, densely pubescent. Pods with both straight and uncinate hairs **1. C. gyroides**

2. Terminal leaflet narrowly lanceolate, lower surface appressed pubescent. Flowers 5.5–8 mm long. Pedicels 1–2 mm long, densely puberulent. Pods with straight hairs **3. C. motorius**

1. Codariocalyx gyroides (Roxb. ex Link) X.Y.Zhu, Legumes China: 146. 2007 (Figures 1A–B & 2A).

Hedysarum gyroides Roxb. [Hort. Beng.: 57. 1814, *nom. nud.*] ex Link, Enum. Hort. Berol. Alt. 2: 247. 1822. Type: Silhet, donated by M.R. Smith in 1811 (not located).

Desmodium gyroides (Roxb. ex Link) DC., Prodr. 2: 326. 1825.

Meibomia gyroides (Roxb. ex Link) Kuntze, Revis. Gen. Pl. 1: 196. 1891.

Figure 1. Morphology of three species of *Codariocalyx* in Thailand: A.–B. *C.gyroides*; C.–D. *C. microphyllus*; E.–F. *C. motorius*. Photographs by W. Saisorn.

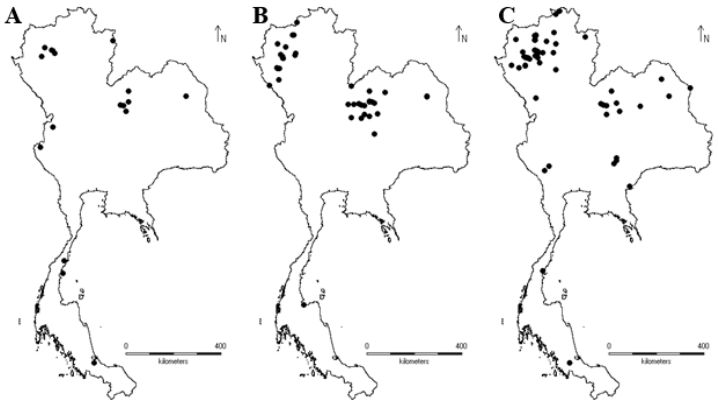

Figure 2. Distribution maps of three species of *Codariocalyx* in Thailand: A. *C. gyroides*; B. *C. microphyllus*; C. *C. motorius.*

Codariocalyx conicus Hassk., Flora 25(2, Beibl. 49): 62. 1842, *fide* Ohashi (1973).

Pseudarthria polycarpa Hassk., Cat. Hort. Bog. Alt.: 282. 1844, *fide* Ohashi (1973).

Desmodium pseudogyroides Miq., Fl. Ned. Ind. 1(1): 244. 1855. Type: Indonesia. Java, bij Banjoemas, door Dr. Th. Horsfield ontdekt (not located).

Meibomia pseudogyrodes (Miq.) Kuntze, Revis. Gen. Pl. 1: 198. 1891.

Desmodium bracteatum Micheli, Vidensk. Meddel. Dansk Naturhist. Foren. Kjøbenhavn: 73. 1875. Type: Brazil. ad Quinta prope Rio de Janeiro, *M.A. Glaziou* 4784 (lectotype C C10012098!, designated by Lima, de Queiroz, Tozzi, & Lewis (2014); isolectotypes P P00706586!, P P00706587!, R R000008495! [digital image] & S S13-12505! [digital image]).

Meibomia bracteata (Micheli) Hoehne, Anex. Mem. Inst. Butantan. Bot. 1: 30. 1921.

Desmodium papuanum C.T.White in H.J.Priestley, Proc. Roy. Soc. Queensl. 34: 34. 1922. Type: Papua New Guinea. Astrolabe Range, Stephansort, bei Erima am Strande, 20 August 1899, *Lewandowsky* 62, (holotype BRI-AQ0022852! [digital image]).

Erect herb to 3 m high; stems and twigs terete or subterete, glabrescent, sparsely sericeous to tomemtose. *Leaves*: stipules narrowly triangular, 5–15 by 1–2.5 mm, apex long acuminate, abaxial side sparsely sericeous, adaxial side glabrescent; petioles 0.5–3 cm long, glabrescent to tomentose; rachis 2–10 mm long, glabrescent to tomentose. *Leaflets*: stipels narrowly triangular, 3–5 by 0.5 mm, apex long acuminate, glabrescent to pubescent; petiolules 1.5–3 mm long, densely appressed pubescent, sericeous to tomentose. *Terminal leaflet* ± obovate to elliptic, 1–6.5 by 1–4.5 cm, apex obtuse to rounded or shallowly emarginate, base obtuse or subcordate, upper surface appressed pubescent to sparsely sericeous, lower surface densely appressed and whitish sericeous; lateral veins 5–8 per side. *Lateral leaflets* ± obovate to elliptic, 0.5–2.5 by 0.5–1.5 cm, apex obtuse to rounded, base cuneate to obtuse, both surfaces like terminal leaflet; lateral veins 3–6 per side. *Inflorescence* 5–20 cm long; rachis and rachilla densely puberulous, with simple hairs. *Primary bract* 7.5–8 by 4 mm, apex long acuminate, margin fimbriate, both surfaces glabrescent, enclosing 2-immature flowers. *Flowers* in a fascicle of 3 flowers, 9–10 mm long; pedicels 3.5–6 mm long, densely pubescent, without uncinate hairs. *Calyx* reddish green, 4–4.5 mm long, base cuneate; tube *ca.* 3 mm long, abaxial side glabrescent, adaxial side glabrous; teeth 0.5–1.5 mm long, prominently shorter than tube, upper two teeth shorter than the others, margin fimbriate. *Corolla* pink, purple or greenish purple; standard ± obovate, 9–10 by 6–6.5 mm, apex shallowly emarginate, base cuneate, claw 1–1.5 mm long; wings triangular, lower side not angular, 6–7 by 3–3.5 mm, apex ± truncate, base attenuate, claw *ca.* 1 mm long, auricle less than 0.5 mm long; keels *ca.* 7 by 2 mm, apex obtuse, base cuneate, claw *ca.* 5 mm long, auricle *ca.* 0.5 mm long. *Stamens* 7–9 mm long; anthers ellipsoid, *ca.* 0.5 by 0.3 mm. *Ovary* without groove along upper suture, densely pubescent; style *ca.* 5 mm long, bent upward, glabrescent, upper part slender. *Pods* brownish black, oblong, 2–4 by 0.4–0.5 cm, densely puberulous to tomemtose, with simple and uncinate hairs, upper suture repand to straight, grooved; lower suture less constricted, 1–1.5 mm deep; articles 5–9, indistinct, 3–5 mm long; pod stipe *ca.* 1 mm long or absent; fruiting pedicels 5–10 mm long, densely appressed pubescent, without uncinate hairs. *Immature seeds* brownish black, 1–1.5 by 1 mm, *ca.* 0.3 mm thick.

Thailand—NORTHERN: Chiang Mai (Ban Pha Mon, Doi Inthanon National Park, Doi Suthep, Mae Taeng, Samoeng), Nan (Sapan Waterfall), Tak (Thi Lo Su Waterfall); NORTH-EASTERN: Phetchabun (Nam Nao National Park), Loei (Phu Kradueng, Phu Luang Wildlife Sanctuary), Sakon Nakhon (Phu Phan National Park); EASTERN: Chaiyaphum (Khon San); SOUTH-WESTERN: Kanchanaburi (Sangkhla Buri); PENINSULAR: Chumphon (Ko Maphrao, Pathio), Songkhla (Hat Yai).

Distribution—The Himalayas, India, Sri Lanka, southern China, Myanmar, Indo-China and Malesia.

Ecology—Mixed evergreen, pine-oak and dry dipterocarp forests; 0–1,200 m a.s.l. Flowering: August to February.

Vernacular—Kratue pae, ton khao chi (Loei); i-niao yai (Chaiyaphum); tan sai, che ke pho, sa hom (Chiang Mai).

Specimens examined—*BGO. Staff* 4475 (QBG-2 sheets), *D. Bunpheng* 197 (BKF), *Dee* 28 (BKF), *A.F.G. Kerr* 745 (BM-2 sheets, K, L, P), 10489 (ABD, BK, BM, K) & 11431 (AAU, ABD, BK, BM, C, E, K), *K. Larsen* 5146

(BKF), *K. Larsen, S.S. Larsen, C.T. Nørgaard, K. Pharsen, P. Puudjaa & W. Ueachirakan* 44488 (AAU), *C. Leeratiwong* 99-161 (KKU), *S. Mattapha* 170 (KKU), 335 (KKU) & 812 (KKU), *J.F. Maxwell* 87-1359 (CMU, L-2 sheets), 87-1559 (BKF) & 88-1406 (BKF, CMU, L), *G. Murata, C. Phengklai, S. Mitsuta, T. Yahara, H. Nagamasu & N. Nantasan* T-40232 (BKF, KYO) & T-43109 (BKF, KYO-2 sheets, L), *M. Norsaengsri* 1095 (QBG), *C. Phengklai et al.* 7454 (BKF-2 sheets, C), *Put* 791 (K), *W. Ramsri* 1 (BKF, PSU), *W. Saisorn* 372 (KKU), *Soradet* 182 (BKF), *Th. Sørensen, K. Larsen & B. Hansen* 4959 (C, E, SING) & 5146 (BKF, C), *S. Sutheesorn* 9808 (BK), *Umpai* 433 (BK), *J.E. Vidal* 5291A (AAU, P), *Winit* 791 (BKF), *C. Wongsatit* 72 (BK) & *S.N.* 24 (BKF).

2. Codariocalyx microphyllus (Thunb.) H.Ohashi, J. Jap. Bot. 79(1): 109. 2004 (Figures. 1C–D & 2B).

Hedysarum microphyllum Thunb. in Murray, Syst. Veg. ed. 14: 675. 1784. Type: Japan. *Thunberg* s.n. (holotype UPS-THUNB no. 17273, n.v.).

Desmodium microphyllum (Thunb.) DC., Prodr. 2: 337. 1825.

Hedysarum tenellum Buch.-Ham. ex D.Don, Prodr. Fl. Nep.: 243. 1825. Type: ad Narainhetty Nepalensium, *Hamilton* s.n. (lectotype BM BM000521603!, designated here).

Desmodium parvifolium DC., Ann. Sci. Nat. 4: 100. 1825. Type: Nepal. *Wallich* s.n. (lectotype G-DC G00479 813!, designated here; isolectotypes G-DC G00479814!, G-DC G00479876! & G-DC G00479879!).

Desmodium microphyllum (Thunb.) DC. var. *longipilum* Ohwi, J. Jap. Bot. 26(8): 234. 1951, **syn. nov.** Type: Taiwan (Formosa). Mt. Arisan, *U. Faurie* 467 (holotype KYO KYO00022355!; isotypes BM BM000839620! [digital image], KYO KYO00022356!, P P02939635! & TI!).

Erect or prostrate herb 0.5–2 m long; stems and twigs terete, glabrescent to pilose and with sparsely uncinate hairs. *Leaves*: stipules narrowly triangular, 2.5–6 by 0.5–1.1 mm, apex long acuminate, glabrescent to pilose; petioles 1–10 mm long, sparsely long pilose; rachis 4–12 mm long, sparsely long pilose. *Leaflets*: stipels ovate, 0.3–0.5 by 0.3 mm, apex acuminate, glabrous, margin fimbriate; petiolules 0.5–1 mm long, glabrous to appressed pubescent. *Terminal leaflet* elliptic or ± lanceolate, 4–15 by 2–7 mm, apex acute to mucronate apiculate, base ± cordate, upper surface glabrescent to sparsely pilose, lower surface appressed pubescent; lateral veins 4–5 per side. *Lateral leaflets* narrowly lanceolate to narrowly elliptic, 4–7 by 1–2 mm, apex acute to mucronate apiculate, base cuneate or asymmetrical, upper surface glabrescent to sparsely pilose, lower surface appressed pubescent; lateral veins indistinct. *Inflorescence* 5–10 cm long; rachis and rachilla pilose, with puberulent and uncinate hairs. *Primary bract* 3–4 by 2–2.5 mm, apex long acuminate, margin densely fimbriate, appressed pubescent, enclosing 1–2-immature flowers. *Flowers* in a fascicle of 1–2 flowers, 3–5 mm long; pedicels 5–9 mm long, pilose, with uncinate hairs. *Calyx* light green, 3–4 mm long, base cuneate; tube *ca.* 1 mm long, outside densely pubescent, inside glabrous; teeth 3–4 mm long, prominently longer than tube, margin densely fimbriate. *Corolla* white to pink or purple; standard ± obovate, 3–3.5 by 2–2.5 mm, apex shallowly emarginate, base attenuate, claw less than 0.5 mm long; wings oblong, lower side not angular, *ca.* 3 by 1–1.2 mm, apex obtuse, base indistinct, claw *ca.* 1 mm long; keels *ca.* 3.5 by 1–1.2 mm, apex obtuse, base indistinct, auricle *ca.* 0.8 mm long. *Stamens* 5.5–6 mm long; anthers ellipsoid, *ca.* 1.2 by 1 mm. *Ovary* appressed pubescent with 3–4 ovules, grooved along upper suture; style *ca.* 3 mm long, bent upward, glabrescent. *Pods* brownish black, incurved, 3–13 by 3–4 mm, reticulate, with dense covering of uncinate hairs; both sutures constricted, *ca.* 1 mm deep; articles 1–4, distinct, obliquely rhombic to elliptic, 4–5 mm long; pod stipe 1 mm long or absent; fruiting pedicels 9–12 mm long, with dense covering of uncinate hairs. *Seeds* brownish, 2.5–2.7 by 1–1.6 mm, 0.5–0.6 mm thick; aril *ca.* 1 by 0.5 mm.

Thailand—NORTHERN: Chiang Mai (Chiang Dao, Doi Ang Khang, Doi Inthanon National Park, Hot, Mae Chaem, Mae Sanam, Mae Sariang, Omkoi, Samoeng, San Pa Tong); NORTH-EASTERN: Phetchabun (Camp Son, Lom Sak, Nam Nao National Park), Loei (Na Haeo, Phu Kradueng, Wang Saphung), Nong Bua Lam Phu, Sakon Nakhon (Phu Phan National Park), Khon Kaen; EASTERN: Chaiyaphum (Phu Khiao); PENINSULAR: Surat Thani (Yan Yao).

Distribution—India, Sri Lanka, China, Taiwan, Japan, Myanmar, Indo-China, Malesia and Australia (Queensland and Arnhem Land).

Ecology—Evergreen, pine, pine-oak, mixed deciduous, bamboo and dry dipterocarp forests, grasslands, swamp places and roadsides; 100–1,900 m a.s.l. Flowering: September to May.

Vernacular—Klet kradi (Chaiyaphum).

Specimens examined—*BGO. staff* 11 (QBG-2 sheets) & 17 (QBG-2 sheets), *P. Chantaranothai* 683 (KKU), *Ch. Charoenphol, K. Larsen & E. Warncke* 4704 (AAU, BKF, P), *Dee* 668 (BKF, L), *H.B.G. Garrett* 1037 (E, L-2 sheets, P, SING), *R. Geesink, T. Hattink & C. Phengklai* 7034 (BKF, L), *R. Geesink, P. Hiepko & C. Phengklai* 8024 (L), *B. Hansen, G. Seidenfaden & T. Smitinand* 11035 (BKF, C) & 11238 (BKF, C), *Kasem* 240 (BK), *A.F.G. Kerr* 8603 (BK), 18245 (BK, C-2 sheets, L) & 18265 (E), *H. Koyama & C. Phengklai* T-40067 (BKF, KYO, L), *T. Koyama, C. Phengklai, C. Niyomdham, G. Murata, H. Okada & P.J. O'Connor* 15469 (BKF), *M.C. Lakshnakara* 1465 (BK), *K. Larsen, S.S. Larsen, I. Nielsen & T. Santisuk* 31496 (AAU, KYO) & 31595 (AAU); *C. Leeratiwong* 99-136 (KKU), *C. Maknoi* 4486 (QBG), *S. Mattapha* 896 (KKU-2 sheets), *J.F. Maxwell* 96-357 (BKF, CMUB, L) & 98-1439 (BKF, CMUB), *S. Mitsuta, H. Nagamasu, T. Yahara & N. Nantasan* T-42365 (BKF, KYO), *G. Murata, C. Phengklai, S. Mitsuta, T. Yahara, H. Nagamasu & N. Nantasan* T-41614 (BKF, KYO), T-41615 (BKF, KYO, L, TI) & T-51575 (BKF, KYO), *W. Nanakorn* W.N.859 (QBG, SING), *C. Niyomdham, M. Suangtho & B. Sangkhachand* 98 (AAU, BKF-2 sheets), *Y. Paisooksantivatana* y1752-86 (BK), *R. Pooma* 82 (BKF), *R. Pooma & W. Werner* 33 (BKF), *S. Sadakorn* 371 (BK), *W. Saisorn* 249 (KKU), 262 (KKU), 339 (KKU) & 370 (KKU), *W. Sankamethawee* 140 (BKF, CMUB), *T. Santisuk* s.n. (BKF), *T. Shimizu, H. Toyokuni, H. Koyama, T. Yahara & C. Niyomdham* T-23006 (BKF, C, KYO, L), T-23021 (BKF, KYO, L) & T-23045 (BKF, KYO), *E. Smith* 69 (BK), *T. Smitinand* 2086 (BKF, L), *T. Smitinand & E.C. Abbe* 6310 (BKF), *T. Smitinand & I. Alsterlund* 6710 (BKF), *Th. Sørensen, K. Larsen & B. Hansen* 3267 (BKF, C) & 6324 (C, E), *P. Srisanga, P. Suksathan, P. Panyachan & A. Keratikorkul* 3061 (QBG), *P. Suksathan* 2075 (QBG), *K.*

Suvatabandhu 181 (BKF), *M. Tagawa, K. Iwatsuki & N. Fukuoka* T-2634 (AAU, BKF, KYO, L, P, TI), *C.F. van Beusekom, R. Geesink, C. Phengklai & B. Wongwan* 4217 (BKF, C, L, P) & 4612 (BKF, L) & *C.F. van Beusekom & C. Phengklai* 2575 (AAU, BKF, C, E, L, P) & 2650 (E, KYO).

3. Codariocalyx motorius (Houtt.) H.Ohashi, J. Jap. Bot. 40: 367. 1965 (Figures 1E–F & 2C).

Hedysarum motorium Houtt., Nat. Hist. II, 10: 246. 1779. Type: Cult. at Leiden, Sept. 1778, *van Royen* (L no. 908.115-344, n.v.), *fide* Ohashi (2004).

Desmodium motorium (Houtt.) Merr., J. Arnold Arb. 19(4): 345. 1938.

Hedysarum gyrans L.f., Suppl.: 332. 1781. Type: Cult. Upsala from seeds sent by Forster in 1778 (n.v.), *fide* Merrill (1938).

Desmodium gyrans (L.f.) DC., Prodr. 2: 326. 1825.

Codariocalyx gyrans (L.f.) Hassk., Flora 25(2): Beibl.: 49. 1842.

Desmodium roylei Wight & Arn., Prodr. Fl. Ind. Orient. 1: 227. 1834, Type: gathered in Bengal, *Royle* s.n. (Wight's herbarium, n.v.), *fide* Dy Phon *et al.* (1994).

Desmodium gyrans (L.f.) DC. var. *roylei* (Wight & Arn.) Baker in Hook.f., Fl. Brit. Ind. 2: 175. 1876.

Codaricalyx gyrans (L.f.) Hassk. var. *roylei* (Wight & Arn.) Schindl., Repert. Spec. Nov. Regni Veg. 20: 281. 1924.

Codariocalyx motorius (Houtt.) H.Ohashi var. *glaber* X.Y.Zhu & Y.E.Du, Legumes China: 634. 2007. Type: China. Yunnan, Shang-pa Hsien, 2,000 m, 18 September 1933, *H.T. Tsai* 56510 (holotype P PE00099206! [digital image]; isotype P PE00099207! [digital image]).

Herb up 3 m high; stems and twigs terete, glabrous to puberulous. *Leaves*: stipules narrowly triangular, 10–11 by 1–2 mm, apex long acuminate, glabrous; petioles 0.5–2 cm long, sparsely long fimbriate along petiolar ridges; rachis 2–7 mm long, sparsely long fimbriate along rachis ridges. *Leaflets*: stipels narrowly triangular, 3–4 by 0.5 mm, apex long acuminate, glabrous, margin fimbriate; petiolules 1.5–3 mm long, appressed pubescent. *Terminal leaflet* narrowly lanceolate, (2–)4–8.5 by 0.5–3 cm, apex acute to obtuse, base cuneate, obtuse or subcordate, upper surface glabrous to appressed pubescent, lower surface appressed pubescent; lateral veins 7–10 per side. *Lateral leaflets* narrowly lanceolate to elliptic or narrowly oblanceolate, 8–20 by 2–3 mm, apex acute, base cuneate to obtuse, upper surface glabrous to appressed pubescent, lower surface appressed pubescent; lateral veins indistinct. *Inflorescence* 6–20 cm long; rachis and rachilla with uncinate hairs. *Primary bract* 6–8 by 4–5.5 mm, apex long acuminate, margin fimbriate, sparsely puberulent, enclosing 2-immature flowers. *Flowers* in a fascicle of 2 flowers, 5.5–8 mm long; pedicels 1–2 mm long, densely puberulent, without uncinate hairs. *Calyx* orange-red, 2–2.5 mm long, campanulate, base truncate; tube 1.5–2 mm long, outside glabrescent, inside glabrous; teeth *ca.* 0.5 mm long, prominently shorter than tube, margin fimbriate. *Corolla* yellow-orange to dark orange; standard ± obovate, 6–7 by 5–7 mm, apex ± emarginate, base cuneate, claw *ca.* 1 mm long; wings angular, 6–7 by 2.5–4 mm, apex obtuse, base indistinct, claw 0.7–1.5 mm long, auricle up to 0.5 mm long; keels angular or triangular, 5–7 by 2–3.5 mm, apex obtuse, base indistinct, auricle *ca.* 0.7 mm long. *Stamens* 6–9 mm long; anthers ellipsoid, 0.5 by 0.4–0.5 mm. *Ovary* puberulous, with a groove along upper suture, 8–9-ovulate; style 3–4 mm long, bent upward, glabrescent. *Pods* brownish black, 5–11-articulated, oblong, 2.5–3.6 by 0.5–0.6 cm, puberulous, without uncinate hairs, upper suture repand with a groove, lower suture less constrict, *ca.* 1 mm deep; articles indistinct, 3–4 mm long; stipe *ca.* 1 mm long or sessile; fruiting pedicels 4–5 mm long, pubescent, without uncinate hairs. *Seeds* brownish black, 3.3–3.5 by 2–2.5 mm, 0.7–1 mm thick; aril *ca.* 2.2 by 0.5 mm.

Thailand—NORTHERN: Mae Hong Son (Khun Yuam, Mae Sariang-Mae La Noi, Pai, Pang Mapha, Tham Pla-Namtok Pha Suea National Park, Sob Moei), Chiang Mai (Ban Bing Kong, Bo Luang, Chiang Dao, Doi Suthep, Hot, Doi Inthanon National Park, Mae Rim, Mae Taeng, Omkoi, San Kamphaeng, San Pa Tong, San Sai), Chiang Rai (Doi Tung, Doi Luang National Park, Mae Fa Luang, Wiang Kaen), Phayao (Doi Luang National Park), Nan (Chiang Klang), Lamphun (Doi Khun Tan National Park), Lampang (Chae Hom, Khun Tan, Mae Tha, Wang Nuea), Tak (Doi Kha); NORTH-EASTERN: Phetchabun (Nam Nao National Park), Loei (Phu Kradueng), Sakon Nakhon (Phu Phan National Park, Wanon Niwat), Nakhon Phanom (Kut Khulu), Khon Kaen (Chum Phae, Nam Phong); EASTERN: Chaiyaphum (Phu Khiao), Nakhon Ratchasima (Pak Thong Chai, Sakaerat, Wang Nam Khiao); SOUTH-WESTERN: Kanchanaburi (Erawan National Park, Tham Than Lot National Park); SOUTH-EASTERN: Sa Kaeo (Aranyaprathet), Rayong; PENINSULAR: Chumphon (Ban Ta Ngaw), Songkhla (Boriphat Waterfall).

Distribution—India, Sri Lanka, southern China, Taiwan, Indo-China and Malesia.

Ecology—Dry evergreen, pine, pine-oak, dry dipterocarp-oak, mixed deciduous, bamboo, dry dipterocarp and pine-decidouous forests, grasslands, limestone mountains, partly shaded places, sunny places and near streams; 50–1,450 m a.s.l. Flowering: August to November.

Vernacular—Choi chang ram, nang ram (Central); choi nang ram (Central, Chaiyaphum, Chiang Mai, Khon Kaen); khoei-mae-khwa (Karen-Mae Hong Son); phaeo daeng (Sa Kaeo); wan mit phap (Lamphun).

Specimens examined—*BGO. Staff* 1557 (QBG-2 sheets) & 4773 (QBG-2 sheets), *H. Banziger* 770 (CMU), *Bjørnland & Schumacher* 396 (AAU, C), *P. Chantaranothai, J. Parnell, D. Simpson & R. Pooma* 90/595 (K, KKU), *P. Chantaranothai et al.* 682 (KKU), *K. Chayamarit et al.* 2110 (BKF), *Damrongsak* 94 (BKF), *Dee* 209 (BKF) & 328 (BKF, L), *R. Geesink, D. Phanichaphol & T. Santisuk* 6040 (L), *C.C. Hosseus* 156 (BM, K, P), *K. Iwatsuki & N. Fukuoka* T-10312 (AAU, BKF, KYO, L, P), *K. Iwatsuki, N. Fukuoka, M. Hutoh & D. Chaiglom* T-11047 (AAU, BKF, KYO-2 sheets, L, P), *A.F.G. Kerr* 816 (BM, K, L, P) & 11453 (ABD, BK, BM, E, K), *H. Koyama & C. Phengklai* T-39596 (BKF, KYO), *C. Lakoet* 217 (QBG-2 sheets), 330 (QBG) & 510 (QBG), *M.C. Lakshnakara* 1448 (BK), *K. Larsen & S.S. Larsen* 34109 (AAU), *K. Larsen, S.S. Larsen, C. Niyomdham, W. Ueachirakan & P. Sirirugsa* 42400 (AAU, PSU), *K. Larsen, S.S. Larsen, C.T. Nørgaard, K. Pharsen, P. Puudjaa & W. Ueachirakan* 44515 (AAU), *C. Leeratiwong* 98-61 (KKU) & 99-106 (KKU), *S. Mattapha* 445 (KKU) & 810 (KKU), *J.F. Maxwell* 87-1045 (BKF, CMU, L), 87-1291 (BKF, CMU, L), 88-1192 (BKF, CMU, L), 89-1122 (L), 89-1439 (L), 90-1018

(CMU, L), 96-1211 (BKF, CMUB, L-2 sheets), 96-1313 (BKF, CMUB, L), 97-1222 (CMUB, L), 97-1309 (CMUB, L), 01-709 (BKF) & 07-709 (CMUB, QBG), *N. Muangyen* 341 (QBG), *G. Murata, N. Fukuoka & C. Phengklai* T-16819 (BKF, KYO) & T-16822 (AAU, BKF, KYO, L), *G. Murata, C. Phengklai, S. Mitsuta, T. Yahara, H. Nagamasu & N. Nantasan* T-41671 (BKF, KYO), T-41706 (BKF, KYO, TI) & T-51570 (BKF), *W. Nanakorn* 7829 (QBG), *W. Nanakorn et al.* 171 (QBG-2 sheets), 1212 (QBG-2 sheets), 1438 (QBG-2 sheets), 1482 (QBG-2 sheets), 2019 (QBG-2 sheets), 4163 (QBG-2 sheets), 4794 (QBG), 7406 (QBG), 7663 (QBG-2 sheets), 7950 (QBG-2 sheets), 9827 (QBG-2 sheets), *I.C. Nielsen, R. Pooma, N. Koonkhunthod & M. Poopath* 1792 (BKF, SING), *Y. Paisooksantivatana* y379-80 (BK-2 sheets, KKU) & y2561-89 (BK), *P. Palee* 161 (CMUB, L), 169 (BKF-2 sheets, CMUB, L-2 sheets) & 350 (CMUB, L), *M. Panatkool* 214 (CMUB) & 452 (CMUB), *O. Petrmitr* 395 (CMUB), *C. Phengklai et al.* 6596 (C), 12306 (BKF) & 12321 (BKF), *M. Pinyosak & P. Wessumritt* 77 (QBG), *W. Pongamornkul* 2799 (QBG-2 sheets) & 5636 (QBG), *Pradet* 604 (BK), *Put* 1973 (AAU, ABD, BK, BM, E, K) & 3126 (AAU, ABD, BK, BM, E, K), *W. Saisorn* 250 (KKU), 260 (KKU), 334 (KKU) & 338 (KKU), *P. Sangkhachand* 60 (BK), *W. Sankamethawee* 316 (BKF, CMUB), *L.C. Saratae* 63 (BK-2 sheets), *T. Shimizu, H. Toyokuni, H. Koyama, T. Yahara & C. Niyomdham* T-22063 (BKF, KYO) & T-22522 (BKF, KYO), *T. Shimizu, H. Toyokuni, H. Koyama, T. Yahara & T. Santisuk* 18269 (BKF, L) & T-18278 (BKF), *T. Smitinand* 8430 (BKF, KYO, L, TI), *T. Smitinand & W. Nanakon* 144 (BKF), *Th. Sørensen, K. Larsen & B. Hansen* 4584 (C-2 sheets, P), 4704 (C, L), 4779 (C), 5024 (C, E, SING) & 5474 (C), *M. Tagawa, K. Iwatsuki, H. Koyama, N. Fukuoka, A. Nalampoon & A. Chintayungkun* T-9143 (BKF, KYO-2 sheets), *N. Tanaka, H. Nagamasu, A. Naiki, S. Nishida, P. Srisanga & S. Watthana* HN8235 (QBG), *T.T.* 39 (KKU), *C.F. van Beusekom, & C. Charoenpol* 1985 (AAU, BKF, C, KYO, L, P), *C.F. van Beusekom, C. Phengklai, R. Geesink & B. Wongwan* 3879 (BKF, C, KYO, K, L, P), *M. van de Bult* 690 (BKF, CMUB), *S. Watthana* 2 (QBG-2 sheets), *S.N.* 11 (BK258890), *S.N.* 69 (BKF31928) & *S.N.* 4327 (QBG-2 sheets).

3.2 Anatomical study

The anatomical characters of the three species of *Codariocalyx*, such as cross-sections of stems and petioles, stomatal types, the presence of papilla on leaf epidermis, shape of epidermal cells and anticlinal walls and trichome types, are quite similar. However, the presence of ridges on stems and three main vascular bundles in the petioles and the absence of an accessory bundle on petioles are diagnostic for *C. microphyllus*. Various shapes of crystals were also found in leaf epidermis of *C. gyroides*. These characters can be used for species identification (Table 1 and Figure 3). The anatomical characters of stems and leaves can be described as follows:

Stems: There are three types of stem outlines in cross-sections: subcircular, circular and elliptic shapes with 0–3 ridges and two types of trichomes: multicellular uniseriate and uncinate trichomes.

Petioles: Two types of petiole outlines in cross-sections: triangular and cordate with 3–7 discontinuous vascular bundles and 0 or 1 accessory bundle in each petiolar ridge. There are two types of trichomes; multicellular uniseriate and uncinate trichomes.

Leaf epidermis: Stomata are paracytic and anomocytic types. Epidermal cells are jigsaw-like or irregular shapes, with repand to deeply undulate anticlinal walls and papillae on outer periclinal walls. There are three types of trichomes: multicellular uniseriate, hooked, and stalked gland (with two apical cells) trichomes. Various shapes of crystals were found, viz. rectangular, solitary or paired styloid, dumbbell-like, and ellipsoid.

Mesophyll: There is one layer of palisade mesophyll cells and 4–5 layers of spongy mesophyll cells. Paraveinal mesophyll cells are found.

Table 1. Anatomical characters of genus *Codariocalyx*. an = anomocytic, ci = circular, co = cordate, de = deeply undulate, el = elliptic, ho = hooked trichome, ir = irregular, ji = jigsaw-like, mu = multicellular uniseriate trichome, pa = paracytic, re = repand, sci = subcircular, st = stalked trichome with 2-apical cells, su = shallowly undulate, tr = triangle, un = undulate, * = various shapes of crystals are found especially in leaf epidermis of *C. gyroides*, ** = accessory bundle on each petiolar ridge; specimens examined: *C. gyroides*, *W. Saisorn* 372 (KKU); *C. microphyllus*, *W. Saisorn* 249 (KKU), 262 (KKU) & 339 (KKU); *C. motorius*, *W. Saisorn* 250 (KKU), 260 (KKU), 334 (KKU) & 338 (KKU).

			Taxa		
			*C. gyroides**	*C. microphyllus*	*C. motorius*
stems		outlines	ci, sci	ci, sci, el	ci, sci
		number of ridges	0	1-3	0
petioles		outlines	tr	tr, co	tr
		number of vascular bundles (+ accessory bundle**)	5–6 (+1)	3 (+0)	5–7 (+1)
leaf epidermis	upper	stomatal types	pa	an, pa	an, pa
		shape of epidermal cells	ji	ji, ir	ji, ir
		anticlinal walls	de	de, un	de, su
		trichome types	ho, mu, st	ho, mu, st	ho, mu, st
	lower	stomatal types	pa	an, pa	an, pa
		shape of epidermal cells	ji	ji, ir	ji, ir
		anticlinal walls	de	de, re, un	de, su
		trichome types	ho, mu, st	mu, st	ho, mu, st

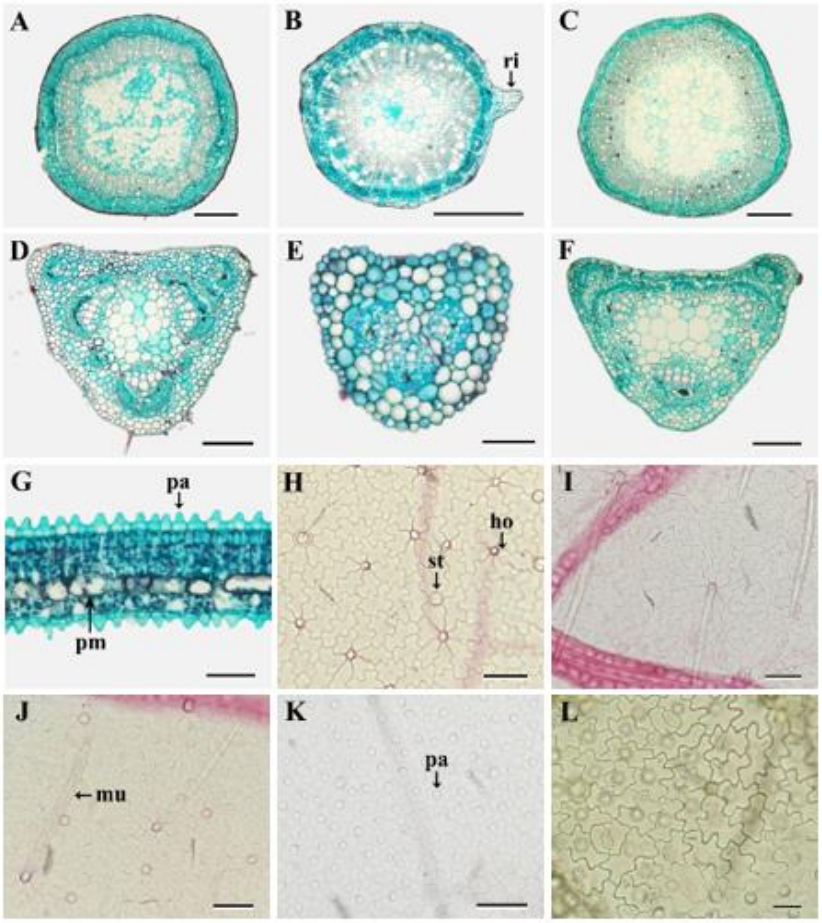

Figure 3. Anatomy of genus *Codariocalyx*: A.–C. cross-sections of stems A. *C. gyroides*, B. *C. microphyllus* and C. *C. motorius*; D.–F. cross-sections of petioles D. *C. gyroides*, E. *C. microphyllus* and F. *C. motorius*; G. cross-sections of leaf blade of *C. microphyllus*; H.–J. upper (H.) and lower (I.–J.) leaf epidermis of *C. motorius*; K. upper leaf epidermis of *C. microphyllus*; L. various shapes of crystals in upper leaf epidermis of *C. gyroides* (scale bars A.–C. 500 µm, D.–F. 200 µm, G.–L. 50 µm; ho = hooked trichome, mu = multicellular uniseriate trichome, pa = papilla, pm = paraveinal mesophyll cell, ri = ridge, st = stalked trichome with 2-apical cells).

Acknowledgements

We gratefully thank to directors, curators and staff of all herbaria cited above for their facilities and we also thank the Department of Biology, Faculty of Science, Khon Kaen University for the laboratory facilities. We would like to thank the Science Achievement Scholarship of Thailand, the Carlsberg Foundation, Denmark and Center of Excellence on Biodiversity (BDC-PG3-160013) for financial support.

References

Dy Phon, P., Ohashi, H., & Vidal, J. E. (1994). Leguminosae (Fabaceae) Papilionoideae Desmodieae. In P. Morat (Ed.), *Flore du Cambodge du Laos et du Vietnam* (pp. 1-154). Paris, France: Muséum National d'Histoire Naturelle.

Hasskarl, J. K. (1842). Plantarum genera et species novae aut reformat ae javenses. *Flora oder Allgemeine Botanische Zeitung*, *25*(2, Beiblätter 3), 1-146.

Lima, L. C. P., de Queiroz, L. P., Tozzi, A. M. G. de A., & Lewis, G. P. (2014). A taxonomic revision of *Desmodium* (Leguminosae, Papilionoideae) in Brazil. *Phytotaxa*, *169*(1), 1-119. doi:10.11646/phytotaxa.169.1.1

Merrill, E. D. (1938). A critical consideration of Houttuyn's new genera and new species of plants, 1773-1783. *Journal of the Arnold Arboretum*, *19*(4), 291-375. Retrieved from https://www.biodiversitylibrary.org/page/8102981#page/303/mode/1up

Ohashi, H. (1973). *Ginkgoana, contribution to the flora of Asia and the Pacific Region: the Asiatic species of Desmodium and its allied genera (Leguminosae)*. Tokyo, Japan: Academic Scientific Book.

Ohashi, H. (2004). Taxonomy and distribution of *Desmodium* and related genera (Leguminosae) in Malesia (I). *Journal of Japanese Botany*, *79*(2), 101-139.

Pedley, L. (1999). *Desmodium* Desv. (Fabaceae) and related genera in Australia: a taxonomic revision. *Austrobaileya*, *5*(2), 209-261. Retrieved from http://www.jstor.org/stable/41739140

Thiers, B. (2016, January 19). Index herbariorum: A global directory of public herbaria and associated staff, New York Botanical Garden's Virtual Herbarium. Retrieved from http://sweetgum.nybg.org/science/ih/