Oroxylum indicum (L.) Kurz
Bignoniaceae

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Synonyms

Arthrophyllum ceylanicum Miq., *A. reticulatum* Blume ex Miq., *Bignonia indica* L., *B. lugubris* Salisb., *B. pentandra* Lour., *B. quadripinnata* Blanco, *B. tripinnata* Noronha, *B. tuberculata* Roxb. ex DC., *Calosanthes indica* (L.) Blume, *Hippoxylon indica* (L.) Raf., *Oroxylum flavum* Rehder, *Spathodea indica* (L.) Pers. (POWO 2020)

Local Names

Cambodia: *Pika* (Khmer), *ung ka, pou long* (Bunong), **Indonesia:** *bentolan* (Kalimantan), *pongporang* (Sundanese), *kayu lanang, mungli, Pokok bonglai* (Javanese), **Laos:** *lin mai ba* (Brou, Kry, Saek), *pi ka, lin may,* **Malaysia:** *beka, bonglai, kulai, Sabah-parang pamol* (Malay), pokok bekah (Kensiu), *binkuli, parang nyabor* (Ibans of Sarawak), *gimurai, murai* (Bidayuh of Sarawak), *ulunan sangku* (Kadazandusun: Rungus, Ranau, Tambunan, Muruts: Timugon of Sabah), **Myanmar:** *kyaung shar*, *sot-gren-itg* (Mon), *maleinka* (Mak, Shan), *yawng li* (Müün, Ng'gah, Da'ai), **Philippines:** *pingka-pingkahan* (Tagalog), *abong-abong* (Bisaya), *kamkampilan* (Iloko), **Thailand:** *du kae sae* (Pwo), *pekaa* (Karen), *phe kaa* (central), *litmai* (northern), *lin faa* (north-eastern), **Vietnam:** *núc nác, hoàng bá nam, mộc hồ diệp* (Berhaman 1995; Kulip 2003, 2005, Sam et al. 2008; de Boer et al. 2012; Mohammad et al. 2012; Mohammad 2014; Chassagne et al. 2016, 2017; Falahd and Hadiwibowo 2017; Rasadah 2017; Ismail et al. 2018; Ong et al. 2018; DeFilipps and Krupnick 2018; Elliott et al. 2019; Pongamornkul et al. 2020).

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Botany and Ecology

Description: Trees, up to 10 m high (Fig. 1); barks thick, corky, lenticelate, and yellowish-gray. Leaves deccusate, 2–3-pinnate, oddpinnate, and 1–1.8 m long; leaflets elliptic-ovate, 5–15 × 3–9 cm, obliquely cuneate at base, entire at margins, and caudate-acuminate at apex; lepidotted, glabrous; petiole *c.* 30 cm long, swollen at base. Inflorescence a raceme, terminal, and 30–100 cm long; peduncle *c.* 35 cm long; pedicel 5–7 cm long, articulate at base. Flowers bisexual, *c.* 10 cm long, and nocturnal (Fig. 2). Calyx campanulate, 3–4.5 × *c.* 2 cm, limb truncate–obscurely toothed, and leathery. Corolla funnel form, maroon to reddish purple outside, and yellowish or pinkish with glandular inside; tube cylindric, *c.* 7 cm long; lobes 5, subequal, obovate, 4–5 × 3–4 cm, and wavy at margins. Stamens 5, posterior one short, and inserted on the base of the tube; filaments *c.* 3, 4, and 5 cm long respectively, villous at base; anthers linear-oblong, *c.* 1 cm long. Ovary superior, 2-celled, and many-ovuled; style *c.* 5 cm long; stigma *c.* 5 mm across. Capsule linear-oblong, 45–85 × 7–10 cm, cuneate at base and apex, and flat. Seeds numerous, elliptic, *c.* 2 cm across, flat, and winged on both side; wings *c.* 2.5 cm long, membranous.

Phenology: Flowering peaks from April to August, and fruiting from October to December (Sam et al. 2004).

Distribution: *Oroxylum indicum* grows natively in Bangladesh, Cambodia, China, India, Java, Laos, Lesser Sunda Islands, Malaysia, Myanmar, Nepal, Philippines, Sri Lanka, Sulawesi, Sumatera, Thailand, and Vietnam; also introduced into Trinidad-Tobago (POWO 2020).

Fig. 1 Habit of *Oroxylum indicum.* (© N. Dhatchanamoorthy)

Fig. 2 Flowers of *Oroxylum indicum.* (© N. Dhatchanamoorthy)

Ecology: It thrives well in secondary forests, thickets, forest fringes, road sides, field margins, and also planted in home gardens and near human settlements up to 1200 m.a.s.l. elevation. *Alangium kurzii* Craib. and *Gironniera subaequalis* Planch. are known to grow in association with this species (Sam et al. 2004; Rasadah 2017). The generic name *Oroxylum* is derived from the Greek words meaning *oros* – mountain, *xylon* – wood, and the specific epithet *indicum* means it is indigenous to India (Berhaman 1995). It is pollinated by both self-pollination, as well as fruit bats. This species also serves as a good source of food for the fruit eating bat *Eonycteris spelaea* in Thailand and Cambodia (Srithongchuay et al. 2008; Bumrungsri et al. 2013; Stewart and Dudash 2017; Thavry et al. 2017).

Local Medicinal Uses

Cambodia: Bunong people in Mondulkiri province consume root decoction, and bark or leaves in stream bath to cure malaria. They also consume a combination including bark/leaves of *Oroxylum indicum*, *w*hole plant of *Helicteres angustifolia*, leaves of *Ananas comosus,* and *Chromolaena odorata* decoction to cure malaria. Bark pounded with water is applied topically to alleviate burn. Bark or root decoction, when taken orally, cures cough. Combination of *pou long* and *Dillenia pentagyna* bark or wood decoction is used for the treatment of cold and fever. Bunong people also use a decoction from *Amphineurion marginatum* (bark/wood), *Cananga latifolia* (bark/wood), *Harrisiona perforata* (bark/wood), *Hoya kerrii* (leaves/wood),

Leea spp. (root), *Oroxylum indicum* (root), *Polyalthia cerasoides* (bark/wood), *Uvaria rufa* (bark/wood), *Ziziphus cambodiana* (bark/wood), and *Ziziphus oenopolia* (bark/wood) to alleviate Leucorrhea. A fruit decoction, or fruits pounded with alcohol, is consumed for postpartum care (Chassagne et al. 2016). Khmer traditional healers use *pika* bark or wood in the form of decoction or combination or pills to alleviate liver diseases such as *trocheak* and *psah* (Chassagne et al. 2017).
Indonesia: *Bentolan* root decoction is used to alleviate the maternal disorders in east Kalimantan. It is also used in the treatment of fever, malaria, and kidney ache in Kalimantan, stomach ache in Kutai, snake bite in Mentawai, and swelling in Sabah (Malaysia) (Falah and Hadiwibowo 2017). Fresh barks chewed after parturition serve as a depurative. It is also used as Antihemorrhagic. The flowers are used to treat eyes inflammation (DeFilipps and Krupnick 2018). In Java, pounded bark paste is taken orally to alleviate gastritis, and as blood purifier. The inner bark is used as coagulant in northern Sulawesi (Rasadah 2017).
Laos: *Oroxylum indicum* is used as the remedy for infant diarrhea, jaundice, and headache by the Bru, Saek, and Kry communities. Roasted bark decoction is used to alleviate dizziness. Bark or fruit decoction is orally taken or used in the steam bath to cure headache. They also use a paste from roasted bark as poultice to alleviate fever, and to heal wounds. Roasted wood decoction is taken orally to cure arthralgia. Neonatal rashes and itches are cured using water boiled with *lin mai ba* barks. Bark is also eaten to treat diarrhea. Roasted bark decoction is consumed orally to cure jaundice by Saek people. Kry people uses bark as cold infusion to alleviate cold and to prevent hangover (de Boer et al. 2012). Traditional healers of Champasak province, southern lowlands of Laos, prepare a portion of seven medicinal plant roots including *hak ien don* (*Eurycoma harmandiana* Pierre), *ya nang leuang* (*Limacia triandra* Miers), *ya nang khao* (*Tiliacora triandra* (Colebr.) Diels), *dtoum ga don* (*Strychnos nux-blanda* A.W. Hill), *bi khon* (*Brucea javanica* (L.) Merr), *lin mai ba* (*Oroxylum indicum* (L.) Kurz), and *dtoum ga kheua* (*Strychnos axillaris* Colebr.), which is given orally thrice per day for the treatment of uncomplicated malaria (Elliott et al. 2019).
Malaysia: Muruts–Timugon people of Sabah soak *ulunan sangku* bark in hot water and wipe it topically to reduce swellings (Kulip 2003, 2005). *Ulunan sangku* is also used to treat cuts, wounds (Ranau), boneache, sprain or muscle dislocation (Rungus), and vomit and skin disease (Tambunan) by Kadazandusun communities of Sabah (Kulip 2005). The Kensiu people in Lubuk and Kedah eat raw *pokok bekah* bark to cure nausea (Mohammad et al. 2012). *Bekah* barks are eaten raw to cure nausea and vomiting by the Orang Asli at Lubuk Ulu Legong (Mohammad 2014). Leaf decoction is used to cure stomach ache, and as poultice for the treatment of childbirth, rheumatic swellings, and as remedy for enlarged spleen, toothache, and headache (Rasadah 2017). *Pokok bonglai* leaves or roots with garlic (*Allium sativum*) clove are wiped on adolescents' joints to prevent seizure by the Javanese-Malay community in Parit Jelutong, Batu Pahat, and Johor. Roots, stems, and leaves are also eaten raw in postpartum healthcare (Ismail et al. 2018).
Myanmar: Cooked leaves and fruits of *yawng li* are eaten to cure swollen spleen, hypertension, and dyspepsia, and also used as carminative by the Müün, Ng'gah, and

Daai Chin indigenous people. These communities also use bark powder mixed with water as ear drops to cure Otitis media; bark ash is applied on burns; paste of bark pound with water is applied on cuts and wounds (Ong et al. 2018). Bark powder mixed with ginger juice (*Zingiber officinale*) and honey taken for asthma and bronchitis. Hot water soaked powder is taken twice per day for chronic indigestion. Bark soaked water is gargled as remedy for dry throat and dry perioral skin. Bark of root and stem are used as tonic to cure dysentery, diarrhea, and rheumatism. Pounded roots are applied topically to treat skin disorders. Fresh leaf juice is used to treat opium toxicity, and boiled leaves are eaten to stimulate defecation. Boiled or roasted young fruit is eaten as salad to cure skin furuncle. A young fruit cooked with chicken is eaten to cure asthma. It is also cooked with striped snakehead fish (*Ophiocephalus striatus*) and eaten for indigestion, diarrhea, and for liveliness. Fruit cooked with prawn is eaten to alleviate palpitations or fatigue disorders. It is also cooked with *hilsa/ilisha* fish (*Tenualosa ilisha*) and eaten to alleviate inflammation, gain weight, and for heart problems. Fruit cooked with *nga-mway-toh* fish (*Mastacembelus armatus*) is eaten as aphrodisiac, remedy for menstruation disorders and for piles/haemorrhoids (DeFilipps and Krupnick 2018).

Philippines: Root decoction is taken orally to alleviate rheumatism, dysentery, and as diuretic. Leaves are used in the steam bath to cure rheumatic disorders (Rasadah 2017). Crushed fresh bark juice is applied externally to relieve body pain after fever or malaria. It is also used in the treatment of asthma, bronchitis, chronic indigestion, diarrhea, and skin disorders (DeFilipps and Krupnick 2018).

Thailand: *Pekaa* roots and root barks are used as a tonic to alleviate diarrhea and dysentery; stem barks are used in the treatment of ulcers and abscesses; seeds are utilized as a laxative and expectorant (Rasadah 2017). Thai-Karen and Lawa ethnic people use *pekaa* flowers and fruits to alleviate sensory system disorders (Shin et al. 2018; Punchay et al. 2020). *Du kae sae* stem decoction is taken orally to treat HIV, and flowers and fruits are used to alleviate muscle pain by the Pwo indigenous people in Chiang Mai province (Pongamornkul et al. 2020).

Vietnam: Seeds of *O. indicum* is used in the treatment of stomach ache, chronic cough, pleuro-pneumonia, and pimples by the ethnic communities of Laos and Vietnam (Sam et al. 2004). *Núc nác* bark and fruit decoction is taken orally to alleviate muscle sprain and bark decoction to cure dysentery by the ethnic peoples in Ben En National Park (Sam et al. 2008). Seeds are applied externally to cure ulcers. Bark of root and stem decoction is used to alleviate allergic problems, urticaria, jaundice, asthma, sore throat, laryngitis, hoarseness, gastralgia, diarrhea, and dysentery (Rasadah 2017).

Phytochemistry

Phytochemicals such as chrysin, baicalein, oroxylin A, and Oroxylin B are the major components present in most of the parts. Sankara and his team reported three flavonoids baicalein, biochannin A, and chrysin (Sankara and Nair 1972a, b). Joshi et al. (1977) identified the presence of prunetin and β-sitosterol from the heart wood.

Vasanth et al. (1991) extracted Ellagic acid, 8, 8′ Bis-baicalein, Oroxylin A, and Oroxyloside methylester from the root bark. Ali et al. (1998) separated flavonoids (bacailein and chrysin) and a naphthoquinone (lapachol) from the roots.

Bioactive compounds identified include Adenosine, Apigenin, Baicalein, Baicalin, Baicalein-7-*O*-glucoside, Baicalein-7-*O*-diglucoside (Oroxylin B), Baicalein 7-*O*-*β*-D-glucuronopyranosyl-(1 → 3)[*β*-D-glucopyranosyl-(1 → 6)]-*β*-Dglucopyranoside, Baicalein-7-*O*-*β*-D-gentiobioside, Baicalein-7-*O*-gentiobioside, Baicalein 6-methoxy-7-glucuronide, Carboxylic acid, Chrysin, Chrysin-diglucoside, Chrysin 6-C-*β*-D-glucopyranosyl-8-*O*-*β*-D-glucuronopyranoside, Chrysin-6-C-*β*-D-glucopyranosyl-8-C-*α*-L-arabinopyranoside, Chrysin-7-*O*-glucuronide, Chrysin-7-O-*β*-D-gentiobiosid, Chrysin-7-glucuronide, Chrysin-7-O-gentiobioside, Dihydrooroxylin A-7-*O*-methyl glucuronide, 5- hydroxyl-7-methoxy-2-(2-methoxy-6-(3,4,5-trihydroxy-6-(hydroxymethyl)tetrahydro-2H-pyran-2-yloxy)phenyl)-4H-chromen-4-one, Dihydro iso-*α*-lapachone, 7-*O*-methylchrysin, 5-hydroxy- 40,7-di methoxy flavone, Dihydro oro xylin A, Dimethyl sulfone, Echinulin, Ellagic acid, Hispidulin, Isoverbascoside, Lupeol, Oroxylin A-7-*O*-*β*-glucopyranoside, Oroxylin-A-7-*O*-glucoside, Oroxylin A-7-*O*-*β*-Dglucuronide butyl ester, Pinocembrin, Pinobanksin, Scutellarein, Scutellarein 7-*O*-*β*-D-glucopyranosyl- (1 → 6)-*β*-D-glucopyranoside, Scutellarein-7-*O*-glucopyrano side, *β*-sistosterol, Ursolic acid, 2-methyl-6-phenyl-4H-pyran-4-one, 2*α*-hydro xyllupeol, 5,6,7-trimethoxyflavone-8-*O*-b-D-glucopyranoside, 6-Hydroxyluteolin and 6-Methoxy-baicalein, 5,7-dihydroxy–flavone (Nakahara et al. 2001, 2002; Jiwajinda et al. 2002; Chen et al. 2003, 2005; Dinda et al. 2007; Yuan et al. 2008; Hari Babu et al. 2010; Liu et al. 2010; Majumdar et al. 2010; Yan et al. 2011, 2014; Kruger and Ganzera 2012; Cao et al. 2013; Li et al. 2014a, b; Das et al. 2014; Fan et al. 2015; Fuentes et al. 2015; Rojsanga et al. 2017; Sun et al. 2017a; Nagasaka et al. 2018; Chetry and Bharali 2018; Sithisarn et al. 2019; Hemantha et al. 2019; Peng et al. 2019; Rojsanga et al. 2020).

Volatile oils including 2-Furancarboxaldehyde, 5-(hydroxymethyl), Nonanoic acid, n-Decanoic acid, 2-Cyclohexen-1-one, 2-methyl, 2-Dodecenoic acid, Benzeneethanol, 4-hydroxy, 3-Hydroxy-2-methylbenzaldehyde, Cyclobutane-carboxylic acid, decyl ester, Dodecanoic acid, Ethyl N-(o-anisyl) formimidate, 1,6-Dihydro-5-(2-hydroxyethyl)-4-methyl-6-oxopyrimidine, Tetradecanoic acid, Hexadecanoic acid, methyl ester, n-Hexadecanoic acid, Hexadecanoic acid, ethyl ester, Phytol, Linoleic acid ethyl ester, Linolenic acid ethyl ester, Glycerol 1,3-dipalmitate, Linolelaidic acid, methyl ester, 9,12,15-Octadecatrienoic acid, 2-phenyl-1,3-dioxan-5-yl ester, Dotriacontane, Glycerol 1-monopalmitate, *β*-Mono-linolein, Campesterol, Stigmasterol, and γ-Sitosterol are reported from the young pods (Dunkhunthod et al. 2020).

Bioactivity

O. indicum exhibited significant therapeutic activities against various disorders including genotoxic (Tepsuwan et al. 1992), anti-inflammatory activity (Ali et al. 1998; Tenpe et al. 2009; Upaganlawar et al. 2009; Siriwatanametanon et al. 2010;

Doshi et al. 2012; Tran et al. 2015; Lalrinzuali et al. 2016; Begum et al. 2019; Dunkhunthod et al. 2020), antioxidants (Ng et al. 2000; Jiwajinda et al. 2002; Palasuwan et al. 2005; Zaveri et al. 2006; Gupta et al. 2008; Kalaivani and Mathew 2009; Mishra et al. 2010; Joshi et al. 2011; Kumar et al. 2011; Singh and Kakkar 2013; Sithisarn et al. 2016; Rojsanga et al. 2017; Trang et al. 2018), anticarcinogenic activity (Nakahara et al. 2001, 2002; Palasuwan et al. 2005), antiarthritic activity (Laupattarakasem et al. 2003; Karnati et al. 2013), anticancer (breast, bladder) (Lambertini et al. 2004; Lalou et al. 2007; Roy et al. 2007; Naveen Kumar et al. 2012; He et al. 2016; Nagasaka et al. 2018; Yang et al. 2018; Buranrat et al. 2020), antitumor (Costa-Lotufo et al. 2005; Siriwatanametanon et al. 2010), antiprotease activity (Majumdar et al. 2010), gastroprotective potential or antiulcer (Hari Babu et al. 2010; Begum et al. 2019), antilipoperoxidative (Joshi et al. 2011), nephroprotective (Mishra et al. 2014), analgesic agent (Upaganlawar et al. 2007; Das et al. 2014; Lalrinzuali et al. 2016), antiobesity or antiadipocyte activity (Singh and Kakkar 2014; Mangal et al. 2016; Hengpratom et al. 2018, 2020), antilymphoma therapy (Yang et al. 2015), anthelmintic property (Deori and Yadav 2016), anti-allergic (Lee et al. 2016), hepatoprotective (Tenpe et al. 2009; Mohan et al. 2016), antidiabetic (Sun et al. 2017a, b; Zhang et al. 2017; Begum et al. 2019), anti-melanogenesis (Zhao et al. 2018), antiviral (Mohamat et al. 2018), antiproliferative activity (Chetry and Bharali 2018; Chassagne et al. 2018; Li et al. 2018a, b), wound healing (Lalrinzuali et al. 2018; Mairuae et al. 2019), antidyslipidemic activity (Begum et al. 2019), cardio-protective activity (Menon et al. 2019), and as a source of nutraceutical supplement (Fuentes et al. 2015; Dunkhunthod et al. 2020).

Extracts from the various parts show activity against clinical pathogenic bacteria such as *Bacillus cereus, B. subtilis, Escherichia coli, Klebsiella pneumoniae, Proteus* sps., *Pseudomonas aeruginosa, Shigella dysentriae, S. flexneri, S. sonnei, Staphylococcus aureus, S. intermedius, Streptococcus suis* and *Vibrio cholerae* (Ali et al. 1998; Uddin et al. 2003; Das and Choudhury 2010; Radhika et al. 2011; Moirangthem et al. 2013; Fan et al. 2015; Panda et al. 2016; Sithisarn et al. 2016, 2019; SatyaEswari et al. 2018; Kim et al. 2020), fungal species including *Aspergillus fumigatus, Candida albicans,* and *Macrofomina phaeolina* (Ali et al. 1998; Moirangthem et al. 2013), the worm *Hymenolepis diminuta* (Deori and Yadav 2016), and Chikungunya virus (Mohamat et al. 2018).

Local Food Uses

Tender leaves, shoots, flower buds, flowers, and tender fruits are eaten raw or after cooked by many Southeast-Asian communities. Karen people of Kanchanaburi province, Western Thailand, eat roasted *pekaa* fruits and boiled flowers (Paisooksantivatana and Kako 1995). Karen and Lawa ethnic communities of Thailand use fresh bark, tender leaves, shots, and pods as a seasonal vegetable (Punchay et al. 2020). Brou, Kry, and Saek ethnic people of Lao consume raw young leaves, boiled flowers, and boiled or roasted tender pods of *lin mai ba.* They also use bark powder as one of the main ingredients in traditional rice wine brewing (de Boer et al. 2012).

Tender leaves, shoots, and fruits are eaten by the ethnic communities of Vietnam and Java in Indonesia (Vu and Nguyen 2017; Rasadah 2017). In Malaysia, *beka* tender fruits are used in the preparation of salad and chicken curry. It is also used as a vegetable in traditional fish curry preparations involving striped snakehead fish (*Ophiocephalus striatus*), *hilsa/ilisha* fish (*Tenualosa ilisha*), *nga-mway-toh* fish (*Mastacembelus armatus*), and prawns (DeFilipps and Krupnick 2018).

Biocultural Importance

The ethnic communities of Thailand, Myanmar, and Laos cultivate *phe kaa* in their home gardens, near human settlements, and as mixed crop in the fields for consumption (Nath et al. 1999; Sam et al. 2004; Ochiai 2012). *Phe kaa* bark and wood chips of *Artocarpus heterophyllus* are boiled with water and the filtrate is traditionally used as dye to obtain greenish-khaki color in Thailand (Subansenee 1995). Most of the upland farmers of Northern Laos exempt *phe kaa* tree from felling during agriculture, which shows its importance in local livelihood (Roder 2001).

Economic Importance

Phe kaa flowers are collected as a NTFP and sold in the local markets by the hill farmers of northern Laos (Roder et al. 1995). Soft wood of this species is used for making match sticks, papers, and as firewood in Vietnam and Laos (Sam et al. 2004).

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