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Pterocymbium R. Br (Sterculioideae, Malvaceae), a genus new to China and suggestions for conservation

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Abstract

The genus *Pterocymbium* R. Br. is new to China, and the remarkable discovery is reported in the present study. *P. macranthum* Kosterm., a winged-boot tree published in 1962, has recently been spotted in the border regions of China and Laos. The main detailed anatomical characteristics of the flower are photographed, and supplementary descriptions of the species are made based on fresh materials, herbarium collections, and available literature. Historically, the tree is only recorded in Southcentral Myanmar to Northern and Southwestern Thailand. The new record in the present study extends the known geographical range of *P. macranthum* to the northern edge of the Asian tropics and contributes to the knowledge of the tree flora both in China and Southeast Asia. Aided by drones, the population size of China has been rapidly assessed, and ca. 1000 individuals were recognized from high-resolution photos in ca. 2000 ha area. Herbaria were prepared and deposited in the herbarium of Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences (HITBC).

Keywords

Pterocymbium, Malvaceae, biogeography, Indo-Burma Biodiversity Hotspot, transboundary biodiversity conservation

Introduction

The genus *Pterocymbium* was established by Robert Brown (1844: 219), and it currently includes 12 species and one variety, which are distributed from the Eastern Himalayas (NE India) through the Indo-China Peninsula (Thailand, Myanmar, Laos, Cambodia, Viet Nam and Malaysia) to some Pacific islands (Indonesia, Philippines, Papua New Guinea and Fiji) (POWO 2023). *Pterocymbium* was previously placed in the Sterculiaceae, but based on molecular data, the genus is now placed under the subfamily Sterculioideae, of the family Malvaceae (Bayer et al. 1999). Studies based on chloroplast genomic data showed that *Pterocymbium* is a sister genus to *Scaphium*, and, together with the genera *Cola* and *Firmiana*, form the *Cola* clade of the subfamily Sterculioideae (Wilkie et al. 2006; Li et al. 2021).

The species of the *Pterocymbium* genus have been rarely studied in the past decades, and little is known about their biological and ecological characteristics. Among the existing literature, Nurshahidah et al. (2013) pointed out that leaf venation and trichome characteristics have good taxonomic value to be used for taxonomy, and Singh et al. (2013) confirmed *P. tinctorium* (Blanco) Merr. as new to mainland India. In contrast to other species in the genus, the IUCN Critically Endangered, Fiji endemic species *P. oceanicum* A.C.Sm. (Rivers 2016) has drawn more attention. Keppel et al. (2021) showed that *P. oceanicum* has a narrow ecological niche, that its habitats are degraded, and that its population may be threatened by an alien species of similar ecological niche (the invasion of *Spathodea campanulata* P.Beauv.). Only 433 individuals of *P. oceanicum* A.C.Sm were found after an intensive fieldwork survey of its largest subpopulation and three newly found stands. Subsequently, Taoi et al. (2022) estimated its global population in over 1670 individuals in Fiji.

During an expedition to survey the Asian elephant (*Elephas maximus* L.) forage plants in Shangyong Sub-Reserve, Xishuangbanna National Nature Reserve (hereinafter referred to as SSR-XNNR), Mengla County, in February 2023, a magnificent emergent deciduous tree with full bloom flowers was encountered in the transboundary region between China and Laos. After carefully studying the living plants and specimens, and comparing them with available literature and herbarium

resources, we confirmed that the species and the genus are new to China.

In the present study, population size of *P. macranthum* in SSR-XNNR was assessed, and an IUCN endangerment category was designated. In addition, forest communities contain and dominated by the tree were briefly described, implications of the new discovery and conservation suggestions were summarized and discussed.

Materials and methods

Study area. SSR-XNNR, located in the southernmost part of Yunnan Province, has a long border with Laos. The climate is dominated by the southwest monsoon, with high rainfall from May to October and low rainfall from November to April. The annual mean temperature is 21.0°C, with a historical extreme low temperature of 8.9°C. The annual mean precipitation is 1700.0 mm, with more than 85% occurring in the rainy season and a historical extreme minimum annual rainfall of 1322 mm. Climate data refers to the historical record data of the township of Mohan, where SSR-XNNR is located.

Population size assessment. Given that no specific population endangerment status assessment has been carried out for this species in its range states at present, neither in Thailand nor in Myanmar. For the sake of guiding the development of a management plan, we undertook a rapid population size estimate using high-resolution photos from a drone (DJI M300, mounted with a 31.7–556.2 mm of 35 mm equivalent focal length zoom lens, 20-megapixel COMS camera, Zenmuse H20T). By reviewing the habitats of *Pterocymbium* spp., we set the priority survey areas to the broad river valley, below 1000 m in elevation. In order to obtain high-quality aerial images without losing much working efficiency, we kept the flight height around 100 m above the ground, and when there was a suspected individual, we lowered the drone's flight height or zoomed in the lens for confirmation. Canopy heights and associated tree species in the targeted areas were measured and identified with the assistance of the drone simultaneously. Flowering and fruiting *P. macranthum* individuals were then identified and counted directly from photos. We also recorded the distribution and interviewed local people to evaluate current threats for the population. The main concerns were focused on whether the tree had been noticed in the past, usages, and whether domestic or international

trades of the timber had been seen. The conservation assessment of the newly-recorded species was evaluated using the IUCN categories of threat (IUCN 2012).

<insert Fig. 1 here>

Results

***Pterocymbium* R. Br.** in Benn., Pl. Jav. Rar. 219, t. 45. 1844; Kosterm., Reinwardtia 1: 41. 1950.

Chinese vernacular name: 舟翅桐属.

Description. Deciduous trees. Leaves simple, margin entire, spirally arranged. Inflorescence terminal or subterminal on branchlets, paniculate. Flowers 5-numerous, unisexual, petals absent, appearing before leaves. Calyx large, orange, orange-red or green, campanulate or tubular, 5-lobed, persisting in fruit. Male flowers with 8–10 stamens, in a whorl around the base of carpels at the apex of androgynophore, anther 2-celled, undeveloped pistil present. Female flowers: ovary 5-locular, sub-connate, each locule with a rudder-like hook at the base outside, basally enclosed by undeveloped anthers; styles sub-connate; stigmas as many as carpels; ovules 2 per locule. Follicles stipitate, endocarp membranous, dehiscent long before maturity, foliaceous, nerves conspicuous. Seed 1–2 per follicle, ovoid or ellipsoid, on the base of the foliaceous endocarp.

***Pterocymbium macranthum* Kosterm. Reinwardtia 6: 295, fig. 13. 1962.**

Fig. 1. A-M.

Chinese vernacular name: 大花舟翅桐

Type. MYANMAR, Mekhrein Chaung, Dawnas Amherst, 14 February 1927, *Parkinson, C.E.* 5218 (lectotype K, photo! [barcode no. K000671560], designated here; isolectotype, K, photo! [barcode no. K000671559]).

Description. Trees deciduous, bole straight, up to 50 m tall, and 1.5 m in diameter. Bark grey, smooth, exfoliating in small pieces, lenticellate; twigs stout, glabrescent, with prominently raised, large leaf scars. Stipules subulate, caducous. Leaves ovate or cordate, 5–17 × 8–12 cm, leaf blade sub-coriaceous, base cordate, apex acute to acuminate, both surfaces densely pilose when young, glabrescent above, pilose below, with 5–7 palmate basal veins, lateral veins 6–7 pairs, tertiary veins reticulate, midrib

conspicuous raised abaxially, margin entire. Inflorescences erect, terminal or subterminal, lax panicle in upper leaf scars, 6–12 cm long, covered with stellate hairs, glabrescent. Pedicel slender, 6–8 mm long, broadened at the apex and articulately attached to the stalk-like, 4 mm long base of the flower. Flower unisexual, orange to orange-red, with male and female flowers on the same plant stalked, in clusters of 3–5, narrowly funnel-shaped, 5-lobed, united 2/3 at the base, 3–3.5 cm long and 2 cm diameter at apex, the upper part of inner surface sparsely covered with glandular hairs; calyx lobes 6–10 mm long, triangular with red dots scattered, the inner surface and margin densely tomentose; bract caducous; male flowers with (8–) 10 stamens, in a regular ring of the apex of minutely pilose androgynophore, undeveloped pistil covered with short glandular hairs; female flowers with five sub-connate carpels, carpel covered with short glandular hairs, androgynophore minutely pilose; style sub-connate and free apically, curved towards the base, stigmas 5. Fruit of 5 follicles, within a persistent calyx, pendulous, dehiscing before ripening; follicle membranous, winged, boat-shaped, 5–8 × 1.5–2 cm, with a spur, inner surface of wing glabrous with some red dots, outer surface glabrous or with very sparse stellate hairs, inner surface shiny, outer surface look dull, with a prominent dorsal lobe. Seed 1–2 at the base of each follicle, ellipsoid, wingless, 1.5–1.8 × 1.1–1.2 cm.

Phenology. Flowering: February–March; Fruiting: April–May.

Distribution and habitat. Thailand (Chiang Mai, Lampang, Kanchanaburi), Myanmar (Amherst) (Phengklai, 1995). China: Shangyong, Mengla, Xishuangbanna, Yunnan. Grows in tropical monsoon forests with an elevation of 600–1000 m.

Population size. Aided by the photos taken by drone, the flowering individuals of *Pterocymbium macranthum* can be easily recognized in the top layer of tropical monsoon forest in the dry season (Fig. 2 A-E). The 5-day rapid fieldwork survey covered an area of ca. 2000 ha, and 1432 aerial photos were obtained, where ca. 1000 *P. macranthum* individuals were recognized and counted. Although the total size of the tree distribution range in SSR-XNNR is relatively large, we find one site with ca. 80 individuals in a highly clustered distribution, while the other individuals were scattered in the forest.

Current threats. In the survey, a total of eighteen people, including seven experienced woodcutters of the past, five forest rangers and six managers from both forestry and SSR-XNNR management authority were interviewed. No domestic or international trades or illegal cutting information was identified. The tree had little usage neither in the past nor at present locally. Three people from SSR-XNNR management authority had noted the tree before but without further identification work had been done.

Habitat and community structure. Distribution sites of *P. macranthum* are basically located in the riparian areas of SSR-XNNR. Vegetation can be categorized as tropical monsoon forest.

The height of communities that contain or are dominated by *P. macranthum*, is usually below 30 m and the tree layer is two-storied. The upper layer is around 20–30 m, canopy irregular, coverage ca. 40%, and commonly associated tree species are *Pterospermum lanceifolium* Roxb. ex DC., *Tetrameles nudiflora* R. Br., *Antiaris toxicaria* Lesch., *Chukrasia tabularis* A. Juss., *Terminalia myriocarpa* Van Huerck et Muell.-Arg., and *Ficus callosa* Willd., among others. The canopy height of the lower stratum is below 15 m, which consisted mainly of *Dendrocalamus membranaceus* Munro, often associated with *Albizia lucidior* (Steud.) Nielsen, *Erythrina stricta* Roxb. *Dillenia pentagyna* Roxb., and *Aphananthe cuspidata* (Bl.) planch. The understory is a dense complex of shrubs, vines, grasses, and ferns.

IUCN endangerment category. Based on the results of the present study and our experience in southern Yunnan, Laos, Myanmar and Thailand, we recommend that *P. macranthum* be designated as category Vulnerable (VU) for attention and conservation according to the IUCN criteria for evaluating endangerment levels (IUCN 2012). However, additional surveys are needed, especially in Southeast Asian countries such as Laos and Myanmar, where the flora remains poorly investigated.

<insert Fig. 2 here>

Discussion

Along with the technique development of micro-UAVs (unmanned aerial vehicles) and high-performance airborne photographic system, more and more studies of plant

ecology, including vegetation mapping over small to medium-sized regions, have applied the new macroscopic research method, providing new knowledge on both species and ecosystem levels (Olariu et al. 2016; Sun et al. 2022). The approach implemented here to assess the population size of *P. macranthum* sets an excellent example of a rapid estimate of the population size of emergent deciduous trees in tropical montane areas, especially in forests with dangerous animals (elephants) or areas of difficult accessibility.

The study area has limited accessibility due to the presence of a population of around 60 wild Asian elephants that pose a high-risk to researchers entering the forest. Consequently, in our efforts to estimate the population size of *Pterocymbium macranthum* we could only cover part of this transboundary region. Despite this limitation, we could still conclude that *P. macranthum*'s population size in China is small for the following reasons. First, it is not difficult to notice such giant deciduous trees with hysteranthous habit in the flowering season, its inflorescences are large, with numerous brightly colored flowers. Second, Xishuangbanna is a famous place where plant resources have been long studied by numerous Chinese and foreign botanists, not only for its extreme diverse plants and the largest, best-preserved tropical rainforest in China, but also for its long history and profound ethnobotany culture. Moreover, the flora of Mengla county has been well investigated, with 3170 vascular plants having been recognized in its 6860.84 km^2 administrative territory (Chen et al. 2013). The fact that *P. macranthum* had not been described earlier suggests that its population size is likely to be small.

From the known ranges of *Pterocymbium* spp., only *P. tinctorium* (Blanco) Merr. and its variety *P. tinctorium* var. *javanicum* (R.Br.) Kosterm. have broad ranges, almost sharing the same range as the genus. All other *Pterocymbium* species are found in very limited geographical areas (POWO 2023), most of them probably can only be found in the original locations described in the protologues. This remarkable new record extends northward the known range of both the species and the genus.

The habitat of *P. macranthum* in SSR-XNNR is mainly tropical monsoon forest, a similar ecological niche to other species like *P. tinctorum* and *P. oceanicum*, and the

tree is an iconic tree species to such forest type, even becoming dominant in some areas (Tripathi et al. 2004; Keppel et al. 2021; Hernandez et al. 2021).

Zhu et al. (2015) confirmed that the tropical rainforests of Xishuangbanna are part of the southeast Asia tropical rainforests by analyzing floristics characteristic. They share lots of rainforests typical species like Dipterocarpaceae spp., Euphorbiaceae spp., Annonaceae spp. and so on, and their rankings of the Importance Value Index are also very similar. However, not many bridging species have been found to the tropical monsoon forest. *P. tinctorium* is a dominant tree species of Asian tropical forests, especially in dry forests. The discovery of its close relative *P. macranthum* in China, further demonstrates that the tropical forest flora of China has powerful connections with tropical Asia.

The Chinese flora increases in size at the rate of about 200 vascular plant taxa annually (Du et al. 2020), but most of the new species are herbs, shrubs and vines. National level new records of tree species have become rare in recent decades, especially at a genus level. For example, in the period from 2000 to 2019, there have been 2646 new vascular plants from the top 25 families in China. Of these, only ~69 (i.e., 2.6%) species, belonging to Fabaceae, Rosaceae, Rubiaceae and Magnoliaceae, are probably trees. *Pterocymbium macranthum* is a large tree with high potential ornamental and timber value, with its characteristic lofty and cylindrical bole, beautiful tree outline, spreading canopy, blooming before leaves, with a large amount of orange or orange-red colored flowers, similar to some commonly used landscape trees, such as *Mayodendron igneum* (Kurz.) Kurz., *Cassia nodosa* Buch.-Ham.ex Boxb., *Catalpa* spp., and *Paulownia* spp. We therefore recommend the collection of its germplasm resources and its artificial breeding to assist in the expansion of its population size. Now, the discovery of the beautiful giant tree not only reveals the urgent needs to undertake more surveys in the transboundary regions, but also narrows the gaps between tropical forests in China and Asia. Furthermore, its emergence enriches plant resources, elevates the biodiversity level in China, and brings an amazing plant to mankind for research and landscaping work.

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Figure 1. *Pterocymbium macranthum* Kosterm. **A** Habit in blooming season and bark characteristics **B** Inflorescence **C** Size of flowers **D** Front view of a flower and hairs inside calyx tube **E** Hairy calyx lobe edges **F** Female flower longitudinal section **G** Androgynophore (female), gynoecium and androecium **H** Size of Androgynophore (leftmost is male) **I** A carpel with 2 ovules **J-M** Leaf characters **J** Veins of leaf basal area and trichome characteristics (abaxial) **K** Venation characteristics (abaxial); L. trichome characteristics (adaxial glabrous) **M** Size and shape of leaves. Photographed by: Mingxu Zhao.

Figure 2. Photographs taken in population size survey **A** Formation of *P. macranthum* Kosterm. and *Pterospermum lanceifolium* Roxb. ex DC., those emergent with orange-colored canopies are *P. macranthum*, ca. 80 individuals **B** Side view of a full bloom individual **C** An individual in the initial stage of fruiting period **D, E** Top view pictures of Inflorescences and flowers for identification in fieldwork. Photographed by: Jinhua Li and Wende Yan.

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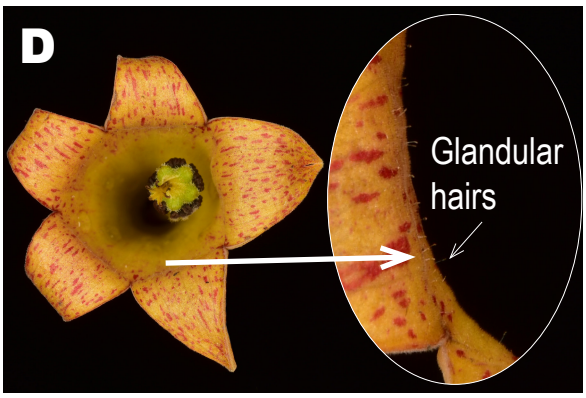

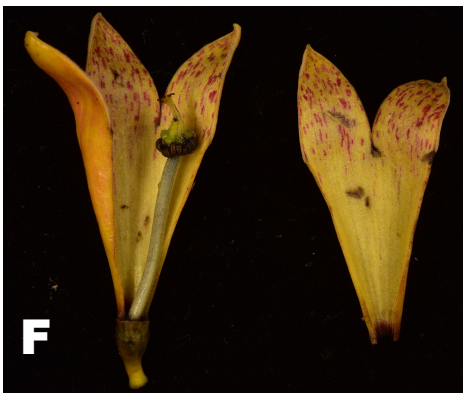

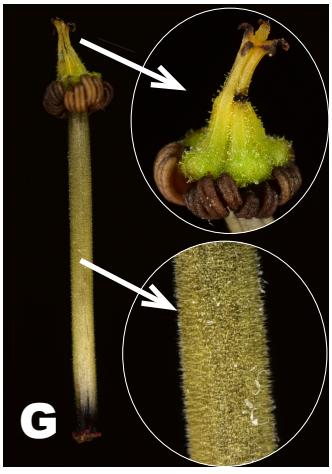

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