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## The rediscovery of *Carya poilanei* (Juglandaceae) after 80 years reveals a new record from China

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### Abstract

Despite having been first published in 1941, *Carya poilanei* (Chev.) Leroy is only known from two original collections in Vietnam and Laos; however, it has not been recollected since then and long suspected to be extinct by repeated deforestation events. Here, we report the rediscovery, and meanwhile the first new record in China, of this extremely rare gigantic hickory species at Yunnan province after 80 years. Three small patchy subpopulations were found with a total of about 50 adult trees have diameter at breast height (DBH) larger than 60 cm, together with some seedlings and saplings, but the fruit set was low. Based on multiple fresh materials, we present a revised morphological description of *C. poilanei*, and an updated distribution map for the species. In addition, we also provided a key for the hickories in China. Lastly, we suggest *C. poilanei* should be listed as Critically Endangered (CR) or Endangered (EN) species according to the latest IUCN Red List Categories and Criteria.

### Keywords

hickory, *Sinocarya*, Ailao Mountains, limestone, Yunnan province

### Introduction

*Carya* Nutt., consisting of ca. 17 currently accepted species (Manning 1978; Chang and Lu 1979; Lu et al. 1999; Zhang et al. 2013; Grauke et al. 2016), is the second largest genus in Juglandaceae DC. ex Perleb after *Juglans* L. (Kozłowski et al. 2018), with a discontinuous distribution in South-Eastern Asia and eastern North America (Stone 1997; Lu et al. 1999). The genus *Carya* include many internationally important and economically valuable nut crops such as pecan (*C. illinoensis* (Wangenh.) K. Koch) and Chinese hickory (*C. cathayensis* Sarg.). All *Carya* species are monoecious, dichogamous and anemophilous, with male and female inflorescences being separate and fruit mature process heterochronic (Grauke and Mendoza-Herrera 2012). Based on the presence, number and arrangement of bud scales, *Carya* was divided into three sections: Sect. *Apocarya* C. DC., Sect. *Carya* and Sect. *Sinocarya* Cheng & R. H. Chang (de Candolle 1864; Chang and Lu 1979). The first two sections were established in eastern North America, while the last section was found in South-Eastern Asia.

So far, five hickory species have been recognized in South-Eastern Asia, specifically in Southern China, Northern Vietnam, Northern Laos and North-Eastern India

(Manning 1963; Chang and Lu 1979). Among the five species, three (*C. cathayensis*, *C. hunanensis* W.C. Cheng & R.H. Chang and *C. kweichowensis* Kuang & A.M. Lu) are endemic to China; they seldom display overlapping distributions and are in general extremely rare (Chang and Lu 1979; Lu et al. 1999; Grauke and Mendoza-Herrera 2012). *Carya tonkinensis* Lecomte seems to be the most widespread species in South-Eastern Asia, distributed in southwest China, northern Vietnam and north eastern India (Manning 1963; Chang and Lu 1979). *Carya poilanei* (Chev.) Leroy was described in 1941 based on a single specimen collected from Northern Vietnam in 1937 (Chevalier 1941; Leroy 1950), and later, Manning (1963) added a record of specimen collected from Laos in 1932 (Fig. 1A). Although botanists have made efforts to seek the surviving members in the areas where the only two elderly specimens were originally located (Grauke et al. 1991; Grauke et al. 2016), living trees of *C. poilanei* have not been found for over 80 years, and thus this species has been suspected to be extinct in wild (Grauke and Mendoza-Herrera 2012; Grauke et al. 2016).

At the end of July, 2021, during a scientific field trip in Jianshui County, southern Yunnan province of China, three fragmented subpopulations of *Carya* were accidentally discovered near the eastern edge of Ailao Mountains. After morphological comparison to the images of type and scrutiny of the primitive description, we confirm that they are *C. poilanei* (Figs 2, 3). This finding allowed us to update its morphological description, discuss its geographic distribution, and assess its conservation status. Furthermore, it would be conducive to inferring its phylogenetic position within *Carya*, and valuable to exploit its genetic resources for breeding and crop development in future days.

## Materials and methods

Specimens were collected in the field of Jianshui county, Yunnan province in July to October, 2021. Except for Fig. 1C and Fig. 3A which were taken by DJI Mavic 2 Pro, the rest of the photos were taken by Canon EOS 70D with Sigma 17-50 mm (f/2.8 EX DC OS HSM) and Canon EF 100 mm (f/2.8L IS USM) lens. Because these four months are the fruiting period, we were unable to investigate the flower phenology and characters. The morphology of the species was observed and measured based on living plants and dry specimens. Morphological measurements for more than six freshly differentiated samples from the adult trees were taken using both a ruler and a digital caliper. All herbarium voucher specimens collected by us are deposited in the Herbarium of College of life science, Beijing Normal University (BNU).

## Taxonomy

***Carya poilanei* (Chev.) Leroy, Rev. Int. Bot. Appl. Agric. Trop. 30: 428. 1950.** Figs 2, 3

*Juglans poilanei* Chev. Rev. Bot. Appl. Agric. Trop. 21: 496. 1941.

**Type.** Vietnam. Lai-Chau province, within the great forest near the slopes of Pou-Nhou, in calcareous soil, at 1000 m. elev., 31 Dec. 1937, *Poilane* 26964, (Isotype: P [barcode P00223582, P00605884, P00605885, P00605886, image!]). Images available via

<https://plants.jstor.org/>.

**Revised description.** Trees to 25–40 m tall, deciduous, monoecious. Trunks to 0.5–2 m thick, barks smooth or somewhat rough, gray to whitish. Branches brown or gray-brown, initially with orange-yellow glandular and white pilose above, later almost glabrous and sparsely glandular, with roughish, scattered lenticellat; pith solid in stem. Terminal buds 12–15 mm, naked, grey brown or brown. Leaves length 30–60 cm, imparipinnate, soft green, papery; petiole 6–12 cm, enlarged at base, pubescent or glabrous; rachis pubescent or glabrous, sparsely glandular; leaflets (3 or) 5 (or 7), apical one shortly petiolulate, terminal petiolule 5–12 mm, lateral ones sessile or subsessile, broad obovate, occasionally obovate lanceolate or ovate-lanceolate, base skewed to nearly round, apex shortly obtuse or acuminate, margin serrate; adaxially smooth or finely scabrid, abaxially glabrous except for hairs along midvein and in axils of secondary veins, secondary vein 15–25 pairs, sometimes old leaflets blade densely brown scales; apical and middle leaflets 25–40 × 12–20 cm, much larger than base leaflets. Flowers not seen. Fruits subglobose or compressed-globose, 2.8–3.2 × 3–3.5 cm, with peduncle, 1.5–6 cm length; husk wingless, sparsely orange-glandular, shortly pubescent, 3.6–5.6 mm thick, moderate keels extending to middle, cracks into 3 or 4 petals when dried; shell subglobose, closely white tomentose, with 2 longitudinal ridges, apex slightly convex, 2.8–3.5 mm thick; 3, 4 or 6 chambered at base, lacunae present in the wall near the secondary septa. Flower unclear. Fruit Sep. Germination hypogeal.

**Distribution.** China: Yunnan province, Jianshui county; Vietnam: Lai-Chau province, Pou-Nhou; Laos: Xiangkhouang (Chiengkong) province, Muang Cha (Fig. 1A).

**Habitat and ecology.** It grows on southeast and southern slope of the limestone or calcareous mountain at an elevation of 1000–2050 m (Fig. 1B, C). The three sites we discovered are places in subtropical region, eastern edge of Ailao Mountain, and 15 kilometers to the south are hot dry valleys (elevation about 200 m). Of these three distribution points, the closest distance between the two points is about 2 km, while the farthest is just about 6km. Among the three threatened relic forest, *C. poilanei* are dominant and impressive trees.

**Representative specimens examined: China:** Yunnan Province, Jianshui County, Potou Town, Dajinglaozhai Village, on limestone, 23°23'.40.42"N, 102°51'.34.42"E, 1895 m, 30 Jul. 2021, *Zhang BNU20210730-1* (BNU) (Fig. 2), *ibid.*, 23°23'.42.33"N, 102°51'.36.65"E, 1889 m, 31 Jul. 2021, *Zhang 20210731-30* (BNU); Ximatang Village, on limestone, 23°24'.5.68"N, 102°52'.17.38"E, 2019 m, 31 Jul. 2021, *Zhang 20210731-3* (BNU), *ibid.*, 23°24'.5.28"N, 102°52'.11.25"E, 1980 m, 31 Jul. 2021, *Zhang 20210731-14* (BNU); Yuchu Village, on limestone, 23°20'.47.75"N, 102°51'.35.90"E, 1892 m, 31 Jul. 2021, *Zhang 20210731-17* (BNU), *ibid.*, 23°21'.44.46"N, 102°51'.27.65"E, 1859 m, 5 Oct. 2021, *Zhang 20211005-1* (BNU).

### Key to the five native species of *Carya* Nutt. in China

- 1a. Limestone habitat; leaflets (3) 5 (7); nuts compressed-globose; husk smooth without longitudinal ridges, sparsely orange-glandular; lacunae present in nut shell ..... **2**
- 1b. Soil habitat; leaflets 5–7 (9), with abundant or slight golden peltate scales abaxially;

- nuts obovoid, ellipsoid or subglobose; husk wrinkle with longitudinal ridges; densely orange-glandular; lacunae absent in nut shell ..... 3
- 2a. Leaflets most broad obovate, papery, rough, margin serrate ..... *C. poilanei*
- 2b. Leaflets elliptic to elliptic-lanceolate, more or less leathery, glossy, margin obtusely serrate ..... *C. kweichowensis*
- 3a. Petiole tomentose; husk winged slightly ..... *C. tonkinensis*
- 3b. Petiole glabrescent; husk winged obviously ..... 4
- 4a. Husk winged to middle ..... *C. hunanensis*
- 4b. Husk winged to base ..... *C. cathayensis*

## Discussion

Initially French botanist Auguste Chevalier put *C. poilanei* under the genus *Juglans* after he observed the only specimen collected from Vietnam in 1941 (Chevalier 1941). The possible reason is that *C. poilanei* has the lacunae character (Fig. 3Q–R) which superficially resembles some species in the genus *Juglans*. Subsequently, Leroy (1950) changed the species to the *Carya* genus, based on the morphological features easy to distinguish from the *Juglans* genus such as unicular strands in the shell (Fig. 3O) and basal plexus, solid rather than chambered pith in the stem (Fig. 3D) (Leroy 1955). Although the presence of lacunae in the septum and/or shell walls is an atypical characteristic of relict hickory species, it has been recorded in seven fossil species from Europe (Mai 1981), which may help to better understand the biogeographic histories of *Carya*. Besides, we also see evident lacunae in the shell walls of *C. kweichowensis*, which seems to be related to the limestone habitat they are located (Fig. 1B, C). However, *C. poilanei* differs from *C. kweichowensis* in having broad obovate leaflets (Figs 2, 3C, G, J vs. elliptic to elliptic-lanceolate leaflets in *C. kweichowensis*) and grey brown or brown buds (Fig. 3E vs. black buds in *C. kweichowensis*) (Chang and Lu 1979). Significantly, the basal nut compartment of *C. poilanei* is not stable, with 3, 4 or even 6 chambers (Fig. 3Q–R). This phenomenon allowed us to suspect that whether hybridization events are occurred, after all, we also found *C. tonkinensis* 20 kilometers away from the *C. poilanei*. Molecular data would be necessary to verify the hypothesis and to explore its systematic status passingly.

The hickory trees are not found in any nature reserve, but in the back hills of some aged village (Fig. 1C). Fortunately, these trees are close to villages and tall enough to be regarded as sacred trees by local villagers, and hence saved from being deforested. Based on our fieldwork in these areas, we found a total of three small and fragmented subpopulations, preserving about 50 adult trees with diameter at breast height (DBH) larger than 60 cm (Fig. 3B) as well as some understory seedlings (Fig. 3C) and juvenile trees; however, fruit sets were low. We evaluated the conservation status for the *C. poilanei* according to the latest IUCN Red List guidelines (IUCN Standards and Petitions Committee 2019) and suggested that the species should be ranked as critically endangered (CR) or Endangered (EN). Meanwhile, we recommend that the species should be added to the new version of the List of National Key Protected Wild Plants, China. Given its rather limited number of individuals and narrow potential geographical

range, this species clearly needs to be properly protected, even in the absence of known strategies of utilization. More efforts are required for strengthening its in situ and ex situ conservation, as well as studying its systematic position and genetic diversity. We propose that in the future protected areas should be established in situ, and a more exhaustive investigations could be launched into the nearby limestone mountains.

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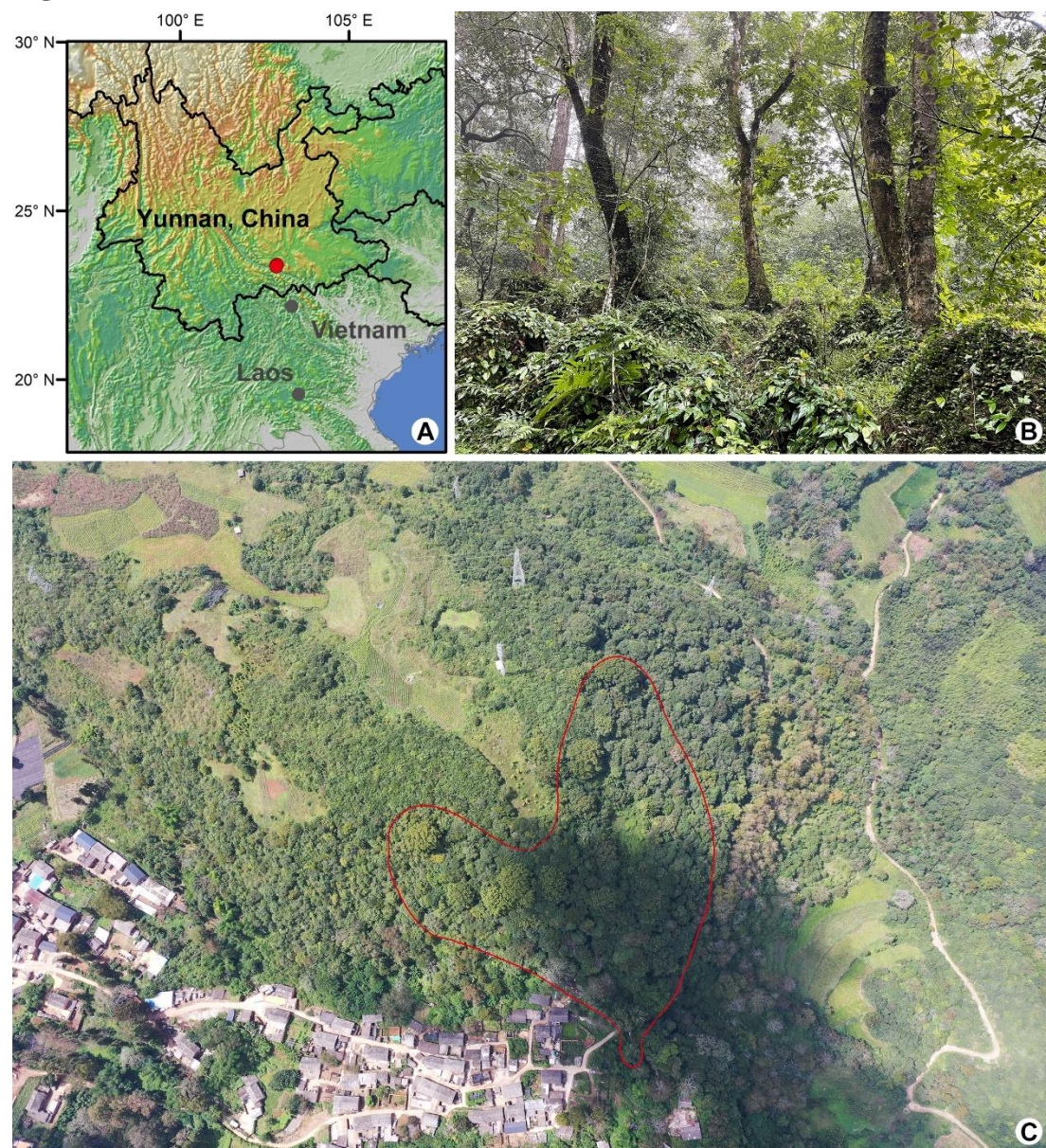
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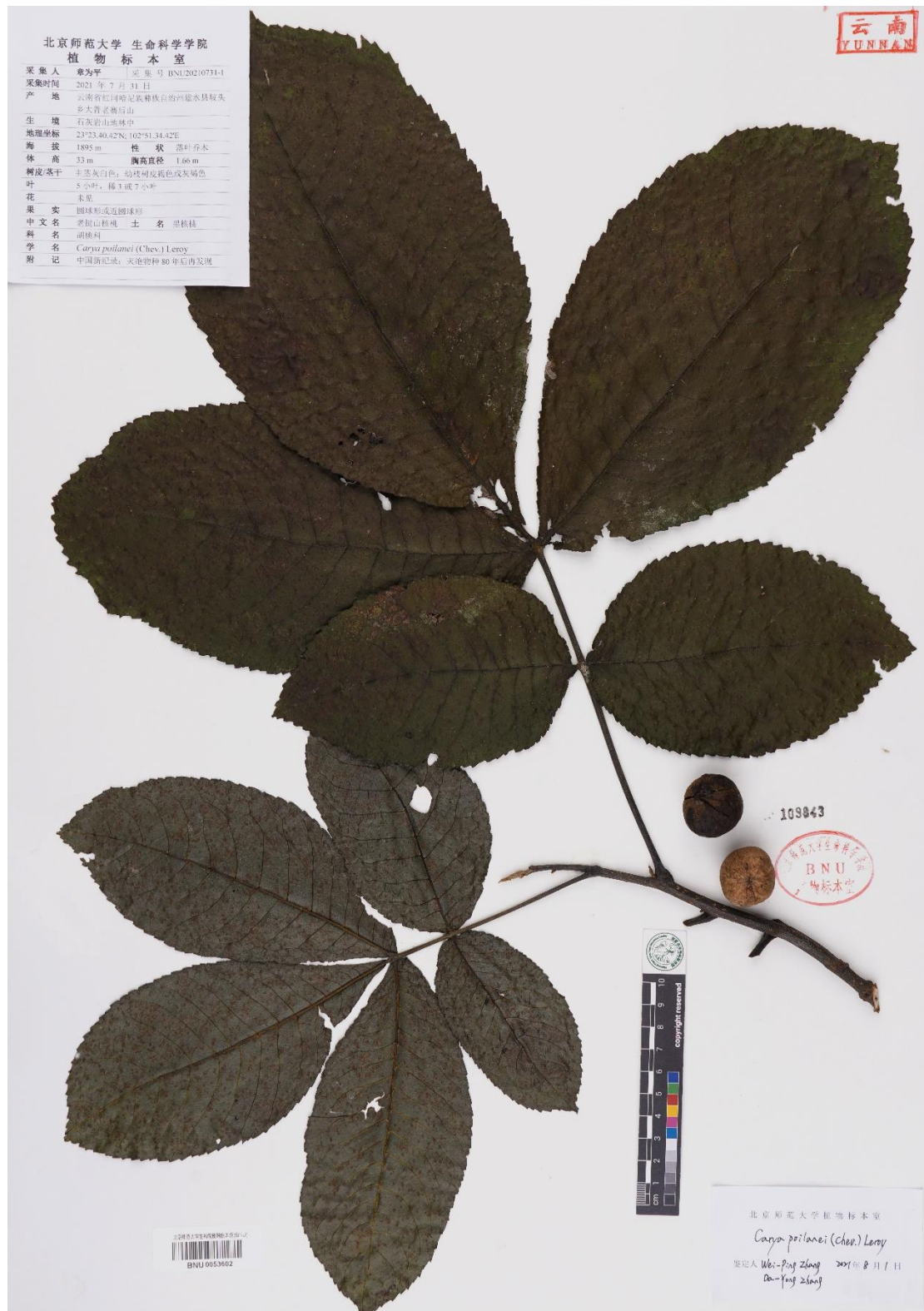


## Figures



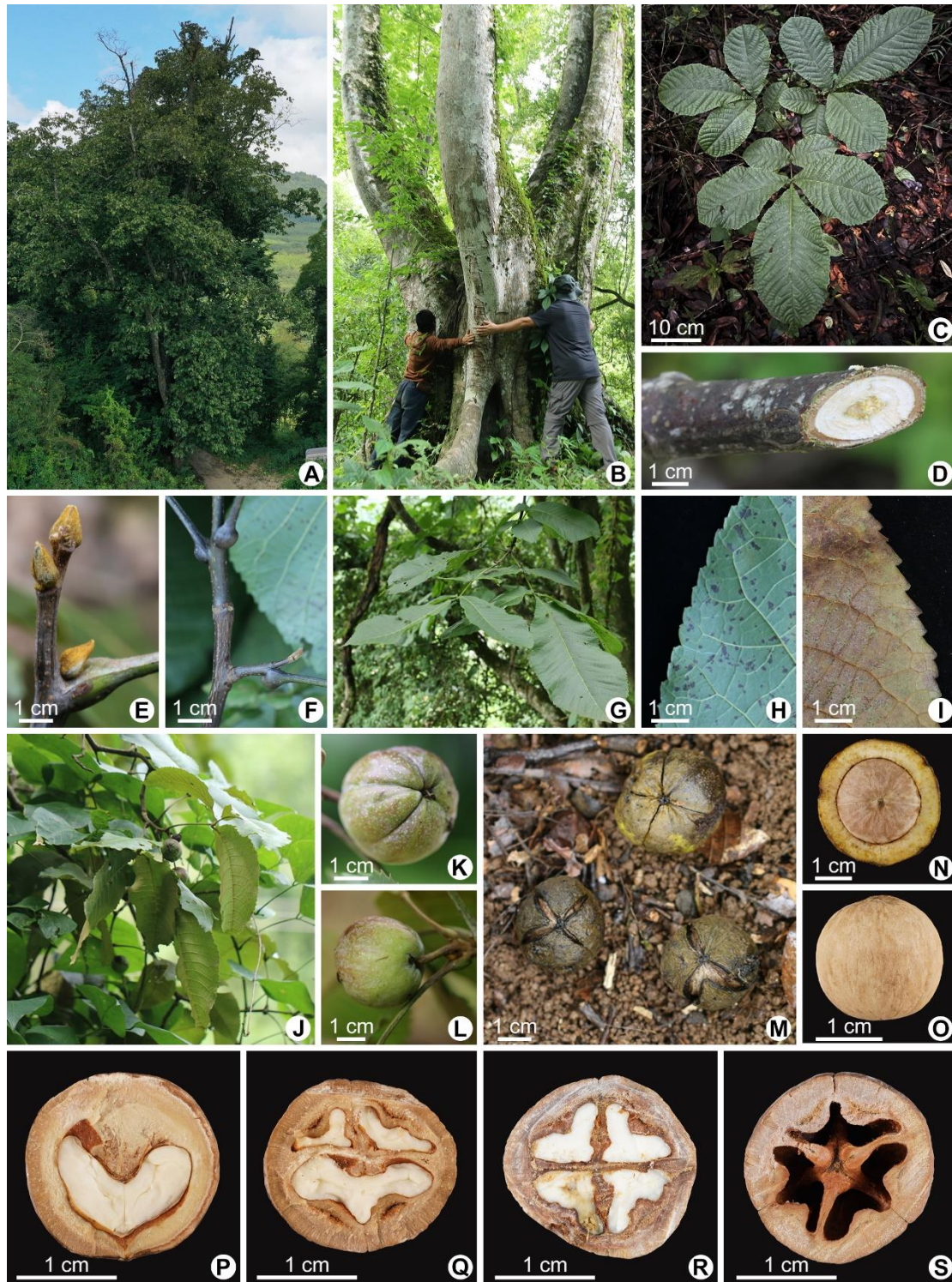
**Figure 1.** Distribution and habitat of *Carya poilanei* (Chev.) Leroy. **A** Three distribution sites in Yunnan province of China, Vietnam and Laos. Red circle indicates the localities taken from the new record areas, and grey circles indicate historical distribution localities where the trees have been presumably extirpated. **B** The limestone habitat. **C** Eastern edge of Ailao Mountains, with human habitation in plateau. Red lines mark the boundary of the *C. poilanei* distribution in Dajinglaozhai Village.





**Figure 2.** *Carya poilanei* (Chev.) Leroy (representative specimen, BNU20210731-1, BNU).





**Figure 3.** Living plants of *Carya poilanei* (Chev.) Leroy. **A** Tree. **B** Trunk, with a maximum diameter at breast height (DBH) of 1.97 m. **C** Sapling. **D** Twig. **E** Naked buds. **F** Petiole enlarged at base. **G** Leaf, showing 5 leaflets. **H** Leaf abaxial glabrous. **I** Leaf abaxial densely brown scales. **J** Fruiting branch. **K** Husk, showing base. **L** Husk, showing peduncle. **M** Husk, irregularly dehiscent. **N** Shell, vertical view. **O** Shell, lateral view. **P** Longitudinal section of nut. **Q-S** Transversal section of nuts, with 3, 4 and 6 chambers, respectively; lacunae present.