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Original Article

Lithocarpus pacoensis (Fagaceae) a New Species from Hoa Binh Province, Vietnam

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Abstract: *Lithocarpus pacoensis* Ngoc & Son from Hoa Binh province, Northern Vietnam, was described and illustrated. The new species is similar to *Lithocarpus komtumensis* A. Camus and *Lithocarpus laoticus* (Hickel & A. Camus) A.Camus in having long petioles; big cupules, usually clustered in sets of three, flat apical, nearly completely enclosing the nut; nut subglobose apex rounded or flat; scar covering 2/3 to most of the nut, convex. But the new species significantly differs from *L. kontumensis* and *L. laoticus* in having bigger leaf blades, longer petiole, much bigger cupule and nut, much more number of secondary veins, and shorter infructescences. The morphological description, comparison with related species, photographs, and preliminary conservation status assessment of the new species are also provided.

Keywords: Fagales, Hang Kia, Lithocarpus, Pa Co, Taxonomy.

1. Introduction

Lithocarpus Blume is a genus belonging to the family Fagaceae, which is mainly distributed from East and Southeast Asia, extending to New Guinea [1, 2]. The genus is known as the second-largest group in the family Fagaceae with approximately 350 spp. over the world [3]. In Vietnam, *Lithocarpus* is the biggest and most diversified genus of Fagaceae, it comprises 120 species and varieties and is widely distributed from northern to southern parts of Vietnam [4-8].

Hang Kia - Pa Co Nature Reserve is located within six communes, including Hang Kia, Pa Co, Tan Son, Bao La, Phieng Ve, and Cun Pheo in the northern part of Mai Chau district, Hoa Binh Province with a total of 7091 ha. The plant diversity in the Hang Kia - Pa Co Nature Reserve is remarkable, comprising 880 species belonging to 498 genera of 153 families [9].

During our floristic inventory research in Hang Kia - Pa Co Nature Reserve of Hoa Binh Province in 2019, we discovered an undescribed species of the genus *Lithocarpus*. It is described and named *Lithocarpus pacoensis* Ngoc & Son, sp. nov., the morphological

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comparison with the related species, photographs, and preliminary conservation status assessment of the new species also are provided.

2. Materials and Methods

2.1. Plant Materials

In the present study, the specimens of the new species (HB01) were collected from Pa Co, Mai Chau District, Hoa Binh Province (Figure 1). For morphological analysis, we used type specimens as well as specimens collected from the type locality of the following species: *L. kontumensis* and *L. laoticus*, which are the most morphologically similar to the new species and localities of the above materials are listed in Table 1.

2.2. Morphological Analysis

The morphological traits of the new species were examined and compared with its morphological related species using taxonomic literature [2, 4, 5, 10-16], type specimens kept in the herbaria (BKF, DLU, HN, P, and VNM), and digitized images of type specimens available on the web of JSTOR Global Plants (https://plants.jstor.org/) and Chinese Virtual Herbarium (http://www.cvh.org.cn/).

The morphological characters (length, width, aspect ratio and circularity of leaf blade, petiole length, and size of cupules) of the new species and related species were measured from type specimens and images of type specimens by using ImageJ software [17]: Aspect ratio and circularity are defined as length/width of the leaf blade and $4\pi \times$ (area/ perimeter squared), respectively. Analysis of variance (ANOVA) and post hoc Tukey's honestly significant difference test (Tukey's HSD) [18] were conducted to reveal the statistically significant difference among species. All statistical analyses were performed in R version 4.0.5 [19] via R-Studio ver. 1.4.1106 [20] with ggstatsplot package [21] and other built-in packages available in R.

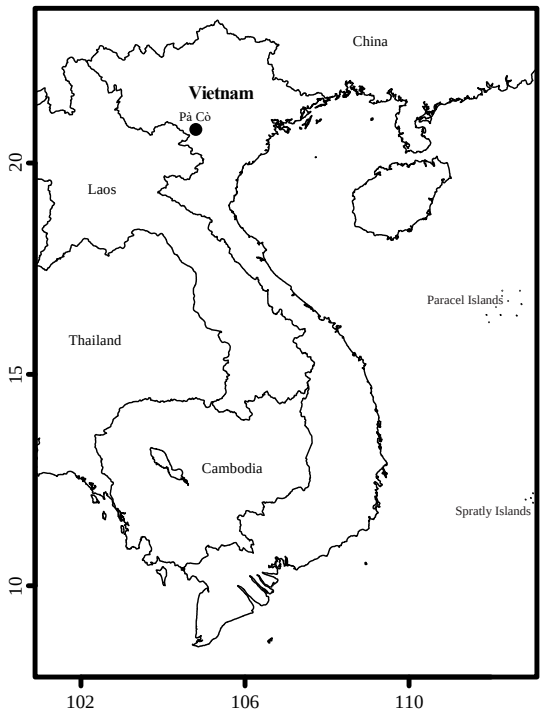

Figure 1. Type locality of *Lithocarpus pacoensis* Ngoc & Son (Black dot).

Table 1. List of specimens that were used for morphological analysis

Species	Specimens ID	Localities
L. kontumensis	*Poilane E. 32232, 32255*; (P: P00744466, P00744467, P01011216, P06843888)	Tu Mơ Rông, Kon Tum Province, Vietnam
	Son H.T. KT04 (DLU)	Măng Đen - Konblong, Kon Tum Province, Vietnam
L. laoticus	*Poilane, E. 1922* (P: P00744471, P00744472, P00744473)	Sam Neva Province, Laos
	Ngoc et al. V3193 (DLU)	Bao Lam, Lam Dong Province, Vietnam
L. pacoensis	*Ngoc & Son NAF220* (DLU)	Pa Co, Mai Chau, Hoa Binh Province, Vietnam

3. Results

3.1. Morphological Analysis

Taxonomic literature review of *Lithocarpus* and evidence from morphological comparison with type specimens of all of the previously described

species in Vietnam and surrounding countries reveal that *L. pacoensis* is most similar to *L. kontumensis* A. Camus and *L. laoticus* A.Camus in having long petioles; big cupules, usually clustered in sets of three, truncated, umbilical at the top, nearly entirely covering the fruit, wall and scales thick and woody; nut subglobose to turbinate, apex rounded or flat, wall woody and thick; scar covering 2/3 to most of the nut, convex.

The petiole length of *L. pacoensis* has not significantly different from that of *L. kontumensis* but is significantly longer than that of *L. laoticus* (Table 2, Figure 2).

The measurements of morphological features from fruiting specimens (Table 2) of those species and ANOVA with a post-hoc Tukey HSD test showed that *L. pacoensis* has significantly differed from *L. kontumensis* and *L. laoticus* in leaf blade size, petiole length, and cupule size. Specifically, the leaf blade length of *L. pacoensis* is significantly longer than that of *L. kontumensis* and *L. laoticus* (21.48±2.87 cm vs. 17.69.38±5.2 cm, and 13.66±3.32 cm, respectively). Also, the leaf blade width of *L. pacoensis* is significantly wider than that of *L. kontumensis* and *L. laoticus* (6.82±1.06 cm vs. 5.57±1,32 cm and 4.67±1.1 cm, respectively).

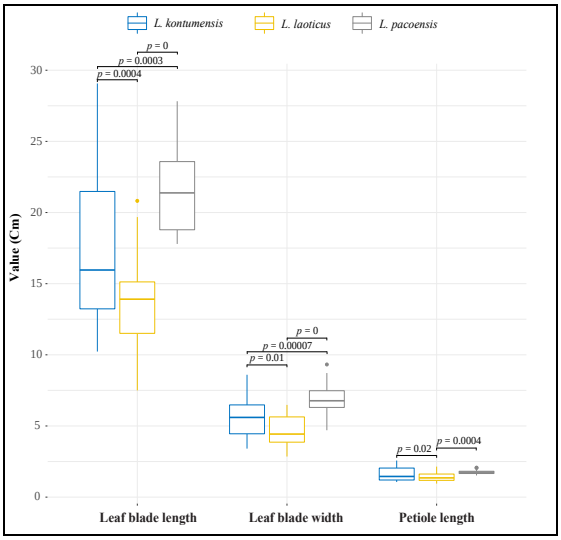

Figure 2. The comparison of leaf blade size and petiole length of *L. pacoensis* and it's related (*p*: indicates statistically significant differences. Comparisons shown: only significant).

For the leaf blade shape, the new species has no significant differences in leaf blade circularity compared to *L. kontumensis* and *L. laoticus*. In addition, there are no significant differences in leaf blade aspect ratio between *L. pacoensis* and *L. kontumensis*, while the leaf blade aspect ratio of *L. pacoensis* is significantly greater than that of *L. laoticus* (Table 2, Figure 3).

Table 2. The comparisons of the mean (X) and standard deviation (SD) values of the leaf blade and cupule size between *L. pacoensis* with related species

Parameters	*L. kontumensis*				*L. laoticus*				*L. pacoensis*			
	Min – Max	X	SD	n	Min – Max	X	SD	n	Min – Max	X	SD	n
Leaf blade length	10.23 – 29.07	17.69	5.2	33	7.5 – 29.82	13.66	3.32	27	17.79 – 27.82	21.48	2.87	36
Leaf blade width	3.41 – 8.6	5.57	1.32	33	2.85 – 6.48	4.67	1.1	27	4.7 – 9.32	6.82	1.06	36
Petiole length	1.06 – 2.57	1.65	0.48	33	0.95 – 2.14	1.42	0.29	27	1.52 – 2.06	1.75	0.13	36
Leaf blade aspect ratio	2.48 – 3.89	3.16	0.39	33	2.03 – 3.62	2.95	0.4	27	2.76 – 3.82	3.18	0.34	36
Leaf blade circularity	0.49 – 0.66	0.56	0.05	33	0.48 – 0.77	0.6	0.07	27	0.44 – 0.67	0.58	0.07	36
Cupule height	1.72 – 3.43	2.38	0.26	17	1.77 – 2.71	2.28	0.26	14	3.1 – 4.35	3.88	0.36	18
Cupule diameter	1.6 – 3.52	2.36	0.55	17	1.86 – 2.46	2.24	0.16	14	3.18 – 4.55	3.91	0.32	18

[1]Derived from type specimens, [2]Derived from this study collections,
n = number of leaf or cupule were measured in this study.

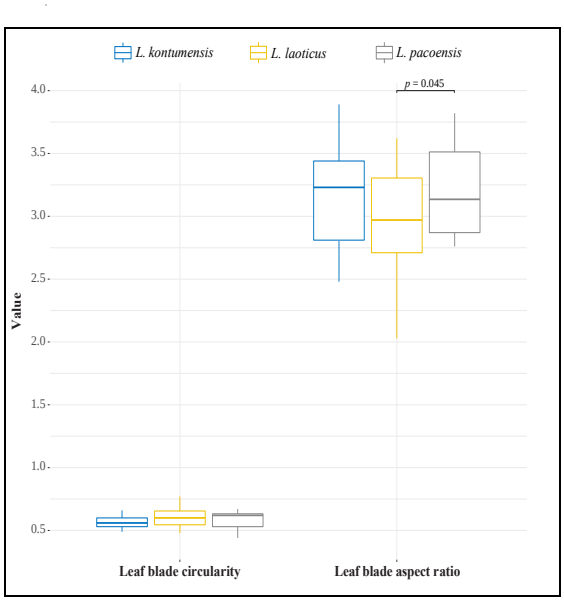

Figure 3. The comparison of leaf blade circularity and aspect ratio of *L. pacoensis* and it's related (*p*: indicates statistically significant differences. Comparisons shown: only significant).

The comparison of the cupule size showed that the new species has much bigger cupule size compared to *L. kontumensis* and *L. laoticus*. Specifically, the cupule diameter of *L. pacoensis* is significantly greater than that of *L. kontumensis* and *L. laoticus* (3.91±0.32 vs. 2.36±0.66 and 2.24±0.16, respectively). The cupule height of *L. pacoensis* is significantly greater than that of *L. kontumensis* and *laoticus* (3.88±0.36 vs. 2.38±0.26 and 2.28±0.26, respectively) (Table 2, Figure 4).

Besides, the number of secondary veins of *L. pacoensis* is much more than that of *L. kontumensis* and *L. laoticus* (14-18 pairs vs. 11-13 pairs and 10-12 pairs, respectively). Also, the new species has much shorter infructescences compared to *L. kontumensis* and *L. laoticus* (6-8 cm long vs. 15-17 cm long and 10-12 cm long, respectively).

3.2. Taxonomic Treatment

Type: *Lithocarpus pacoensis* Ngoc & Son, sp. nov. (Figure 5). Type: VIETNAM. Hoa Binh Province: Mai Chau district, Pa Co commune, 20°44'55.2"N 104°53'42.6"E, 1180 m elev., 7 Sep. 2019, *Ngoc N. V., Son H. T NAF220* (holotype DLU!, isotypes HN!, VNM! VAFS!).

Diagnosis: *Lithocarpus pacoensis* is morphologically similar to *L. kontumensis* and *L. laoticus* in having long petioles; big cupules, usually clustered in sets of three, truncated, nearly completely enclosing the nut, umbilical at the top, wall and scales thick and woody; nut subglobose, apex rounded or flat; scar covering 2/3 to most of the nut, convex. But *L. pacoensis* is distinguished from those two by longer petiole, longer and wider leaf blade, bigger cupule and nut, much more number of secondary veins, and shorter infructescences.

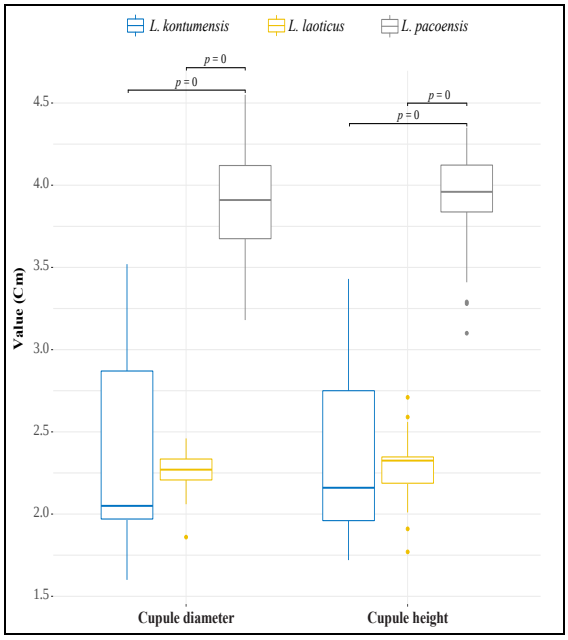

Figure 4. The comparison of the cupule size between *L. pacoensis* and its related (*p*: indicates statistically significant differences. Comparisons shown: only significant).

Description: Evergreen tree, 10–15 m tall. Twigs blackish gray, glabrescent, and densely lenticellate. Buds ovoid, up to 5 mm long, scales imbricate, ovate, 1.5–3.0 × 2.5–4.0 mm, glabrous adaxially, abaxially covered with short white hairs at the margin. Leaves alternate; petiole 1.5–2.0 cm long, puberulent; lamina broadly elliptic, 17.7–27.8 × 4.7–9.3 cm, coriaceous, apex acuminate, acumen 0.6–0.9 cm long, base cuneate, margin completely entire, sparsely white hair adaxially and abaxially; midrib slightly prominent adaxially and strongly prominent abaxially; secondary veins 14–18 pairs, prominent abaxially, forming an angle of 40–50° from the midrib; tertiary veins paralleled or scalariform-reticulate, faintly visible on both surfaces. Inflorescences not seen. Infructescences 6–8 cm long, rachis 8–11 mm in diam. at base. Cupules clustered in sets of three, sessile, subglobose or cup-shaped, truncated at top, 3.1–4.35 cm high, 3.18–4.55 cm in diam., nearly completely enclosing the nut; wall woody, 2–3 mm thick; bracts scalelike or triangular conspicuous, woody, fused into ridges, covered with short white indumentum. Nuts globose, 2.5–2.8 cm high, 2.5–2.7 cm in diam., wall woody, 1–2 mm thick; apex flat or slightly convex, yellowish, tawny minute hairs, short nipped by stigma remnant at the top; basal scar convex and expanded to more than 2/3 of the nut (Figure 5).

Etymology: The specific epithet is derived from the name of the type locality, Pà Cò commune, in Hoa Binh Province, Vietnam.

Vernacular Name: Dẻ đá Pà Cò (suggested here).

Distribution: Vietnam (so far known only from Pa Co commune, Mai Chau district, Hoa Binh Province) (Figure 1).

Preliminary Conservation Status: Critically Endangered (CR D). During our botanical inventory in Pa Co commune in 2019, less than ten mature individuals of *L. pacoensis* were found from 1100 to 1200 m altitude in the evergreen broadleaf forest. According to the criteria established by the IUCN Red list 2012 [22], *L. pacoensis* is qualified as Critically Endangered (CR).

Phenology: Mature fruits were collected in September.

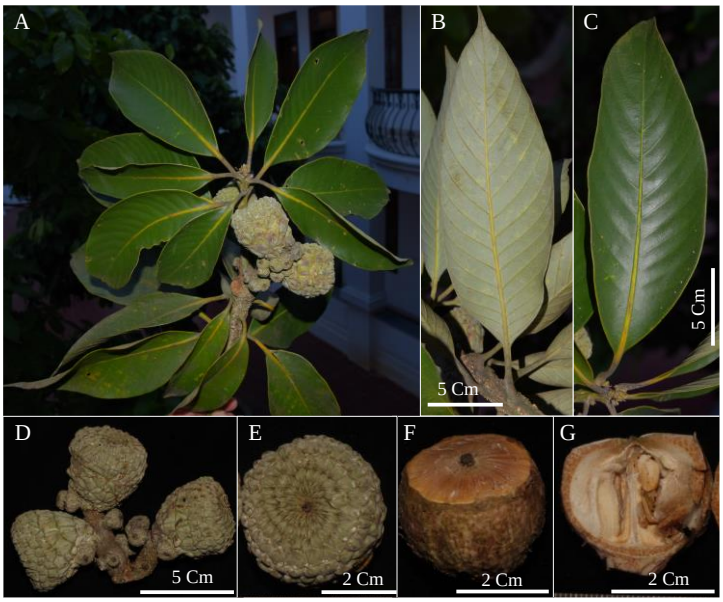

Figure 5. *Lithocarpus pacoensis* Ngoc & Son: **A** leafy twig with fruits **B** abaxial leaf surface **C** adaxial leaf surface **D** Fructescences **E** Top view of mature cupule **F** Top view of mature nut **G** section of mature nut.

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