



IDENTIFICATION MANUAL FOR

Dalbergia cochinchinensis Pierre & *Dalbergia oliveri* Gamble ex Prain

Nguyen Manh Ha, La Quang Trung, Dinh Thi Kim Van, Do Van Ban & Nguyen Tien Hiep



Project title: Strengthening the management and conservation of *Dalbergia cochinchinensis* and *Dalbergia oliveri* in Vietnam

Programme: CITES Tree Species Programme

Project funding: European Union support to CITES Secretariat

Implementing partner: Center for Nature Conservation and Development

Cover illustration: Figure 1 – *Dalbergia cochinchinensis* in Dak Uy Protected Area. Photo: La Quang Trung/CCD – 2020.
Figure 2 – *Dalbergia oliveri* in Cat Tien National Park. Photo: La Quang Trung/CCD – 2020.
Figure 3 – Transverse section of *D. cochinchinensis*. Photo: Do Van Ban – 2021.
Figure 4 – Transverse section of *D. oliveri*. Photo: Do Van Ban – 2021.

Citation: Nguyen Manh Ha, La Quang Trung, Dinh Thi Kim Van, Do Van Ban & Nguyen Tien Hiep (2021). Identification manual for *Dalbergia cochinchinensis* Pierre and *Dalbergia oliveri* Gamble ex Prain. Center for Nature Conservation and Development, Hanoi, Vietnam.

Copyright: Center for Nature Conservation and Development
No. 5, 56/119 Tu Lien Street, Tu Lien Ward, Tay Ho District, Hanoi, Vietnam.
Telephone: +84 (0) 246 682 0486
E-mail: info@ccd.org.vn

Translated by: Dinh Thi Kim Van/CCD – 2022.

Table of contents

Acknowledgement.....	4
Forewords.....	5
1. Introduction.....	6
2. Glossary	7
3. <i>Dalbergia cochinchinensis</i> Pierre	9
3.1. Nomenclature and common names	9
3.2. Distribution	9
3.3. Biology and Ecology.....	10
3.4. Use and Conservation status	12
3.5. Identification.....	12
3.5.1. Morphological characteristics	12
3.5.2. Identification of seedling	15
3.5.3. Identification of logs.....	16
3.5.4. Identification of sawn wood.....	16
3.5.5. Identification of timber product.....	18
3.5.6. Macroscopic characteristics.....	18
4. <i>Dalbergia oliveri</i> Gamble ex Prain.....	21
4.1. Nomenclature and common names	21
4.2. Distribution	21
4.3. Biology and Ecology.....	22
4.4. Use and Conservation status	24
4.5. Identification.....	24
4.5.1. Morphological characteristics	24
4.5.2. Identification of seedling	27
4.5.3. Identification of logs.....	29
4.5.4. Identification of sawn wood.....	30
4.5.5. Identification of timber product.....	31
4.5.6. Macroscopic characteristics.....	31
References.....	34

Acknowledgement

The identification manual for *Dalbergia cochinchinensis* Pierre and *Dalbergia oliveri* Gamble ex Prain was developed under the project “*Strengthening the management and conservation of Dalbergia cochinchinensis and Dalbergia oliveri in Vietnam*”, which was funded by the European Union through the CITES Tree Species Programme.

We would like to express our sincere thanks to Dr. Nguyen Tien Hiep – Botanical Expert, Dr. Do Van Ban – Wood Science Expert, who participated in the compilation of this Manual.

We would like to thank Dr. Nguyen Tu Kim – Wood Science Expert of Forest Industry Research Institute of Vietnamese Academy of Forest Sciences, Dr. Vu Anh Tai – Botanical Expert of Institute of Geography of Vietnam Academy of Science and Technology, and Dr. Do Van Truong – Botanical Expert of Vietnam National Museum of Nature for providing valuable comments and information for us to complete the Manual.

Finally, we would like to express our gratitude to Mr. Hooi Chiew Thang – Regional Coordinator for Asia and Ms. Milena Sosa Schmidt – CITES Tree Species Programme Coordinator and Regional Coordinator for Central and South America and the Caribbean for their huge supports during the implementation of this project.

Director

Nguyen Manh Ha

Forewords

The identification manual for *Dalbergia cochinchinensis* Pierre and *Dalbergia oliveri* Gamble ex Prain was developed with the aim to assist the Vietnamese central and local management authorities, law enforcement forces and technical officers who are working in nature conservation, forestry and law enforcement for reference to identify trees, timber and timber products of these two species.

The Manual describes basic morphological characteristics of seedling and mature tree including stem, leaves, flower and pod, and macroscopic features of timber and timber product of *Dalbergia cochinchinensis* and *D. oliveri*. All macroscopic features are available to observe with unaided eyes or with a hand-held magnifier. The photographs used in the manual were taken from field surveys and wood laboratory. They were carefully selected to illustrate the prominent features to enable the two species to be identified in the field.

We hope that the Manual would be helpful for user in management and monitoring of harvest and commerce as well as support law enforcement for the conservation and development of the two endangered, rare and precious species in Vietnam.

Shortcoming is inevitable during the compilation process. We are looking forward to receiving reader's comments and feedbacks to continue to improve the manual.

Hanoi, August 2021

All authors

1. Introduction

Dalbergia L.f. species (Fabaceaa), also called as rosewood, has a hard, beautiful, yellow-red, dark red or reddish-brown heartwood. Its heartwood tends to be darker in color (dark brown or black) by the time. Rosewood timber has high economic value and could be exported. Therefore, some *Dalbergia* species have been exploited and traded for years to serve the high-end furniture market. Of which, *Dalbergia cochinchinensis* Pierre and *Dalbergia oliveri* Gamble ex Prain are among the most harvested species that led to severe declining in population.

In Vietnam, the two species are naturally distributed from South Central and Central Highlands to Southern provinces. It is good adapted to different habitat and forest types. However, pressure from over-exploitation and slow growth rate has caused natural populations to be destroyed and no longer restored in many areas. Currently, *D. cochinchinensis* and *D. oliveri* are remaining scattered small populations. Viable populations are only found in protected areas, though it is still at risk of illegal logging. Therefore, the two species are seriously threatened in the wild.

So far, many studies on identification of different species and group of species have been developed but none of them have focused on identification of *D. cochinchinensis* and *D. oliveri* based on morphological and macroscopic characteristics, especially which features could be used to rapidly identify species in the field. Meanwhile, the protection and law enforcement practices require rapid and accurate identification of timber, timber products, seedlings, and mature trees of species. For that reason, the Center for Nature Conservation and Development compiled the “**Identification manual for *Dalbergia cochinchinensis* Pierre and *Dalbergia oliveri* Gamble ex Prain**” to assist rapid look-up during field work of local management authorities, and law enforcement forces in the field of forestry in the management, trade control and recording efforts.

2. Glossary

Annual ring	<i>In wood and bark, a growth layer of one year as seen in cross section.</i>
Average Dried Weight	<i>The weight per volume unit at a 12% moisture content, normally in metric units: kilograms per cubic meter (kg/m³). A moisture content of 12% is attained when a wood sample has reached equilibrium moisture content with the surrounding air at a temperature of 70°F (21°C) and a relative humidity of approximately 65%.</i>
Axial parenchyma	<i>Parenchyma cells derived from fusiform cambial initials. On cross section, axial parenchyma banded or not banded, and is perpendicular to rays.</i>
EN	<i>Endangered</i>
Growth ring	<i>In wood and bark, growth layers as seen in cross section.</i>
Heartwood	<i>The inner layers of wood near the pith which was established from sapwood. It is generally darker in color than sapwood.</i>
IUCN	<i>International Union for Conservation of Nature.</i>
Log	<i>A part of the trunk or a large branch of a tree that has fallen or been cut off. It could contain bark, sapwood or not.</i>
Longitudinal section	<i>Plane section of the wood specimen parallel to longitudinal axis of the trunk.</i>
Macroscopic features of wood	<i>Structural components of wood observed in the transverse section by unaided eyes or hand-held magnifier with magnification of 8x or more.</i>
Parenchyma	<i>Tissue composed of cells that are typically brick-shaped or isodiametric and have simple pits. Parenchyma concerned with the storage and distribution of food materials. On transverse section, parenchyma seen as lighter color than other cells, it is much more visible if contacting with water.</i>
Parenchyma bands	<i>Axial parenchyma forming concentric lines or bands, as seen in cross section. Parenchyma bands has light color, surround vessels.</i>
Parenchyma bands surround vessels (pores)	<i>Parenchyma bands surround vessels could be lateral extended with wing-like (aliform). Aliform parenchyma coalesced forming irregular tangential or diagonal bands.</i>
Radial section	<i>Longitudinal section cross pith of the trunk, perpendicular to the annual rings, growth rings or parallel to rays.</i>
Ray	<i>A ribbon-like aggregate of cells extending radially in wood. On cross section, rays forming radial lines from the pith to the cambium.</i>
Sapwood	<i>The outer layers of wood near the bark having lighter in color</i>
Sawn wood	<i>Wood sawn lengthwise or produced by a profile-chipping process. It includes planks, boards, scantlings, laths, boxboards and lumber, etc.</i>

Tangential section	<i>Longitudinal section tangent to the annual rings, growth rings or perpendicular to rays.</i>
Transverse section/Cross section	<i>Plane cross-section of the wood specimen perpendicular to longitudinal axis of the trunk.</i>
Vessels	<i>An axial series of cells that have coalesced to form an articulated tube-like structure of indeterminate length to distribute water. On transverse section, vessels are seen as pores. On tangential section, vessels form tiny streaks along the trunk.</i>
VU	<i>Vulnerable</i>
Wood specimen used to observe macroscopic features	<i>Small wood samples have created cross section, radial section and tangential section. It is taken from good wood in the trunk without defects.</i>

3. *Dalbergia cochinchinensis* Pierre

3.1. Nomenclature and common names

- Scientific name: *Dalbergia cochinchinensis* Pierre
- Vietnamese name: Trắc, Cẩm lai nam bộ, Trắc bông, Trắc đen, Trắc trắng, Giầu ca (Gia Rai), Ka Rắc (Ba Na), Ka-nhung (Khơ-me).
- Common name: Siamese rosewood, Thailand rosewood, Tracwood.
- Another common name: Payung (Thailand); Ka nhoung, Kra nhoung (Cambodia); Kha nhoung (Laos), Suan zhī mù (China).
- Genus: *Dalbergia*
- Family: Fabaceae

3.2. Distribution

- In Vietnam: *Dalbergia cochinchinensis* has scattered distribution in Quang Tri (Cam Lo, Huong Hoa and Dakrong)¹, Da Nang, Quang Nam (Hien and Phuoc Son districts), Kon Tum (Dak Ha, Sa Thay, Ngoc Hoi, and Kon Plong districts), Gia Lai (Krong Pa, Chu Pah, Ia Pa, Ayun Pa, Mang Yang, Dak Doa, Ia Grai, K'Bang and Duc Co districts), Dak Lak (Buon Don, Ea Sup, Ea Kar, Krong Nang and Krong Pong districts), Dak Nong (Cu Jut district), Lam Dong (Cat Tien, Bao Lam and Da Teh districts), Binh Thuan (Ham Thuan Bac district), Dong Nai (Dinh Quan, Vinh Cuu, Tan Phu, Trang Bom and Thong Nhat districts), Tay Ninh (Tan Bien district), and Kien Giang (Phu Quoc district) (La et al., 2021; Nguyen et al., 2019a) (**Figure 3.1**).
- In the world, *Dalbergia cochinchinensis* distributed in Thailand, Laos and Cambodia (Nguyen et al., 2019a).

¹ It should be noted that *Dalbergia cochinchinensis* was also the most recently recorded in three districts of Cam Lo, Huong Hoa and Dakrong of Quang Tri province (Nguyen Manh Ha, personal communication, January 27, 2022).

Growth rate is quite slow. Flowering is from June to July. Fruiting is from September to November. It has strong ability to regenerate from remaining base and roots but natural regeneration from seeds is poor (Nguyen et al., 2019a).



Figure 3.2. *Dalbergia cochinchinensis* trees are distribution in the lowland evergreen broad-leaf tropical monsoon forest of Dak Uy protected area, Dak Ha district, Kon Tum province. (Photo: La Quang Trung – CCD/2019).



Figure 3.3. *Dalbergia cochinchinensis* trees are distribution in the semi-deciduous forest of Dipterocarps mixed with evergreen broad-leaves trees in Yok Don national park, Dak Lak province (Photo: Dinh Thi Kim Van – CCD/2020).

3.4. Use and Conservation status

Dalbergia cochinchinensis timber is among the group of special, rare and precious timber². Its heartwood is fine texture, beautiful, hard, durable, aromatic and termite resistant. Sapwood is susceptible to rot and termites. *D. cochinchinensis* timber is preferably used for high-end ornament and furniture, instruments, artwork.

Timber has high economic value and could be exported.

Dalbergia cochinchinensis is classified as “Endangered” (EN) A1a,c,d in Vietnam Red Data Book (2007), and “Vulnerable” (VU) in IUCN Red list (1998).

Dalbergia cochinchinensis is listed on CITES Appendix II and Group IIA of Decree 06/2019/ND-CP dated 22 January 2019 on management of endangered, precious and rare species of forest fauna and flora.

3.5. Identification

3.5.1. Morphological characteristics

Large trees, up to 30 m in height, diameter of trunk up to 60 – 120 cm. Tree is profusely branched.

Outer bark is brownish yellow, longitudinally fissured or peeled off into fragments. (Figure 3.4).



Figure 3.4. Outer bark of *Dalbergia cochinchinensis* in Dak Uy protected area, Dak Ha district, Kon Tum province (Photo: La Quang Trung – CCD/2020).

² Following Vietnamese standard 12619-2:2019. Timber - Classification. Part 2: According to physical properties.

Leaves are odd-pinnate from 15 – 20 cm in length, petiole is 2.5 – 5 cm long and rachis is 6.5 – 15 cm long and glabrous. 7 – 9 leaflets growing almost opposite. Leaflet is oval to ovoid, 3.5 – 8(–10) cm long, 2 – 4(–5) cm wide, coriaceous, glabrous, dark green on upper surface and white mold on lower surface with acute apex, obtuse or rounded at base. Lateral veins are 7 – 9 pairs and prominent on both sides. Secondary venules are clearly reticulate on the lower surface. Petiolule is 2 – 5 mm long. Stipule is caducous (Nguyen và cs., 2019a) (**Figure 3.5**).

Inflorescence is corymbose-paniculate at or nearly terminal, 7 – 15(–20) cm long. Bracts are caducous. Pedicel is 1 mm long. Flowers are white to milky white, 5.5 – 6 mm long, aromatic. Calyx tube is 5 mm, glabrous; calyx lobes are oval to obtuse; inner calyx lobes are slightly longer than lateral calyx lobes but as long as calyx tube. Petals with straight claws. Standard is obovate, 4 – 6 x 2.5 – 3.5 mm (including claw 1.5 mm long), apex is obtuse or rounded. Wings are irregularly elliptical, 5 – 1.5 mm long, apex is rounded. Keel petals is 5 – 6 mm long, 2 mm wide, apex is rounded. Stamens are 9 – 10; monadelphous (filaments stick together in a group); ovary is 2 – 4 ovules, glabrous to villose at base (Nguyen et al., 2019a) (**Figure 3.6**).

Pods is oblong, 4.5 – 7.5(–8) cm long, 0.8 – 1.2 cm wide, thin, glabrescent with compartments containing 1 – 2 seeds. Septum is thin, glabrous. Calyx is persistent at the base of the pedicel. Seeds are reniform, with a size is 4 x 6 mm, reddish brown (Nguyen et al., 2019a) (**Figure 3.7**).



Figure 3.5. Leaves of *Dalbergia cochinchinensis* (Photo: La Quang Trung – CCD/2020).



Figure 3.6. Inflorescence of *Dalbergia cochinchinensis* (Photo: Luu Hong Truong)



Figure 3.7. Dried pods of *Dalbergia cochinchinensis* (Photo: La Quang Trung – CCD/2019).

3.5.2. Identification of seedling

Dalbergia cochinchinensis regenerates from stump and root strongly but from seed poorly (**Figure 3.8** and **Figure 3.9**). Seedlings have pinnately compound leaves, 15 – 20 cm long, glabrous. 5 – 9 leaflets are nearly opposite. Leaflets have varied shapes from oval to ovoid or nearly rounded, with a size is 4 – 7 cm x 3.5 – 6 cm, dark green on upper surface and white mold on lower surface with acute or nearly rounded apex, obtuse or slightly acute at base. Veins are prominent on both sides (Nguyen et al., 2019a) (**Figure 3.10** & **Figure 3.11**).

Note: Seedlings of *Dalbergia cochinchinensis* are easily confused with seedling of *Pterocarpus macrocarpus*. In order to separate two species, attention should be paid to the appearance of their mother trees. Besides, on the lower surface of *Pterocarpus macrocarpus* leaves are sparsely hairy (Dinh et al., 2020a, 2020b; Ta et al., 2020a, 2020b).



Figure 3.8 (left) and **Figure 3.9** (right) Strongly regeneration of *Dalbergia cochinchinensis* after bushfire and exploitation (Photo: La Quang Trung – CCD/2020).



Figure 3.10 (left) and **Figure 3.11** (right). Variety in shape and size of seedling leaves (Photos: Dinh Thi Kim Van, La Quang Trung – CCD/2020).

3.5.3. Identification of logs

On the transverse section of the trunk, the sapwood and heartwood are sharply distinguished in color. Sapwood is pale yellowish grey or light grey. Heartwood is medium reddish brown, yellow-red or dark brown. Wood becomes darker in color from reddish brown, dark brown to black by the time (Figure 3.12 and Figure 3.13).



Figure 3.12 (left) and **Figure 3.13** (right). Heartwood of *Dalbergia cochinchinensis* (Photo: La Quang Trung – CCD/2020).

Sapwood of *Dalbergia cochinchinensis* is susceptible to rot and termites therefore it is often removed from logs. Logs have small size, sometimes it remains small patches or spots of sapwood after removing.

Large trees of *Dalbergia cochinchinensis* is often hollow in trunk (**Figure 3.14**).

Wood is hard and heavy, average dried weight is 1.035 kg/m³.

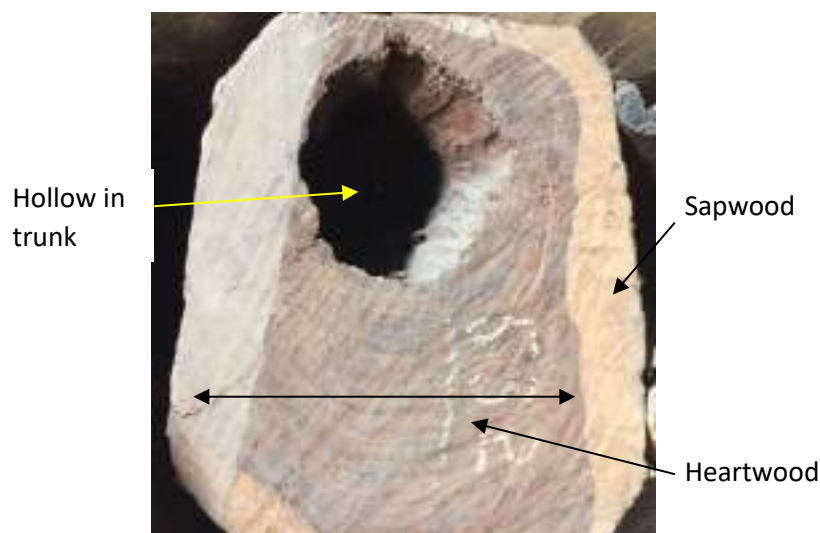


Figure 3.14. Sapwood and heartwood are sharply demarcated in color (Photo: Do Van Ban)

3.5.4. Identification of sawn wood

Newly sawn wood has a slightly sour smell. Heartwood is pinkish brown, reddish brown, or yellowish brown. Brown to black longitudinal streaks is visible on the

radial section forming beautiful grain (**Figure 3.15**). Sawn wood turns to darker brown to black by the time.



Figure 3.15. Grain of *Dalbergia cochinchinensis* on radial section (Photo: Do Van Ban)

Due to high price and value, *Dalbergia cochinchinensis* has been heavily exploited all base and roots, thence, sawn wood and lumber are various in shape and size (**Figure 3.16**).



Figure 3.16. *Dalbergia cochinchinensis* timber has various shape and size. (Photo: Do Van Ban).

3.5.5. Identification of timber product

Identification of *Dalbergia cochinchinensis* timber products is tough, specifically for products that have been made for a long time. *Dalbergia cochinchinensis* timber products are usually not included sapwood. It is hard, heavy, fine and usually covered with vanish, or transparent layer to clearly see natural wood color and grains. *Dalbergia cochinchinensis* timber products turn to darker in color by the time.

3.5.6. Macroscopic characteristics

Heartwood is usually pinkish brown, reddish brown or yellowish brown with darker brown or black stripes on the longitudinal section.

Observation of transverse section with unaided eyes or hand-held magnifier could see:

- Vessels (pores): Wood has diffuse-porous vessels (vessels are distributed over the cross section). Vessels have different sizes (**Figure 3.17**).



Figure 3.17. Transverse section of *Dalbergia cochinchinensis* wood. (Photo: Do Van Ban)

- Vessels is commonly solitary (one vessel) or in short (2 – 3 vessels) radial rows, rarely in radial rows of 4 or more (**Figure 3.18**).

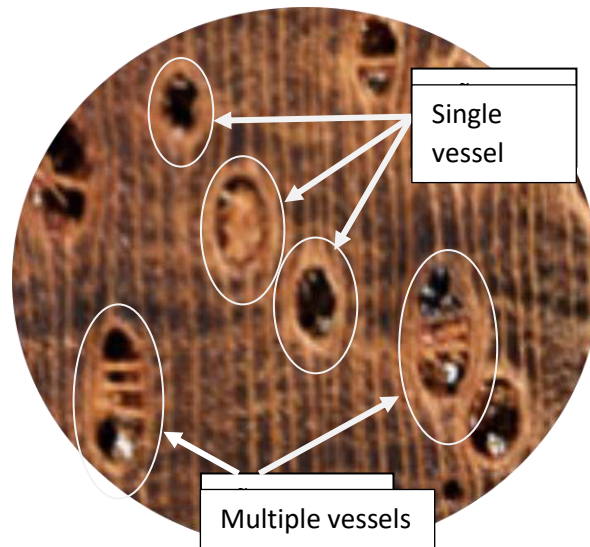


Figure 3.18. Single and multiple vessels of *Dalbergia cochinchinensis* on transverse section (Photo: Do Van Ban)

- Heartwood vessels (pores) usually contains dark brown, reddish brown deposits (**Figure 3.19**).

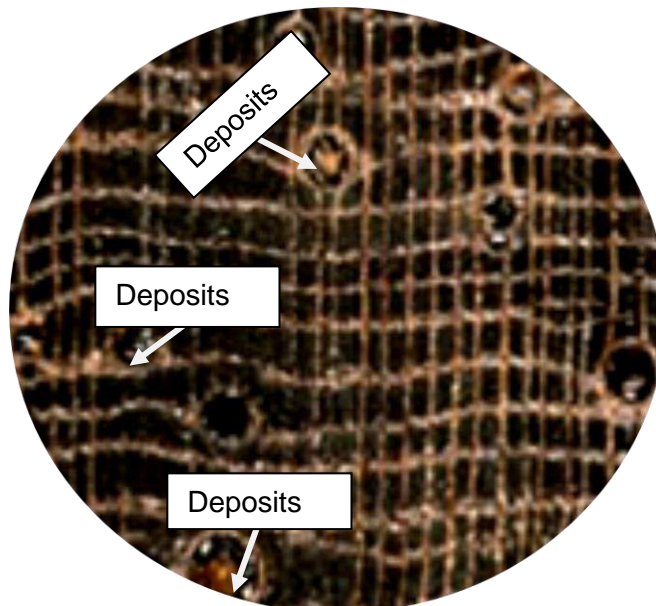


Figure 3.19. Deposits in heartwood vessels observed on transverse section (Photo: Do Van Ban)

- Axial parenchyma (light color) surrounds vessels (pores) forming aliform wing or confluent wing (**Figure 3.20**).

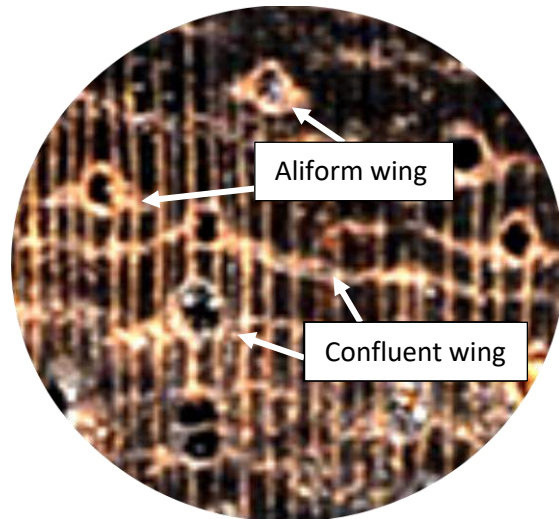


Figure 3.20. Axial parenchyma surrounds vessels (pores) forming aliform wing or confluent wing on transverse section of *Dalbergia cochinchinensis* (Photo: Do Van Ban)

- Axial parenchyma is banded or not banded. Parenchyma bands are narrow, continuous or discontinuous, or sometimes wavy, partially incorporate with rays to form net-shape (**Figure 3.21**).

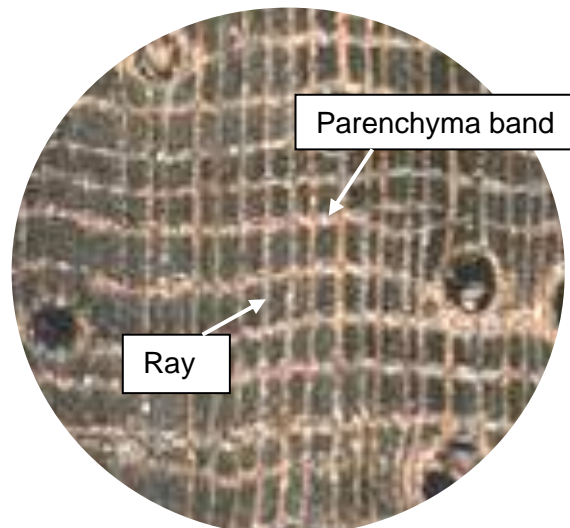


Figure 3.21. Axial parenchyma (light bands on landscape orientation) incorporates with rays (light bands on portrait orientation) forming net shape in *Dalbergia cochinchinensis* wood (Photo: Do Van Ban)

- On tangential section, rays (darker bands) are aggregated and arranged evenly appearing to the unaided eyes or low magnification as a single large ray (**Figure 3.22**).

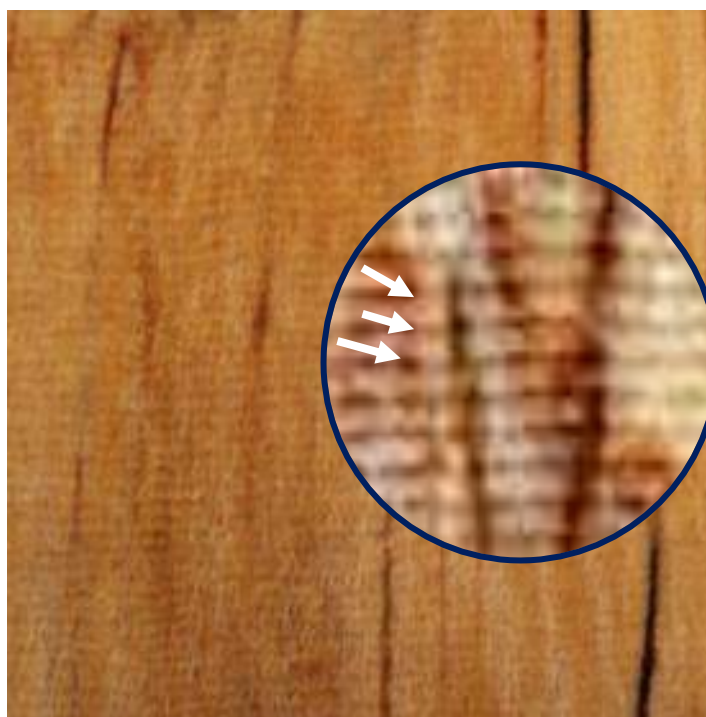


Figure 3.22. Rays cascade as seen on tangential section of *Dalbergia cochinchinensis* by hand-held magnifier (Photo: Do Van Ban)

4. *Dalbergia oliveri* Gamble ex Prain

4.1. Nomenclature and common names

- Scientific name: *Dalbergia oliveri* Gamble ex Prain
- Vietnamese name: Cẩm lai, Cẩm, Cẩm lai bà rịa, Cẩm lai đồng nai, Cẩm lai bông, Cẩm lai mật, Cẩm lai vú, Trắc lai.
- Common name: Vietnamese rosewood
- Another common name: Neang Nuon (Cambodia); Mai Ching Chan (Thailand); Kampee, Mai Kor phee, Pa dong daeng (Laos); Tamalan, Chingchan (Myanmar).
- Genus: *Dalbergia*
- Family: Fabaceae

4.2. Distribution

- In Vietnam: *Dalbergia oliveri* is distributed in Quang Tri (Huong Hoa district), Da Nang (Son Tra district), Kon Tum (Sa Thay, Ngoc Hoi, Dak To districts), Gia Lai (Krong Pa, Duc Co, Chu Prong districts), Dak Lak (Ea Kar, Krong Nang and Lak districts and Yok Don national park), Dak Nong (Dak Mil and Cu Jut districts), Lam Dong (Lang Biang, Lac Duong and Di Linh districts), Dong Nai (Cat Tien national park and Dong Nai nature-culture reserve), Phu Yen, Khanh Hoa, Ninh Thuan (Thuan Nam and Ninh Son districts), Binh Thuan (Ham Thuan Bac – Da Mi watershed protection forest of Ham Thuan Bac district), Binh Phuoc (Bu Dang and

Dalbergia oliveri grows in multiple types of soils and is most preferable to basaltic soils or on soils having thick accretion, relatively flat, low slope. *Dalbergia oliveri* is commonly found in moist areas, along rivers, streams and brocks (**Figure 4.2**).

Trees generally prefer light, but they can tolerate some level of shade at an early age. Growth rate is low. In the forest structure, *Dalbergia oliveri* joins the main forest canopy (**Figure 4.3**). Natural regeneration is good. Flowering from April to May. Fruit is from September to December. (Nguyen et al., 2019b).



Figure 4.2. *Dalbergia oliveri* is distributed in moist areas, along rivers, stream. (Photo: La Quang Trung – CCD/2020).



Figure 4.3. *Dalbergia oliveri* joins the main forest canopy (Photo: La Quang Trung – CCD/2020).

4.4. Use and Conservation status

Dalbergia oliveri timber is among the group of special, rare and precious timber³. This is a hard, durable, beautiful and fine grain rosewood species containing aromatic essential oils and free from termites. Timber is valuable in making furniture, cabinets, handicrafts, instruments, and ornament (processing fine art products). Both sapwood and heartwood are used.

Timber could be exported at a high price.

Dalbergia oliveri is classified as “Endangered” (EN) in Vietnam Red Data Book (2007) and IUCN Red list (1998).

It is listed in CITES Appendix II and Group IIA of Decree 06/2019/ND-CP dated 22/01/2019 on management of endangered, precious and rare species of forest fauna and flora.

4.5. Identification

4.5.1. Morphological characteristics

A large tree, 15 – 30m in height and 60 – 90cm in diameter. Tree is profusely branched; branches are stout and slightly pubescent.

Bark is grey or light grey, and flakes in small dark brown pieces. Lenticels are prominent (**Figure 4.4**).



Figure 4.4. Outer bark of *Dalbergia oliveri* (Photo: La Quang Trung – CCD/2020)

Leaves are pinnately compound, 15 – 25 cm in length. Petiole is 3 – 5 cm long and rachis is 10 – 18cm long and glabrous. Leaflets are from (9 –) 10 – 15, alternate, brittlely soft to slightly coriaceous, oval, oblong to lanceolate, 4 – 8 cm long, 1.5 – 3 cm wide, glabrous, apex obtuse or subacute, often acute, rounded at

³ Following Vietnamese standard 12619-2:2019. Timber - Classification. Part 2: According to physical properties.

base; lateral veins are 9 – 12 pairs and venule is prominently reticulate on both sides; petiolule 3 – 4 mm long. Young leaves are sparsely pubescent or glabrous, light green or pale pink. Leaves at later stage are dark green or grayish, glabrous (Nguyen et al., 2019b) (**Figure 4.5**).

Inflorescence is axillary or terminal panicle, 10 – 15 cm long. Bracts and bracteoles are caducous. Pedicel is 1.5 mm long and pubescent (Nguyen et al., 2019b).



Figure 4.5. Leaves of *Dalbergia oliveri* in Bu Gia Map national park (Photo: La Quang Trung – CCD/2020).



Figure 4.6. Inflorescence of *Dalbergia oliveri* (Photo: Nguyen Manh Ha – CCD/2018).

Flower is bright mauve or purple inside, 12 mm long; calyx tube is 4 – 5 mm, glabrous or pubescent at base; upper calyx lobes are obovate, outer calyx lobes are obtuse oval and nearly the same length, inner calyx lobes are oval, acute and slightly longer than other calyx lobes or nearly as long as calyx tube. Standard is rounded, with a size is 6 – 7 mm x 6 – 7 mm (including claw 1.5 – 2 mm long). Wings are spoon-shaped, curved toward apex, size is 6 – 7.5 mm x 3.5 – 4 mm (including claws 1.5 – 2 mm). Keel petals are ear-shaped, size is 4 – 6 mm x 2.5 – 3.5 mm (including claws 1.5 – 2 mm). Stamens are 10; filaments are diadelphous. Ovary is 3 – 4 mm long, 2 – 3 ovules and pubescent. Style is 2 – 3 mm, glabrous (Nguyen et al., 2019b) (**Figure 4.6**).

Pod is elliptic or lanceolate, 9 – 14 cm long, 2.4 – 4 cm wide, stalk is 1 – 1.5 cm, glabrous, sometimes coriaceous, and bright brown, thin, flat, raised over the seed into a pointed cone. Seed is from 1 – 2 (rarely 3), globose or reniform with a size is 12.5 x 9 mm, and red brown or brown (Nguyen et al., 2019b) (**Figure 4.7** and **Figure 4.8**).



Figure 4.7. Pods of *Dalbergia oliveri* in Bu Gia Map national park (Photo: La Quang Trung – CCD/2020).



Figure 4.8. Pods of *Dalbergia oliveri* in Cat Tien national park (Photo: Dinh Thi Kim Van – CCD/2020)

4.5.2. Identification of seedling

Natural regeneration of *Dalbergia oliveri* is relatively strong. Seedling leaves are light in color, commonly light coral, orange red, yellow orange or pale pink (Dinh et al., 2020a, 2020b; Ta et al., 2020b) (**Figure 4.9**, **Figure 4.10** and **Figure 4.11**).

Seedling leaves and mature leaves are similar in morphology. Leaves are odd-pinnate. In newly seedling (3 – 6 months), leaves are 8 – 12 cm long, with 7 – 11 leaflets. In later stage, leaves are 15 – 25 cm long with (9) 11 – 17 leaflets. Leaflet is obovate or elliptical, with a size is 1 – 1.2 cm x 2 – 2.5 cm, light green in newly regenerated seedling and is oblong, 1.5 x 3 cm in size in later stage or in shoot-regenerated seedling. Petiolule is 2 – 3 mm. Veins are prominent on both sides (Nguyen et al., 2019b).

Dalbergia oliveri seedling can tolerate some level of shade. It is found to be sharply regenerated in three forest types: evergreen broadleaf forests, the mixed evergreen broadleaf forests and bamboo; the mixed evergreen broadleaf forests and Dipterocarpaceae or Lythraceae deciduous forests (Dinh et al., 2020a, 2020b; Ta et al., 2020b).



Figure 4.9. Shoot-regenerated trees in Yok Don national park (Photo: La Quang Trung – CCD/2020).



Figure 4.10. Shoot-regenerated trees in Bu Gia Map national park (Photo: La Quang Trung – CCD/2020).



Figure 4.11. Shoot-regenerated trees in Bu Gia Map national park (Photo: La Quang Trung – CCD/2020).

4.5.3. Identification of logs

Sapwood is clearly demarcated from heartwood as seen on the cross section (**Figure 4.12**). Sapwood is yellowish grey to light grey. Heartwood color ranges from pink-brown, orange to a darker reddish brown. Heartwood color tends to be darker by the time (**Figure 4.13** and **Figure 4.14**).

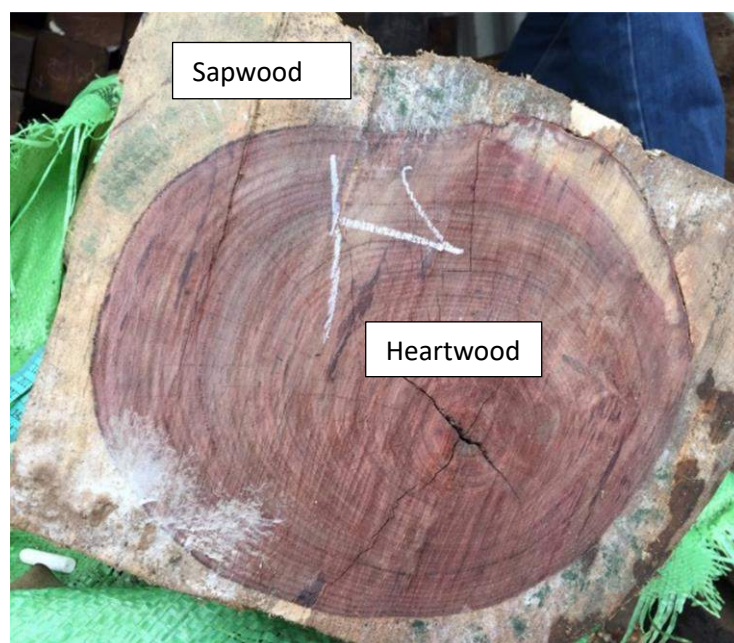


Figure 4.12. Sapwood and heartwood of *Dalbergia oliveri* are distinguished in color (Photo: Do Van Ban)



Figure 4.13 (left) and **Figure 4.14** (right). Color of *Dalbergia oliveri* heartwood
(Photo: La Quang Trung – CCD/2020)

Dalbergia oliveri sapwood has relatively high natural durability, therefore it is also used in carpentry.

Dalbergia oliveri is less prone to hollowing rather than *D. cochinchinensis*.

Dalbergia oliveri is hard and heavy, average dried weight is 940 kg/m³.

4.5.4. Identification of sawn wood

Newly sawn wood of *Dalbergia oliveri* is pungent smell.

Sapwood is yellowish grey to light grey. Heartwood is pink-brown, yellow-brown or reddish brown (**Figure 4.15**).

Dark brown to black streaks is often seen on radial section. These streaks usually form beautiful grain on tangential section.

Wood tends to be darker in color, to red-brown, dark brown by the time.

Due to high price and value, *Dalbergia oliveri* has been heavily exploited all base and roots, thence, sawn wood and lumber are various in shape and size.



Figure 4.15. Sawn wood of *Dalbergia oliveri* (Photo: Do Van Ban)

4.5.5. Identification of timber product

Dalbergia cochinchinensis timber products are usually covered with varnish, or transparent layer to clearly see natural wood color and grains. Besides, some products maintain sapwood with brighter color to identify easily. In general, *Dalbergia oliveri* timber has lighter color and retains its color longer than *D. cochinchinensis* (Figure 4.16).



Figure 4.16. Rosewood vases made from *Dalbergia oliveri* (Photo: Do Van Ban).

4.5.6. Macroscopic characteristics

Heartwood is pink-brown, yellow-brown or reddish brown with darker brown/black streaks that could be seen on tangential section and radial section (Figure 4.17).



Figure 4.17. Dark brown and black streaks seen on radial section of *Dalbergia oliveri*. (Photo: Do Van Ban).

Some features that could be seen on transverse section with unaided eyes or hand-held magnifier includes:

- Vessels (pores): Vessels is diffuse-porous (vessels/pores are distributed over the cross section). Pores are different in size (**Figure 4.18**).

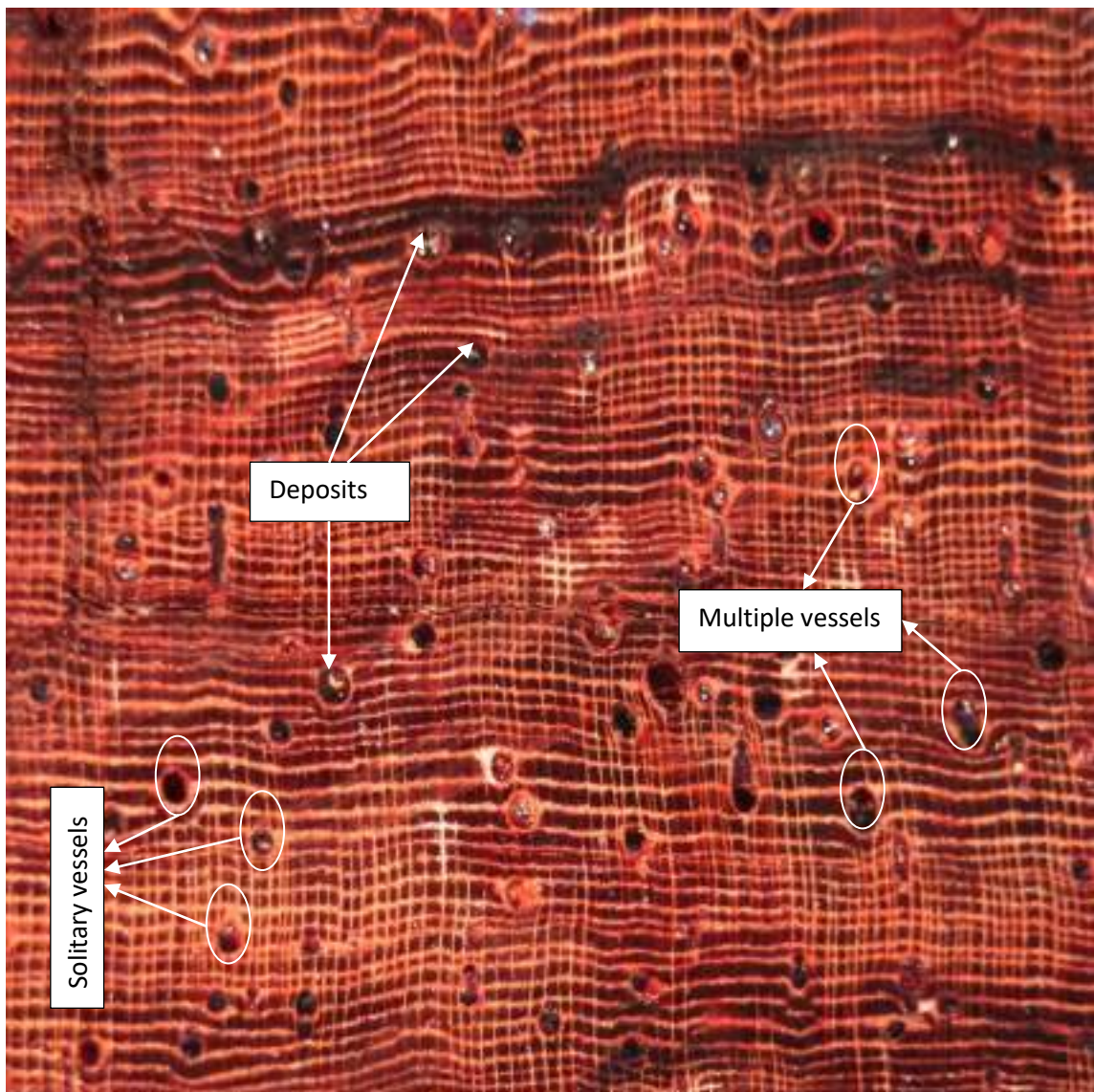


Figure 4.18. Transverse section of *Dalbergia oliveri* timber (portrait direction: radial direction or ray direction; landscape direction: tangential direction). (Photo: Do Van Ban).

- Vessels (pores) are in solitary or radial multiples of 2-3, rarely radial multiples of 4 or more (**Figure 4.18**).
- Heartwood deposits are present and red or dark brown in color (**Figure 4.18**).
- Axial parenchyma surrounds vessels (pores) forming aliform wing or confluent wing.
- Parenchyma bands is narrow, continuous, or discontinuous, or wavy. Parenchyma bands incorporate with rays create net shape (**Figure 4.19**).

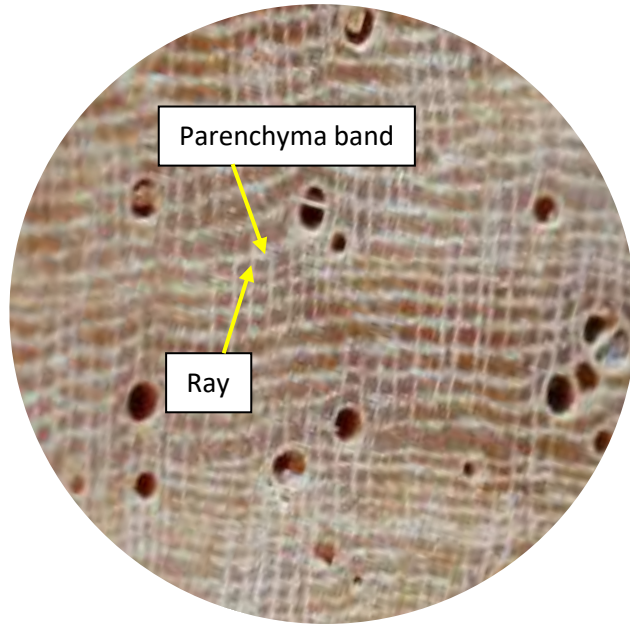


Figure 4.19. Parenchyma bands (lighter bands in landscape orientation) incorporates with rays (lighter bands in portrait orientation) forming net shape (Photo: Do Van Ban)

- Rays (darker bands) are aggregated and arranged evenly appearing to the unaided eyes or low magnification as a single large ray on tangential section (**Figure 4.20**).

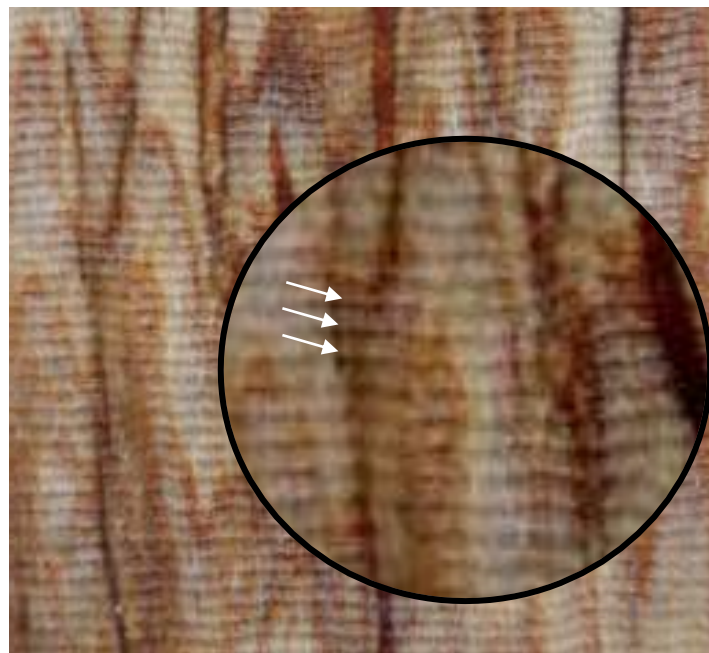


Figure 4.20. Rays cascade as seen on tangential section of *Dalbergia oliveri* by hand-held magnifier (Photo: Do Van Ban).

References

- Đình, T. K. V., Tạ, Q. T., Lã, Q. T., & Hoàng, T. S. (2020a). *Báo cáo điều tra Trắc và Cẩm lai ở Vườn quốc gia Cát Tiên*. Trung tâm Bảo tồn Thiên nhiên và Phát triển, Hà Nội, Việt Nam.
- Đình, T. K. V., Tạ, Q. T., Lã, Q. T., & Hoàng, T. S. (2020b). *Báo cáo điều tra Trắc và Cẩm lai ở Vườn quốc gia Yok Đôn*. Trung tâm Bảo tồn Thiên nhiên và Phát triển, Hà Nội, Việt Nam.
- La, Q. T., Bui, T. T., Nguyen, M. H., Dinh, T. K. Van, & Nguyen, H. N. (2021). *Development of distribution maps for Dalbergia cochinchinensis and Dalbergia oliveri in Vietnam*. Center for Nature Conservation and Development, Ha Noi, Vietnam.
- Nguyen, T. H., Nguyen, M. H., & La, Q. T. (2019a). *Review on the taxonomy, biology, ecology, and the status, trend and population structure and dynamics of Dalbergia cochinchinensis in Vietnam*. https://cites-tsp.org/wp-content/uploads/2020/11/Review-taxonomy...-of-Dalbergia-cochinchinensis_revised_compressed.pdf
- Nguyen, T. H., Nguyen, M. H., & La, Q. T. (2019b). *Review on the taxonomy, biology, ecology, and the status, trend and population structure and dynamics of Dalbergia oliveri in Vietnam*. https://cites-tsp.org/wp-content/uploads/2020/11/Review-taxonomy...-of-Dalbergia-oliveri_compressed.pdf
- Tạ, Q. T., Đình, T. K. V., Lã, Q. T., & Hoàng, T. S. (2020a). *Báo cáo điều tra Trắc và Cẩm lai ở rừng đặc dụng Đắk Uy, huyện Đắk Hà, tỉnh Kon Tum*. Trung tâm Bảo tồn Thiên nhiên và Phát triển, Hà Nội, Việt Nam.
- Tạ, Q. T., Đình, T. K. V., Lã, Q. T., & Hoàng, T. S. (2020b). *Báo cáo điều tra Trắc và Cẩm lai ở Vườn quốc gia Bù Gia Mập, tỉnh Bình Phước*. Trung tâm Bảo tồn Thiên nhiên và Phát triển, Hà Nội, Việt Nam.