

Vegetative Description of Three *Aquilaria* (Thymelaeaceae) Saplings in Malaysia

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ABSTRACT

Plants' reproductive parts are most important for species identification. However, trees such as *Aquilaria* species take many years to mature and produce flowers and fruits. Inconsistent and infrequent flowering periods may cause additional hindrance to classical identification. In this study, descriptions were made based on vegetative parts such as leaf, branch and bark for saplings of three *Aquilaria* species found in Malaysia. It was found that *A. hirta* sapling can be recognized through the densely hairy twigs, young shoots and axillary buds, undersurface of leaf, margin, petiole and midrib besides the strongly raised midrib, and usually unbranched habit; *A. malaccensis* through the many branches and white spots along main axis, entire leaf margin, slightly hairy leaf undersurface and midrib, and glabrous petiole; *Aquilaria* sp.1 from the lower branches that are nearly perpendicular to the stem and wavy leaf margin. These vegetative characters can serve as a basis for the correct identification of *Aquilaria* saplings when growers need to confirm their planting materials.

Keywords: *Aquilaria*, identification, sapling, vegetative characteristics

INTRODUCTION

Aquilaria Lam., a genus from the family Thymelaeaceae, is endangered tree taxa endemic to the Indo-Malesia regions (Mabberley, 2008). *Aquilaria* produces 'gaharu', a valuable forest product that is

sought for its uses in perfumery, incense and religious purposes (Barden *et al.*, 2000). *Aquilaria* species are listed in the IUCN Red List Appendix II, and regarded as highly endangered (IUCN 2011). Demand for conservation is increasing to restore their diversity in nature. In Malaysia, *Aquilaria* has attracted a great number of local planters, entrepreneurs, and individuals who planted the trees on a large scale (Lok *et al.*, 1999). Many of these plantations cultivated

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Aquilaria species of foreign origins because they are believed to be of better in producing quality 'gaharu' (Nor Azah *et al.*, 2008; Rompoei *et al.*, 2009). The genetic diversity of *Aquilaria* species in the country at present has been greatly multiplied with cultivated *Aquilaria* trees. With the introduction of foreign species from the neighbouring countries, there is a risk of losing the native genetic diversity (Adams, 1997).

Information on the taxonomy and morphology of mature *Aquilaria* trees in the wild is currently available. However, descriptions of saplings are lacking. Tropical trees are usually identified together with their reproductive parts, which are the flowers and fruits. *Aquilaria*, however, takes several years to bear flowers and fruits (Kumeto & Ito, 2011). Hence, in the absence of their reproductive parts, identification of saplings can only be done through their vegetative parts, including leaves, branches and bark (Whitmore, 1973; Keller, 2004). The first description of the genus *Aquilaria* was done by Lamarck in 1783 based on *A. malaccensis*. Following works on *Aquilaria* include Ridley and Hutchinson (1924), and the revision by Hou (1960). To date, five *Aquilaria* species have been found in Malaysia, viz., *A. malaccensis* Lam., *A. hirta* Ridl., *A. beccariana* Van Teigh., *A. rostrata* Ridl. and *A. microcarpa* Baill (Chua, 2008), and *Aquilaria* sp.1 (Tawan, 2004). The two former species are vulnerable to over-exploitation and habitat loss while the remaining species are known from single herbarium specimens (Lau & Chua, 2012). The distribution and ecology

of different *Aquilaria* species in Malaysia were also undertaken by Faridah-Hanum *et al.* (2009), while Lau and Chua (2012) carried out conservation assessments of *Aquilaria* for Peninsular Malaysia.

This work was undertaken to provide a vegetative description of three *Aquilaria* saplings, which is deemed necessary for individuals or growers to confirm their planting materials before establishing *Aquilaria* plantations.

MATERIALS AND METHODS

Plant Materials

Three selected local *Aquilaria* species were brought back as wildlings from the following places viz. *A. malaccensis* (Lentang Seed Centre, Karak, Pahang), *A. hirta* (forest near Ladang Merchang, Terengganu) and *Aquilaria* sp. 1 from Semenggoh Forest, Sarawak. They were planted in polybags in a mixture of soil forest and red soil (1:1) and grown in the shade house at the Faculty of Forestry, Universiti Putra Malaysia (UPM). Saplings were watered and fertilized periodically with organic compound fertilizer (HumicFert+) to ensure the growth of leaves and branches.

Herbarium Specimens

Two specimens were taken after the saplings were planted for one year. All the specimens were pressed, dried and mounted, and kept as voucher specimens in the Herbarium, Faculty of Forestry, Universiti Putra Malaysia. Comparisons were made with the following specimens from matured trees:

Aquilaria malaccensis UPM 8871, UPM 8872, UPM 8873, UPM 17460, KEP 37142, KEP 40707, KEP 37045, KEP 34553, KEP 31387; *A. hirta* KEP1679, KEP 71521, KEP 1188, KEP 26898, KEP 23836, KEP 69910, KEP 10542, KEP 2397, KEP 16972, KEP 8298, KEP10673, KEP 8330, KEP 25030, KEP 59689, KEP 59692, KEP 59675, KEP 59602, KEP 58682, KEP 59691, KEP 59601; *Aquilaria* sp. 1 S34204.

The vegetative parts of the saplings were photographed using Leitz MZ8 Low-range Microscope (Leica, Germany). A scale was then added into the photo to provide measurement references. The software Leica QWin Standard Y 2.8 was used to operate the microscope and to analyze the images.

RESULTS AND DISCUSSION

The saplings of the *Aquilaria* species examined are herein described by distinguishing the characters highlighted in **bold** as follows:

Aquilaria sp.1 (Fig.1a, Fig.2a-f)

Sapling with **lower branches nearly perpendicular to the stem**. Twigs slender, slightly hairy. Leaves oblong-ob lanceolate, 6.0-10.4 x 2.2-3.4 cm, base obtuse, apex acuminate, acumen 0.9-1.6 cm; texture chartaceous, slightly hairy below; midrib channelled above, raised and hairy below; lateral veins conspicuous, 12-20 pairs; **leaf margin wavy**. Petiole hairy, 0.3cm long. Young shoots and axillary buds hairy, light green, 0.4-1.0 cm long.



Fig.1: Representatives of *Aquilaria* saplings used in this study; (a) *Aquilaria* sp.1 sapling from Semenggoh, Sarawak, (b) *A. hirta* sapling from Merchang, Terengganu, and (c) *A. malaccensis* sapling from Karak, Pahang.

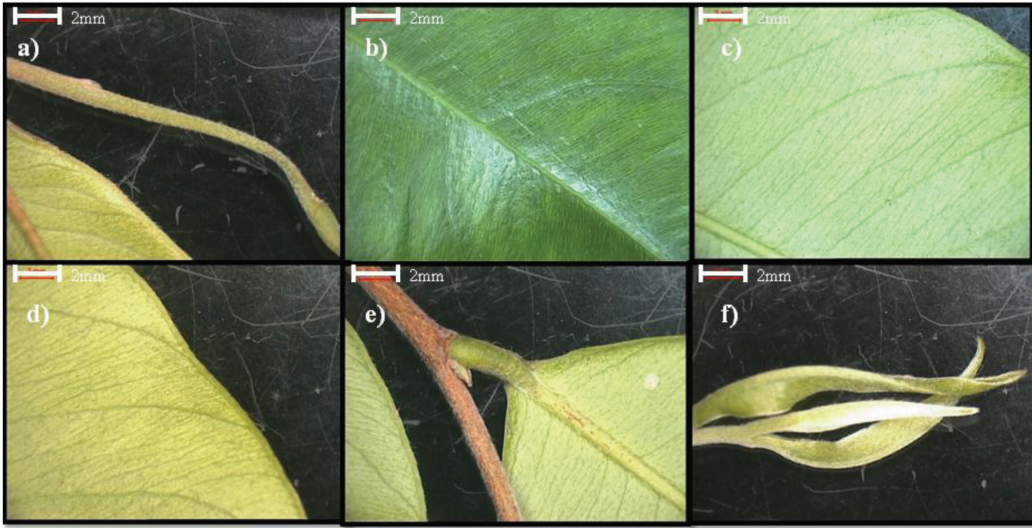


Fig.2: Vegetative characteristics of *Aquilaria* sp.1.; (a) young branch, (b) leaf surface, (c) lateral veins, (d) margin, (e) petiole and (f) young shoot. Reference scale as provided.

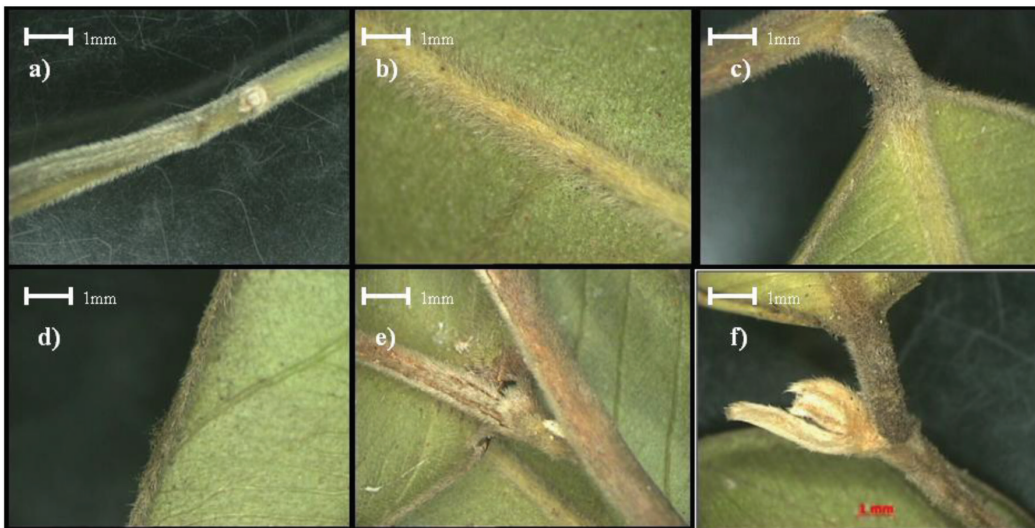


Fig.3: Vegetative characteristics of *Aquilaria hirta*: (a) young branch, (b) midrib, (c) petiole, (d) margin, (e) young shoot and (f) axillary bud. Reference scale as provided.

Aquilaria hirta Ridl (Fig.1b, Fig.3 a-f)

Sapling rarely branching. Twigs densely hairy. Leaves acuminate-lanceolate, 8.5-13.8 x 3.7-6.5 cm, base acute, apex acuminate, acumen of 1.5cm long; texture

coriaceous, glabrous above, **densely hairy below; midrib strongly raised, densely hairy below.** Lateral veins conspicuous below, 14-23 pairs; **leaf margin entire, densely hairy.** **Petiole densely hairy, 0.4-**

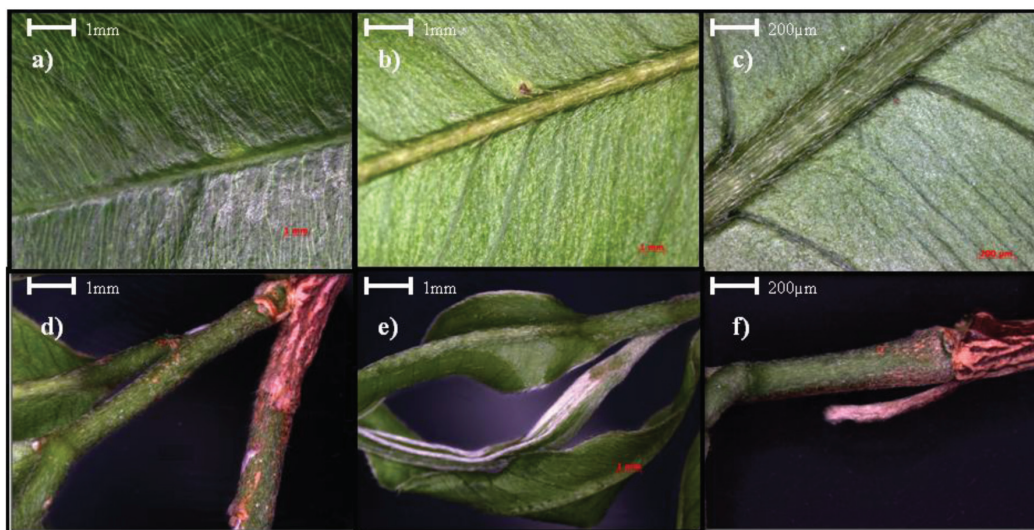


Fig.4: Vegetative characteristics of *Aquilaria malaccensis*: (a) leaf surface, (b) leaf bottom, (c) midrib, (d) petiole, (e) young shoot and (f) axillary bud. Reference scale as provided.

0.7cm long. **Young shoots and axillary buds densely hairy**, light green, 1.5-3.0 cm long.

Aquilaria malaccensis Lam. (Fig.1c, Fig. 4a-f)

Sapling often branching with white spots along the main axis. Twigs greenish, glabrous. Leaf elliptic-lanceolate, 8.5-11.5 x 3.0-4.1cm, base acute, apex acuminate, acumen of 1.8-1.9cm long; texture thinly coriaceous, shiny green above, **slightly hairy below; midrib slightly hairy; lateral veins conspicuous, 19-26 pairs; leaf margin entire. Petiole glabrous**, 0.3-0.4cm long. Young shoots and axillary buds hairy, light green, 0.5-0.7cm long.

From the above descriptions, the distinguishing characters were tabulated (Table 1). The easiest sapling to identify is *A. hirta* due to the nearly unbranched habit, densely hairy throughout the plant

besides the strongly raised leaf midrib. These characters differ remarkably from the saplings of the two other species. Meanwhile, the observations showed that matured *A. hirta* specimens differ from the saplings by having soft velvety hairs on the leaf undersurface, margin, petiole and midrib. *Aquilaria* sp.1 was reported as an incomplete species by Tawan (2004), who noted that it closely resembles *A. beccariana* through its vegetative characteristics. However, its taxonomic status is not confirmed as the reproductive characteristics of *Aquilaria* sp.1 tree do not match the reproductive characteristics of *A. beccariana* tree. Despite this, the *Aquilaria* sp. 1 sapling is easily recognisable from the wavy leaves and lower branches that are nearly perpendicular to the stem, unlike the branches of *A. malaccensis* sapling. The sapling of *A. malaccensis* has many branches

TABLE 1
A comparison of the sapling characteristics between three *Aquilaria* species

Leaf Characteristics	<i>Aquilaria</i> sp.1	<i>A. hirta</i>	<i>A. malaccensis</i>
Lower branches	Nearly perpendicular to stem	Rarely branching	Often branching with white spots along the main axis
Leaf Texture	Chartaceous	Coriaceous	Thinly coriaceous
Leaf Undersurface	Slightly hairy	Densely hairy	Slightly hairy
Midrib	Raised below and channelled above	Strongly raised below	Raised below
	Slightly hairy below	Densely hairy below	Slightly hairy below
Lateral veins	Conspicuous	Raised and prominent below	Conspicuous
Margin	Wavy	Entire and densely hairy	Entire
Petiole	Slightly hairy	Densely hairy	Glabrous
Young shoots and axillary buds	Slightly hairy	Densely hairy	Slightly hairy

and white spots along the main axis, entire leaf margin, slightly hairy leaf undersurface and midrib, and glabrous petiole. However, adult trees of *A. malaccensis* have glabrous plant parts, with conspicuous shiny leaf upper surface, sunken midrib above but raised beneath.

CONCLUSION

Generally, identification of plant taxa relies more on the reproductive parts due to their inherent hence stable characters. However, in this study, young saplings were identified by observing their vegetative parts in the absence of reproductive parts. Like many other tree species, it is difficult to determine the identity of the saplings of *Aquilaria*, especially to inexperienced individuals. In this research work, it was demonstrated that by looking at vegetative parts, saplings could be identified correctly. This could be

a quick solution for the general public to help determine the species identity of young saplings, especially when planning to plant the three *Aquilaria* species on plantations.

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REFERENCES

- Adams, R. P. (1997). Conservation of DNA: DNA Banking. In J. A. Callow, B.V. Ford-Lloyd, & H. J. Newbury (Eds.), *Biotechnology and Plant Genetic Resources*. (p. 163-174). CAB International.
- Barden, A., Anak, N. A., Mulliken, T., & Song, M. (2000). *Heart of the matter: agarwood use and trade and CITES implementation for Aquilaria malaccensis*. Cambridge, Traffic International.
- Chua, L. S. L. (2008). Agarwood (*Aquilaria malaccensis*) in Malaysia. Mexico: NDF Workshop Case Studies.
- CITES. (2004). *Convention on International Trade in Endangered Species of Wild Fauna and Flora – amendments to Appendices I and II of CITES*. Bangkok: Thirteenth Meeting of the Conference of the Parties.
- Faridah-Hanum, I., Mustapa, M. Z., Lepun, P., Tuan Marina, T. I., Nazre, M., Ribka A., & Mohamed, R. (2009). Notes on the distribution and ecology of *Aquilaria* Lam. (Thymelaeaceae) in Malaysia. *The Malaysian Forester*, 72, 247-259.
- Hou, D. (1960). Thymelaeaceae. In *Flora Malesiana*, Series 1, Vol.6-1, (pp. 1-59).
- IUCN. (2011). *Red List of Threatened Species*. Retrieved from <http://www.iucnredlist.org/apps/redlist/search>
- Keller, R. (2004). *Identification of tropical woody plants in the absence of flowers – A field guide* (2nd Edition). Basel, Birkhäuser Verlag.
- Kumeto, Y., & Ito, M. (2011). Genomic organization of δ -guaiene synthase genes in *Aquilaria crassna* and its possible use for the identification of *Aquilaria* species. *Journal of Natural Medicine*, 65, 508-513.
- LaFrankie, J. V. (1994). Population dynamics of some tropical trees that yield non-timber products. *Economy Botany*, 48, 301-309.
- Lau, K. H., & Chua, L. S. L. (2012). Conservation of *Aquilaria* (Thymelaeaceae) in Peninsular Malaysia. In H. C. Sim, A.H. Syuqiyah, & M. Li (Eds.), *IUFRO World Series–Extended Abstract*, Vol. 30 (pp. 43-45). Vienna, IUFRO.
- Lixin, Z. (2003). *Ecology and population dynamics of Aquilaria crassna in Khao Yai National Park of Thailand*. (Unpublished doctoral dissertation). Mahidol University.
- Lok, E. H., Chang, Y. S., & Yusoff, A. M. (1999). Early survival and growth in field trials of *Aquilaria malaccensis* (Karas) and *Azadirachta excelsa* (Sentang). *Journal of Tropical Forest Science*, 11, 852-854.
- Mabberly, D. J. (2008). *Mabberley's Plant-Book: A Portable Dictionary of Plants, Their Classification and Uses*. Cambridge, Cambridge University Press.
- MacDougall, A. S., Loo, J. A., Clayden, S. R., Goltz, J. G., & Hinds, H. R. (1998). Defining conservation priorities for plant taxa in southeastern New Brunswick, Canada using herbarium records. *Biological Conservation*, 86, 325-338.
- Nor Azah, M. A., Chang, Y. S., Mailina, J., Abu Said, A., Abd Majid, J., Saidatul Husni, H., & Nik Yasmin, Y. (2008). Comparison of chemical profiles of selected gaharu oils from Peninsular Malaysia. *The Malaysian Journal of Analytical Sciences*, 12, 338-340.
- Ridley, H. N., & Hutchinson, J. (1924). *The Flora of Malay Peninsula*, Volume III Apetalae. London, Reeve L.
- Rompoei, T., Tantayanon, S., and Ngamprasertsith, S. (2009). Utilization of supercritical CO₂ in essential oil extraction from agarwood *Aquilaria subintergra*. Thailand: 35th Congress on Science and Technology.
- Schatz, G. E. (2002). Taxonomy and herbaria in service of plant conservation: Lessons from Madagascar's endemic families. *Annals of the Missouri Botanical Garden*, 89, 145-152.

- Soehartono, T., & Newton, A. C. (2001). Reproductive ecology of *Aquilaria* spp. in Indonesia. *Forest Ecology and Management*, 152, 59-71.
- Soepadmo, E., Saw, L. G., & Chung, R. C. K. (2004). *Tree Flora of Sabah and Sarawak*. Volume 5. Government of Malaysia.
- Tawan, C. S. (2004). Thymelaeaceae. In E. Soepadmo, L. G. Saw, & R. C. K. Chung (Eds.), *Tree Flora of Sabah and Sarawak*, Vol. 5. (pp. 433-484). Government of Malaysia.
- Von Reis, S. (1962). Herbaria: Sources of Medical Folklore. *Economic Botany*, 16, 283-287.
- Whitmore, T. C. (1973). Thymelaeaceae. Order 28: Myrtiflorae. *Tree Flora of Malaya – A Manual for Foresters* (p. 1:18 & 2:383-391). Selangor, Longman.
- Willis, F., Moat, J., & Paton, A. (2003). Defining a role for herbarium data in Red List assessments: a case study of *Plectranthus* from eastern and southern tropical Africa. *Biodiversity and Conservation*, 12, 1537-1552.