



**Asia-Pacific  
Economic Cooperation**

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**2025/SOM3/EGILAT/DIA/010**

Agenda Item: 4

## **Wood Identification for Legal Timber Trade**

Submitted by: Malaysia



**Dialogues and Mini-Exhibition on Enhancing  
Enforcement and Legal Timber Trade through  
Stakeholder Collaboration and Innovation  
Incheon, Korea  
28 July 2025**

# Wood identification for legal timber trade

Kevin Kit Siong NG, Lee Hong TNAH, Chin Hong NG, Chai Ting LEE, Nurul Farhanah Zakaria, Nur Nabilah Alias, Abd Ramlizaayahudin Mahli & Soon Leong LEE

# Contents

- ❖ Background
- ❖ DNA extraction from wood
- ❖ What is DNA barcoding?
- ❖ DNA barcoding database
- ❖ Development of new DNA barcodes
- ❖ DNA profiling database
- ❖ DNA Database Management System
- ❖ Training to enforcement officials
- ❖ Applications
- ❖ Accreditation and recognition



Numerous **international regulations** have been established to **restrict the import of timber products** derived from **illegal logging**, aiming to promote **sustainable forest management** and **curb deforestation**

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EN

Official Journal of the European Union



REGULATION (EU) 2023/1115 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

of 31 May 2023



on the making available on the Union market and the export from the Union of certain commodities and products associated with deforestation and forest degradation and repealing Regulation (EU) No 995/2010

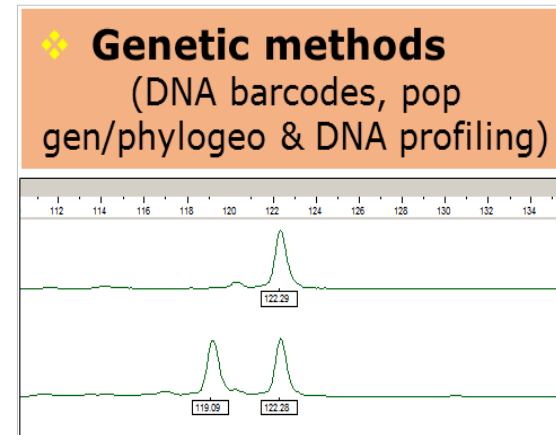
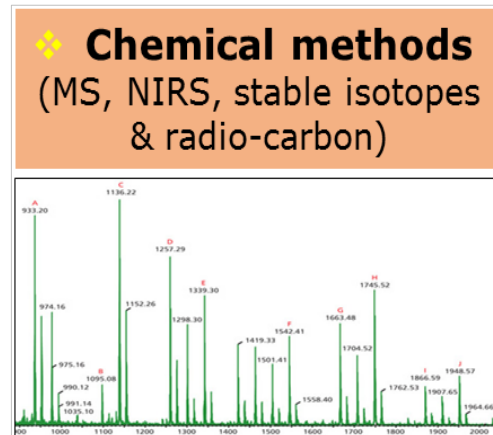
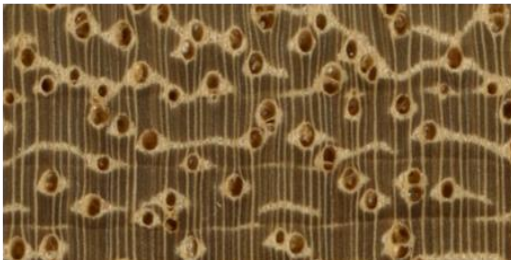
(Text with EEA relevance)

THE EUROPEAN PARLIAMENT AND THE COUNCIL OF THE EUROPEAN UNION,

**Due diligence requirement** - Provide detailed information on the **timber species**, its **source of origin**, and verifiable evidence to demonstrate the **legality** and **authenticity** of the timber product

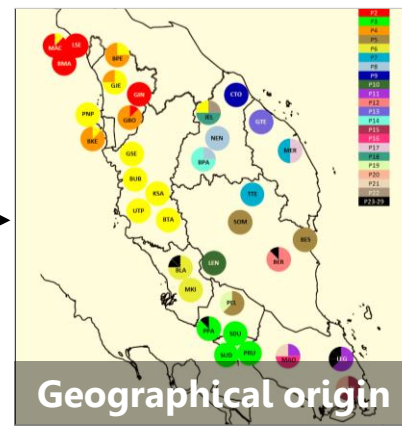
Several **timber tracking** and **species identification** tools can aid in enforcement and regulation efforts

❖ **Image identification**  
(Wood anatomy & dendrochronology)



Since 2008, Malaysia has employed genetic methods to develop comprehensive DNA profiling and barcoding databases for key tropical tree species, supporting efforts in **WOOD TRACKING & SPECIES IDENTIFICATION**

## How to use genetic methods for wood tracking and species identification?



It is possible to extract quality DNA from dry wood/wood product?

**DNA extraction from wood**

How to establish DNA database for species identification?

**DNA barcoding**

How to establish DNA database for population identification?

**DNA profiling**

How to establish DNA database for individual identification?

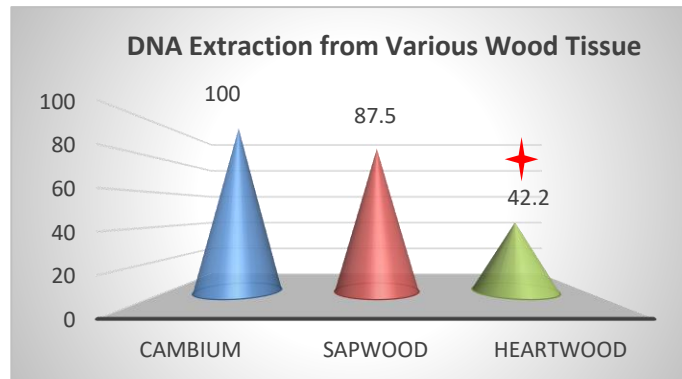
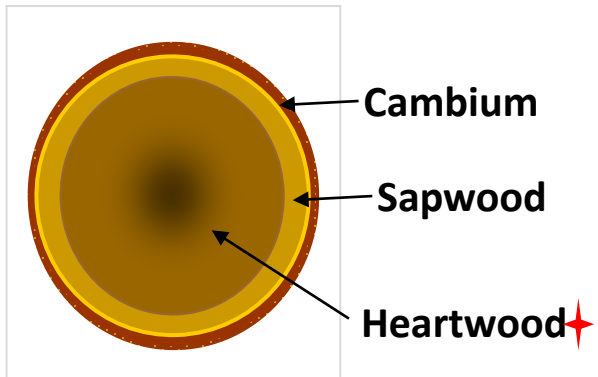
**DNA profiling**

Wood Sci Technol (2012) 46:813–825  
DOI 10.1007/s00226-011-0447-6

ORIGINAL

**DNA extraction from dry wood of *Neobalanocarpus heimii* (Dipterocarpaceae) for forensic DNA profiling and timber tracking**

Lee Hong Tnah · Soon Leong Lee · Kevin Kit Siong Ng · Subha Bhassu · Rofina Yasmin Othman



## DNA from wood products



**DNA Degradation Issues in Wood Products – Exploring nested PCR protocols or genome skimming technique for difficult wood samples**

# What is DNA barcoding?

“A diagnostic technique for species identification or authentication using a short, standardized DNA region”



**Need to establish DNA barcoding database**

# DNA barcoding database (*rbcL*, ITS2 & *trnH-psbA*)

## Timber species (699 species from 154 timber trade name)



Bil	Spesies	Nama dagangan	Bil	Spesies	Nama dagangan
1	<i>Actinodaphne macrophylla</i>	MEDANG	651	<i>Syzygium pseudocrenulatum</i>	KELAT
2	<i>Actinodaphne pruinosa</i>	MEDANG	652	<i>Syzygium pustulatum</i>	KELAT
3	<i>Adinandra dumosa</i>	SAMAK	653	<i>Syzygium pycnanthum</i>	KELAT
4	<i>Adinandra villosa</i>	SAMAK	654	<i>Syzygium pyriformium</i>	KELAT
5	<i>Agathis borneensis</i>	DAMAR MINYAK	655	<i>Syzygium racemosum</i>	KELAT
6	<i>Aglaiia argentea</i>	PASAK	656	<i>Syzygium ridleyi</i>	KELAT
7	<i>Aglaiia cordata</i>	PASAK	657	<i>Syzygium syzygioides</i>	KELAT
8	<i>Aglaiia exstipulata</i>	PASAK	658	<i>Syzygium variolosum</i>	KELAT
9	<i>Aglaiia forbesii</i>	PASAK	659	<i>Tectona grandis</i>	TEAK
10	<i>Aglaiia ganggo</i>	PASAK	660	<i>Teijsmanniodendron coriaceum</i>	ENTAPULOH
11	<i>Aglaiia glabriflora</i>	PASAK	661	<i>Teijsmanniodendron pteropodum</i>	ENTAPULOH
12	<i>Aglaiia grandis</i>	PASAK	662	<i>Terminalia calamansanai</i>	KETAPANG
13	<i>Aglaiia macrocarpa</i>	PASAK	663	<i>Terminalia catappa</i>	KETAPANG
14	<i>Aglaiia odoratissima</i>	PASAK	664	<i>Terminalia phellocarpa</i>	KETAPANG
15	<i>Aglaiia oligocarpa</i>	PASAK	665	<i>Terminalia subspathulata</i>	KETAPANG
16	<i>Aglaiia oligophylla</i>	PASAK	666	<i>Trigonostrium hypoleucum</i>	MARAJALI
17	<i>Aglaiia palembanica</i>	PASAK	667	<i>Triomma malaccensis</i>	KEDONDONG
18	<i>Aglaiia sexipetala</i>	PASAK	668	<i>Upuna borneensis</i>	PENYAU
19	<i>Aglaiia tenuicaulis</i>	PASAK	669	<i>Vatica bella</i>	RESAK
20	<i>Alangium ebenaceum</i>	MENTULANG	670	<i>Vatica cinerea</i>	RESAK
21	<i>Alangium nobile</i>	MENTULANG	671	<i>Vatica dulitensis</i>	RESAK
22	<i>Alangium ridleyi</i>	MENTULANG	672	<i>Vatica flavida</i>	RESAK
23	<i>Alphonsea maingayi</i>	MEMPISANG	673	<i>Vatica havilandii</i>	RESAK
24	<i>Alphonsea elliptica</i>	MEMPISANG	674	<i>Vatica lobata</i>	RESAK
25	<i>Alseodaphne nigrescens</i>	MEDANG	675	<i>Vatica maingayi</i>	RESAK
26	<i>Alseodaphne peduncularis</i>	MEDANG	676	<i>Vatica micrantha</i>	RESAK
27	<i>Alstonia angustiloba</i>	PULAI	677	<i>Vatica nitens</i>	RESAK
28	<i>Anisophyllea corneri</i>	DELEK	678	<i>Vatica pauciflora</i>	RESAK
29	<i>Anisoptera costata</i>	MERSAWA	679	<i>Vatica scortechinii</i>	RESAK
30	<i>Anisoptera curtisii</i>	MERSAWA	680	<i>Vatica stapfiana</i>	RESAK
31	<i>Anisoptera grossivenia</i>	MERSAWA	681	<i>Vatica venulosa</i> subsp. <i>venulosa</i>	RESAK
32	<i>Anisoptera laevis</i>	MERSAWA	682	<i>Vitex pinnata</i>	LEBAN
33	<i>Anisoptera megistocarpa</i>	MERSAWA	683	<i>Xanthophyllum affine</i>	NYALIN/MINYAK BEROK
34	<i>Anisoptera scaphula</i>	MERSAWA	684	<i>Xanthophyllum amoenum</i>	NYALIN/MINYAK BEROK
35	<i>Aporosa arborea</i>	KAYU MASAM	685	<i>Xanthophyllum chartaceum</i>	NYALIN/MINYAK BEROK
36	<i>Aporosa aurea</i>	KAYU MASAM	686	<i>Xanthophyllum ellipticum</i>	NYALIN/MINYAK BEROK
37	<i>Aporosa falcifera</i>	KAYU MASAM	687	<i>Xanthophyllum eurhynchum</i>	NYALIN/MINYAK BEROK
38	<i>Aporosa globifera</i>	KAYU MASAM	688	<i>Xanthophyllum griffithii</i>	NYALIN/MINYAK BEROK
39	<i>Aporosa lucida</i>	KAYU MASAM	689	<i>Xanthophyllum rufum</i>	NYALIN/MINYAK BEROK
40	<i>Aporosa microstachya</i>	KAYU MASAM	690	<i>Xanthophyllum stipitatum</i>	NYALIN/MINYAK BEROK
41	<i>Aporosa nervosa</i>	KAYU MASAM	691	<i>Xerospermum naronhianum</i>	KAMBUTAN PACHAT
42	<i>Aporosa nigricans</i>	KAYU MASAM	692	<i>Xylocarpus granatum</i>	NYIREH
43	<i>Aporosa prainiana</i>	KAYU MASAM	693	<i>Xylocarpus moluccensis</i>	NYIREH
44	<i>Aporosa subcaudata</i>	KAYU MASAM	699	<i>Xylopia malayana</i>	MEMPISANG

# DNA barcoding database (*rbcL*, ITS2 & *trnH-psbA*)



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Forensic timber identification: a case study of a CITES listed species, *Gonystylus bancanus* (Thymelaeaceae)

Kevin Kit Siong Ng<sup>a,\*</sup>, Soon Leong Lee<sup>a</sup>, Lee Hong Tnah<sup>a</sup>, Zakaria Nurul-Farhanah<sup>a</sup>, Chin Hong Ng<sup>a</sup>, Chai Ting Lee<sup>a</sup>, Naoki Tani<sup>b</sup>, Bibian Diway<sup>c</sup>, Pei Sing Lai<sup>d</sup>, Eyen Khoo<sup>e</sup>

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 Short tandem repeats (STRs)  
 Timber tracking

ABSTRACT

Illegal logging and smuggling of *Gonystylus bancanus* (Thymelaeaceae) poses a serious threat to this fragile valuable peat swamp timber species. Using *G. bancanus* as a case study, DNA markers were used to develop identification databases at the species, population and individual level. The species level database for *Gonystylus* comprised of an rDNA (ITS2) and two cpDNA (*trnH-psbA* and *trnL*) markers based on a 20 *Gonystylus* species database. When concatenated, taxonomic species recognition was achieved with a resolution of 90% (18 out of the 20 species). In addition, based on 17 natural populations of *G. bancanus* throughout West (Peninsular Malaysia) and East (Sabah and Sarawak) Malaysia, population and individual identification databases were developed using cpDNA and STR markers respectively. A haplotype distribution map for Malaysia was generated using six cpDNA markers, resulting in 12 unique multilocus haplotypes, from 24 informative intraspecific variable sites. These unique haplotypes suggest a clear genetic structuring of West and East regions. A simulation procedure based on the composition of the samples was used to test whether a suspected sample conformed to a given regional origin. Overall,

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Research paper

DNA databases of a CITES listed species *Aquilaria malaccensis* (Thymelaeaceae) as the tracking tools for forensic identification and chain of custody certification

Soon Leong Lee<sup>a,\*</sup>, Nurul-Farhanah Zakaria<sup>a</sup>, Lee Hong Tnah<sup>a</sup>, Chin Hong Ng<sup>a</sup>, Kevin Kit Siong Ng<sup>a</sup>, Chai Ting Lee<sup>a</sup>, Kah Hoo Lau<sup>b</sup>, Lillian Swee Lian Chua<sup>b</sup>

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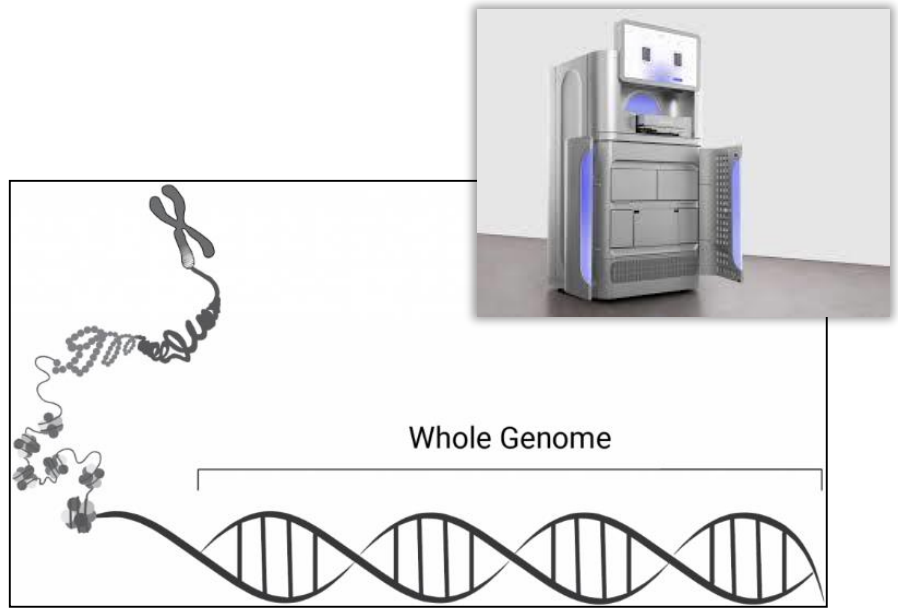
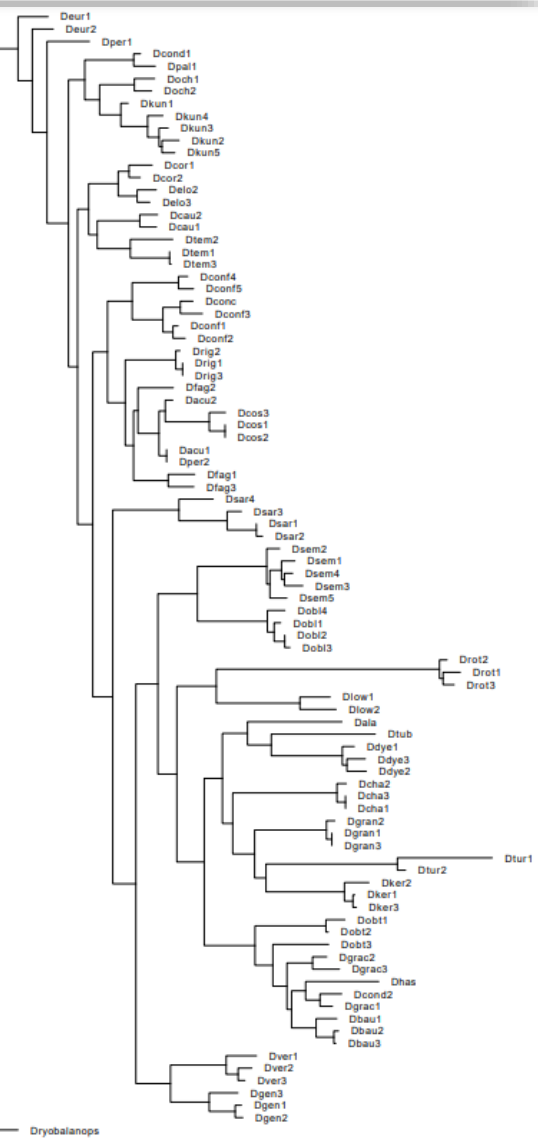
Keywords:  
 Tropical tree species  
 Agarwood/Gaharu  
 Chloroplast DNA  
 Short tandem repeat (STR)  
 DNA barcoding  
 DNA profiling  
 Allelic ladder

ABSTRACT

*Aquilaria malaccensis* (Thymelaeaceae) is the main source of high-grade agarwood in Southeast Asia. Aggressive collections and trade activities over the past decades have put great pressure on the natural stands and raised concerns over the long-term survival potential of *A. malaccensis*. Tracking and authentication of agarwood require method with a high degree of accuracy. Therefore, this study aimed to develop DNA database of *A. malaccensis* as the tracking tools at species, population and individual levels for forensic identification and chain of custody certification. Using two cpDNA (*rbcL* and *matK*) and an rDNA (ITS2) markers, species identification database of *Aquilaria* was developed to distinguish *A. malaccensis* from *A. hirta*, *A. microcarpa*, *A. beccariana*, *A. crasna*, *A. sinensis* and *A. rostrata*. In addition, based on 35 populations of *A. malaccensis* throughout Peninsular Malaysia, cpDNA haplotype and STR allele frequency databases were developed for

# Development of new DNA barcodes

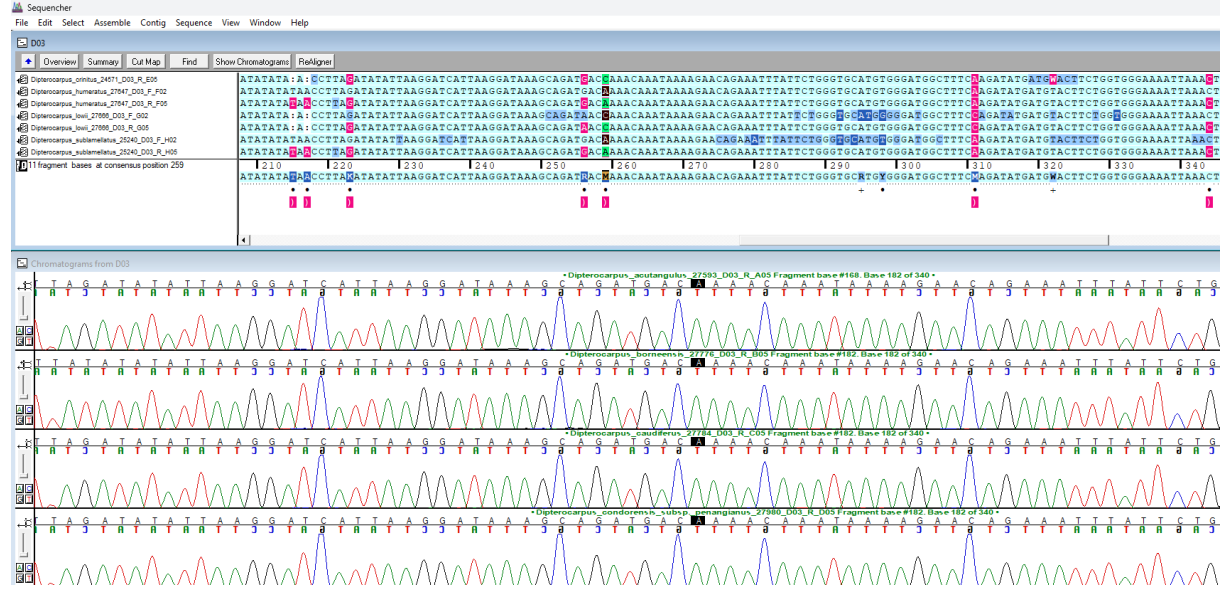
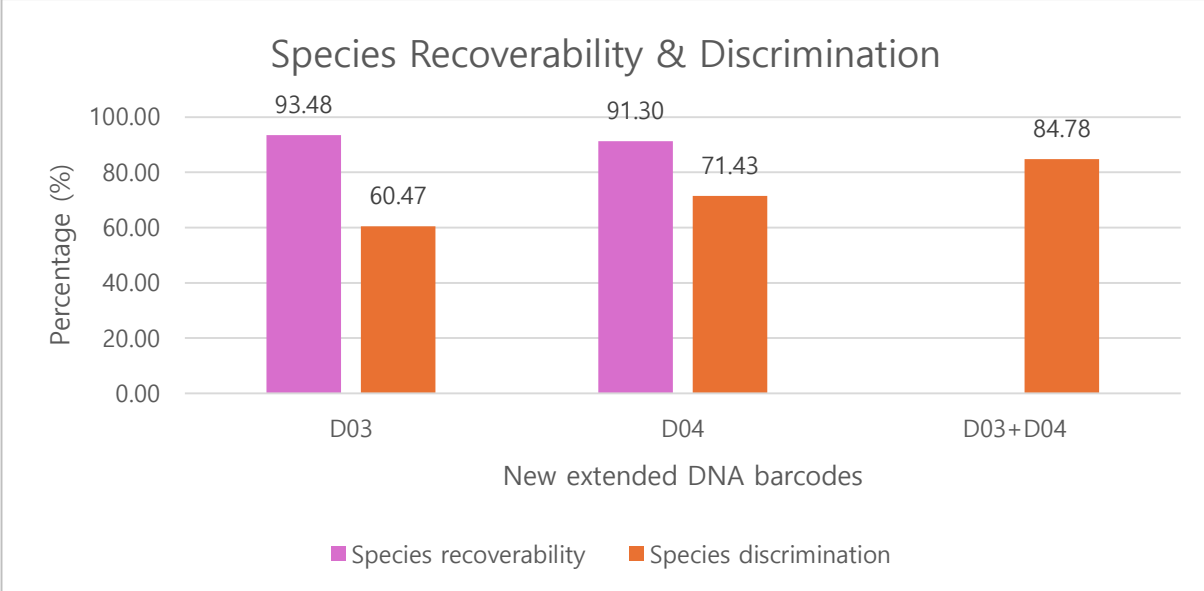
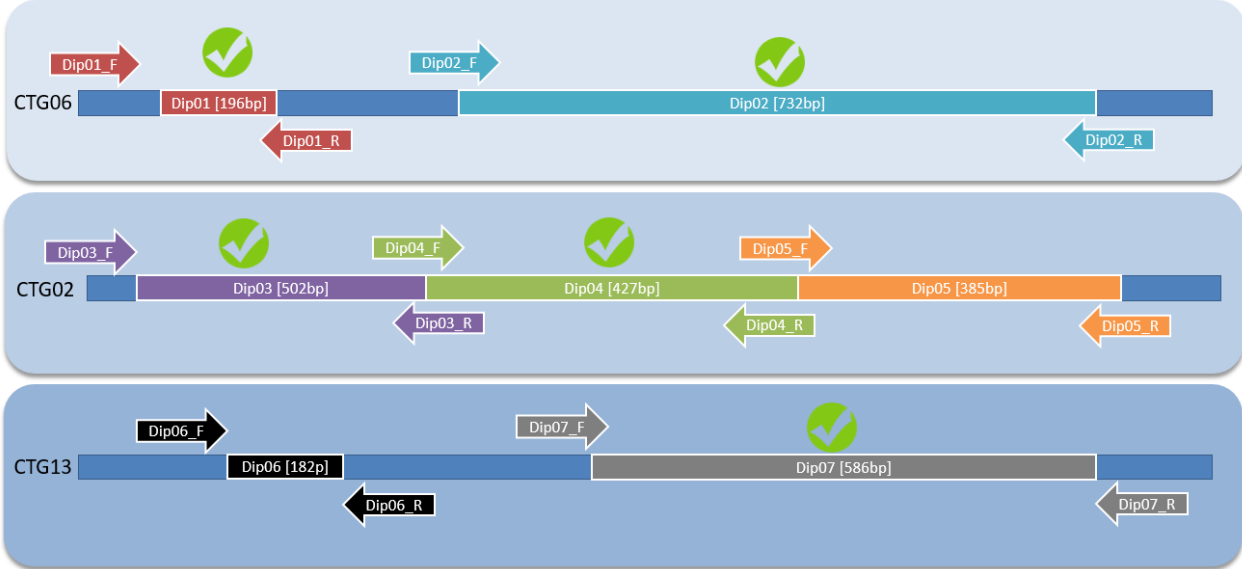
Phylogenetic inference of 31 *Dipterocarpus* species using whole-genome resequencing data



**Development of New DNA Barcodes**

- Genomes from various species can be analyzed collectively to identify unique DNA sequences that are useful for distinguishing between species.

# Development of new DNA barcodes



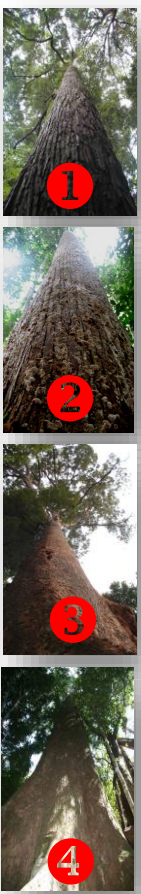
\*Barcodes evaluation based on 46 species of *Dipteroctarpus*

- ✓ Two-locus barcodes: Species discrimination of 84.78%
- ✓ More barcodes (D02 & D07) are included to increase species discrimination

# DNA profiling database (SSR)



**Total 409 pops; 13,196 samples**



- 1 ***Neobalanocarpus heimii*** 30 pops (PM)
- 2 ***Gonystylus bancanus*** 17 pops (Ma)
- 3 ***Koompassia malaccensis*** 64 pops (Ma)
- 4 ***Rubroshorea platyclados*** 30 pops (Ma)
- 5 ***Aquilaria malaccensis*** 35 pops (PM)
- 6 ***Intsia palembanica*** 39 pops (PM)
- 7 ***Rubroshorea leprosula*** 44 pops (PM)
- 8 ***Rubroshorea curtisii*** 41 pops (PM)
- 9 ***Rhizophora mucronata*** 34 pops (PM)
- 10 ***Rhizophora apiculata*** 43 pops (PM)
- 11 ***Dryobalanops aromatica*** 11 pops (PM)
- 12 ***Dryobalanops oblongifolia*** 5 pops (PM)
- 13 ***Dipterocarpus cornutus*** 16 pops (PM)



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Forensic DNA profiling of tropical timber species in Peninsular Malaysia  
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Forensic DNA typing

ABSTRACT

Illegal logging poses a significant threat to the sustainability of tropical forests. By using Neobalanocarpus heimii (Dipterocarpaceae) as an example, the study assessed the feasibility of using Neobalanocarpus heimii (Dipterocarpaceae) as a model to identify the source of illegally logged timber. Thirty natural populations of N. heimii were profiled using 12 STRs to develop the DNA profiling database. By the cluster analysis based on the population genetic cluster corresponding to their geographic location within Peninsular Malaysia, the DNA databases were constructed at the levels of population, subregion and Peninsular Malaysia. Independent tests on null alleles and genotyping errors were conducted at the database due to significant levels of population differentiation and heterozygosity. The effects of population differentiation and heterozygosity on the calculation of random match probability, the random match probability estimated using independent and subpopulation clusters, and the random match probability estimated using independent and subpopulation clusters were compared. The results were based on a total of 13,196 samples. The results showed that the independent and Peninsular Malaysia databases were conservative, and these databases should be able to provide legal evidence for forest provenance against illegal logging in Peninsular Malaysia.  
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Forensic DNA identification: a case study of a CITES listed species, *Gonystylus bancanus* (Thymelaeaceae)

Kevin Kit Siang Ng<sup>a,\*</sup>, Soon Leong Lee<sup>b</sup>, Lee Hong Ng<sup>c</sup>, Zakaria Nurul-Farhanah<sup>d</sup>,  
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Forensic DNA typing

ABSTRACT

Illegal logging and smuggling of *Gonystylus bancanus* (Thymelaeaceae) poses a serious threat to this highly valuable poor trading timber species. Using a case study, DNA markers were used to develop identification databases at the species, population and individual levels. The species level database for *Gonystylus bancanus* consisted of 40 DNA STRs and two cpDNA (trnK-psbA and trnK-psbA) markers based on 20 *Gonystylus bancanus* populations. Last-minute species recognition was achieved with a resolution of 90% (8 out of the 20 species). In addition, based on 13 natural populations of *Gonystylus bancanus* (Peninsular Malaysia), East Coast and West Coast, Malaysia, population and individual identification databases were developed using cpDNA and STR markers respectively. A haplotype database map for Malaysia was generated using a capture marker, resulting in 12 unique haplotypes based on 24 informative microsatellite variables. Two unique haplotypes represent a genetic structure of West and East regions. A simulation procedure based on the composition of the samples was used to evaluate the reliability of the genetic structure. The results showed that the observed type and a series of the databases showed good concordance with the predicted 13 through which indicates that the databases were useful in resolving provenance and identification.

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Research paper

A geographical traceability system for Merbau (*Intsia palembanica* Miq.), an important timber species from peninsular Malaysia

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Forensic DNA typing

ABSTRACT

To fulfil provenance and to trace the origin of timber, the representation of a variability system is necessary for the forensic industry. In this study, we developed a comprehensive genetic database for the important tropical timber species Merbau, *Intsia palembanica*, to trace its geographic origin within peninsular Malaysia. A total of 1270 individuals were sampled from 20 geographic locations and 10 subpopulations were sampled from each population. The results showed that the genetic structure of *Intsia palembanica* was highly heterogeneous. A haplotype map was generated based on 10 informative microsatellite variables, resulting in 14 unique haplotypes based on 13 informative microsatellite variables. In addition, STRs were used to develop individual identification databases at the population and individual levels. The results showed that the observed type and a series of the databases showed good concordance with the predicted 13 through which indicates that the databases were useful in resolving provenance and identification.

PLOS ONE

Geographic origin and individual assignment of *Shorea platyclados* (Dipterocarpaceae) for forensic identification

Chin Hong Ng<sup>a,\*</sup>, Soon Leong Lee<sup>b</sup>, Lee Hong Ng<sup>c</sup>, Kevin Kit Siang Ng<sup>d</sup>, Chai Ting Lee<sup>e</sup>, Bibah Faridah-Tamun<sup>f</sup>, Eyan Khoo<sup>g</sup>

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ABSTRACT

The development of timber tracking methods based on genetic markers can provide scientific evidence to verify the origin of timber products and fulfil the growing requirement for sustainable forestry practices. In this study, the origin of an important Dipterocarpaceae wood, *Shorea platyclados*, was studied by using the combination of seven chloroplast DNA and 15 short tandem repeats (STRs) markers. A total of 27 natural populations of *S. platyclados* were sampled throughout Malaysia to establish population level and individual level identification databases. A haplotype map was generated from chloroplast DNA sequencing for population identification, resulting in 29 multiallelic haplotypes, based on 29 informative microsatellite variables. Subsequently, a DNA profiling database was developed from 15 STRs allowing for individual identification in Malaysia. Cluster analysis divided the 27 populations into two genetic clusters, corresponding to the region of Eastern and Western Malaysia. The conservativeness tests showed that the Malaysian database is conservative after removal of bias from population subdivision and sampling effects. Independent self-assignment tests correctly assigned individuals to the database at an overall 60.25–94.50% of cases for identified populations, and in 95.59–99.23% of cases for identified regions. Both the chloroplast DNA database and the STRs appear to be useful for tracking timber origin in Malaysia. Hence, the DNA based method could serve as an effective addition to the existing forensic timber identification system for ensuring the sustainability management

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Research paper

DNA databases of a CITES listed species *Aquilaria malaccensis* (Thymelaeaceae) as the tracking tools for forensic identification and chain of custody certification

Soon Leong Lee<sup>a</sup>, Nuzki Nurul-Farhanah Zakaria<sup>b</sup>, Lee Hong Ng<sup>c</sup>, Chin Hong Ng<sup>d</sup>,  
Kevin Kit Siang Ng<sup>e</sup>, Chai Ting Lee<sup>f</sup>, Koh Hoo Lee<sup>g</sup>, Lilian Swee Lin Chua<sup>h</sup>

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<sup>b</sup>Forest Research Institute Malaysia, 52100 Kajang, Selangor Darul Ehsan, Malaysia  
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ABSTRACT

*Aquilaria malaccensis* (Dipterocarpaceae) is the main source of high-grade agarwood in Southeast Asia. Aggressive industries and trade activities over the past decades have put great pressure on the natural supply and demand of the long-term survival of *A. malaccensis*. Tracking and substantiation of agarwood origin and supply are important to support law enforcement efforts in ensuring only sustainably harvested timbers are traded in the market. In this study, we developed chloroplast DNA (cpDNA) and simple sequence repeat (SSR) databases as tracking tools for important tropical timber tree species, *Aquilaria malaccensis* from Peninsular Malaysia. A total of 1418 individuals were sampled from 20 natural populations throughout Peninsular Malaysia. Four cpDNA regions were used to develop a cpDNA haplotype database, resulting in a haplotype map consisting of 23 unique haplotypes derived from 29 informative microsatellite variables. This cpDNA database can be used to trace the origin of an unknown log at the regional level. Ten SSR loci were used to develop the SSR alleles frequency database. Bayesian cluster analysis divided the population into two genetic clusters corresponding to Region A and Region B. Based on conservativeness evaluation of the SSR databases for individual identification, the conservativeness indices (CI) were adjusted to 1.000 and 1.100 for Region A and B, respectively. These databases are useful tools to complement existing timber tracking systems in ensuring only legally sourced timbers are allowed to enter the wood supply chain.

scientific reports

OPEN DNA databases of an important tropical timber tree species *Shorea leprosula* (Dipterocarpaceae) for forensic timber identification

Chin Hong Ng<sup>a</sup>, Kevin Kit Siang Ng<sup>b</sup>, Soon Leong Lee<sup>c</sup>, Nuzki Nurul-Farhanah Zakaria,  
Chai Ting Lee & Lee Hong Ng<sup>d</sup>

<sup>a</sup>Forest Research Institute Malaysia, 52100 Kajang, Selangor Darul Ehsan, Malaysia  
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ABSTRACT

International timber trade communities are increasingly demanding that timber in the wood supply chain be sourced from sustainably harvested forests and certified plantations. This is to combat illegal logging activities to prevent further depletion of our precious forests worldwide. Hence, timber tracking tools are important to support law enforcement efforts in ensuring only sustainably harvested timbers are traded in the market. In this study, we developed chloroplast DNA (cpDNA) and simple sequence repeat (SSR) databases as tracking tools for important tropical timber tree species, *Shorea leprosula* from Peninsular Malaysia. A total of 1418 individuals were sampled from 20 natural populations throughout Peninsular Malaysia. Four cpDNA regions were used to develop a cpDNA haplotype database, resulting in a haplotype map consisting of 23 unique haplotypes derived from 29 informative microsatellite variables. This cpDNA database can be used to trace the origin of an unknown log at the regional level. Ten SSR loci were used to develop the SSR alleles frequency database. Bayesian cluster analysis divided the population into two genetic clusters corresponding to Region A and Region B. Based on conservativeness evaluation of the SSR databases for individual identification, the conservativeness indices (CI) were adjusted to 1.000 and 1.100 for Region A and B, respectively. These databases are useful tools to complement existing timber tracking systems in ensuring only legally sourced timbers are allowed to enter the wood supply chain.

scientific reports

OPEN DNA profile database of *Koompassia malaccensis* in Malaysia and its application in forensic investigation

Chai Ting Lee<sup>a</sup>, Chin Hong Ng<sup>b</sup>, Lee Hong Ng<sup>c</sup>, Kevin Kit Siang Ng<sup>d</sup>, Bibah Dwiary<sup>e</sup>,  
Eyan Khoo<sup>f</sup>, Soon Leong Lee<sup>g</sup>

<sup>a</sup>Forest Research Institute Malaysia, 52100 Kajang, Selangor Darul Ehsan, Malaysia  
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ABSTRACT

*Koompassia malaccensis* (Dipterocarpaceae) is a highly valued timber species in Southeast Asia. In this study, we developed a comprehensive genetic database for the important tropical timber species *Koompassia malaccensis* from Peninsular Malaysia. A total of 1418 individuals were sampled from 20 natural populations throughout Peninsular Malaysia. Four cpDNA regions were used to develop a cpDNA haplotype database, resulting in a haplotype map consisting of 23 unique haplotypes derived from 29 informative microsatellite variables. This cpDNA database can be used to trace the origin of an unknown log at the regional level. Ten SSR loci were used to develop the SSR alleles frequency database. Bayesian cluster analysis divided the population into two genetic clusters corresponding to Region A and Region B. Based on conservativeness evaluation of the SSR databases for individual identification, the conservativeness indices (CI) were adjusted to 1.000 and 1.100 for Region A and B, respectively. These databases are useful tools to complement existing timber tracking systems in ensuring only legally sourced timbers are allowed to enter the wood supply chain.

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ABSTRACT

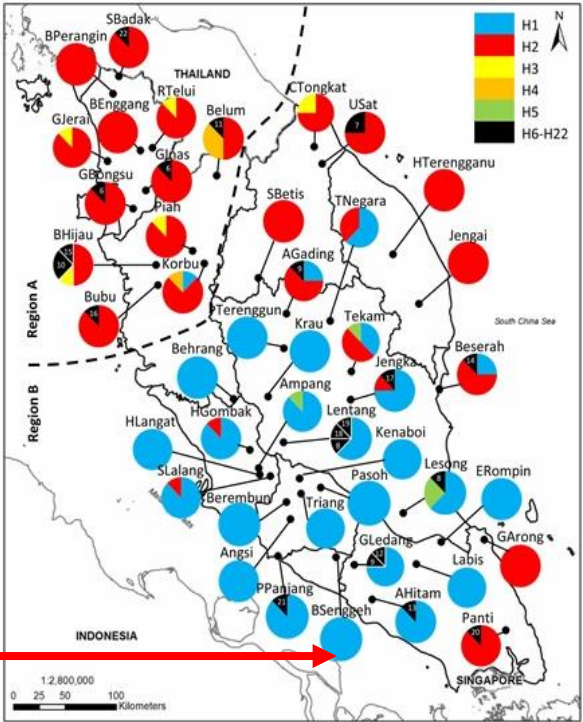
*Koompassia malaccensis* (Dipterocarpaceae) is a highly valued timber species in Southeast Asia. In this study, we developed a comprehensive genetic database for the important tropical timber species *Koompassia malaccensis* from Peninsular Malaysia. A total of 1418 individuals were sampled from 20 natural populations throughout Peninsular Malaysia. Four cpDNA regions were used to develop a cpDNA haplotype database, resulting in a haplotype map consisting of 23 unique haplotypes derived from 29 informative microsatellite variables. This cpDNA database can be used to trace the origin of an unknown log at the regional level. Ten SSR loci were used to develop the SSR alleles frequency database. Bayesian cluster analysis divided the population into two genetic clusters corresponding to Region A and Region B. Based on conservativeness evaluation of the SSR databases for individual identification, the conservativeness indices (CI) were adjusted to 1.000 and 1.100 for Region A and B, respectively. These databases are useful tools to complement existing timber tracking systems in ensuring only legally sourced timbers are allowed to enter the wood supply chain.



## Population identification via assignment test



99.873%



<i>Rubroshorea leprosula</i> (Meranti Tembaga)	
Population	%
1) AGading	32.40
2) AHitam	57.10
3) Ampang	50.00
4) Angsi	34.40
5) Behrang	52.90
6) Belum	51.30
7) B'Enggang	65.70
8) Berembun	55.60
9) Beserah	53.30
10) BHijau	50.00
11) B'Perangin	73.60
12) B'Senggeh	53.30
13) Bubu	38.70
14) C'Tongkat	81.30
15) E'Rompin	65.00
16) G'Arong	65.70
17) G'Bongsu	30.00
18) G'inas	44.40
19) G'Jeral	62.90
20) G'Ledang	26.70
21) H'Gombak	50.00
22) H'Langat	41.40
23) H'Terengganu	37.50
24) Jengai	18.20
25) Jengka	35.30
26) Kenaboi	14.30
27) Korbu	48.60
28) Krau	20.00
29) Labis	33.30
30) Lentang	63.60
31) Lesong	27.30
32) Panti	48.40
33) Pasoh	25.60
34) Piah	45.50
35) P'Ppanjang	46.90
36) R'Telui	57.10
37) S'Badak	70.60
38) S'Betis	47.10
39) S'Lalang	39.10
40) Tekam	33.30
41) Terenggun	60.00
42) T'Negara	30.80
43) Triang	33.30
44) U'Sat	46.20

## Individual identification

		Allele size - frequency													
lpa013	lpa018	lpa022	lpa030	lpa037	lpa049	lpa052	lpa068	lpa099	lpa149	lpaT01	lpaT31	lpaT32	lpaT38		
152 — 0.0299	120 — 0.0008	107 — 0.0033	271 — 0.0041	310 — 0.0008	252 — 0.0008	202 — 0.0025	151 — 0.0008	196 — 0.0099	099 — 0.0017	333 — 0.0207	272 — 0.0008	321 — 0.0008	245 — 0.0008		
154 — 0.3027	122 — 0.2682	111 — 0.0008	273 — 0.0083	312 — 0.1242	254 — 0.0008	210 — 0.0108	155 — 0.0158	198 — 0.0083	112 — 0.0762	338 — 0.0008	274 — 0.0008	324 — 0.0017	251 — 0.0066		
155 — 0.0100	124 — 0.0008	113 — 0.4785	274 — 0.0008	314 — 0.0762	260 — 0.0017	212 — 0.2492	157 — 0.0008	200 — 0.4313	114 — 0.5861	340 — 0.0025	277 — 0.0505	331 — 0.0836	254 — 0.0017		
156 — 0.4934	126 — 0.3584	115 — 0.3700	277 — 0.0356	316 — 0.0017	263 — 0.8104	214 — 0.0397	158 — 0.0075	202 — 0.2086	116 — 0.2997	343 — 0.1407	279 — 0.0008	334 — 0.4553	256 — 0.0033		
158 — 0.1177	130 — 0.0050	117 — 0.1258	278 — 0.0298	318 — 0.0033	265 — 0.1730	216 — 0.0017	164 — 0.5083	204 — 0.0041	118 — 0.0141	347 — 0.0075	282 — 0.0050	337 — 0.3179	258 — 0.0041		
160 — 0.0249	132 — 0.2765	119 — 0.0215	281 — 0.1200	320 — 0.0687	267 — 0.0008	218 — 0.0853	166 — 0.2371	206 — 0.0099	120 — 0.0033	348 — 0.0017	285 — 0.7243	340 — 0.0008	261 — 0.2219		
162 — 0.0191	134 — 0.0654		282 — 0.0323	322 — 0.1209	269 — 0.0124	220 — 0.0364	167 — 0.0506	207 — 0.0025	122 — 0.0033	352 — 0.7310	288 — 0.1863	343 — 0.0894	264 — 0.6722		
164 — 0.0025	136 — 0.0083		284 — 0.4586	324 — 0.0679		222 — 0.0174	168 — 0.0713	212 — 0.2988	124 — 0.0017	357 — 0.0149	291 — 0.0033	346 — 0.0364	267 — 0.0861		
	138 — 0.0166		286 — 0.1374	326 — 0.0025		225 — 0.0058	169 — 0.0240	214 — 0.0265	129 — 0.0008	361 — 0.0803	294 — 0.0008	349 — 0.0132	270 — 0.0033		
			288 — 0.0828	330 — 0.1523		227 — 0.0017	170 — 0.0597		133 — 0.0017		297 — 0.0248	352 — 0.0008			
						229 — 0.1126	174 — 0.0041		135 — 0.0083		300 — 0.0025				
						231 — 0.1647	175 — 0.0017		137 — 0.0008						
						233 — 0.1325	176 — 0.0149		139 — 0.0017						
						234 — 0.0224	178 — 0.0025		141 — 0.0008						
						235 — 0.0935									
						237 — 0.0199									
						239 — 0.0017									
						249 — 0.0008									
						251 — 0.0017									

Homozygote: 
$$P(A_i A_i | A_i A_i) = \frac{[\theta + (1 - \theta)p_i]}{f + (1-f)[\theta + (1 - \theta)p_i]} f^2 + 2f(1-f) \frac{[2\theta + (1 - \theta)p_i]}{(1 + \theta)}$$

+ (1-f)<sup>2</sup> 
$$\frac{[2\theta + (1 - \theta)p_i][3\theta + (1 - \theta)p_i]}{(1 + \theta)(1 + 2\theta)}$$

Heterozygote: 
$$P(A_i A_j | A_i A_j) = 2(1-f) \frac{[\theta + (1 - \theta)p_i][\theta + (1 - \theta)p_j]}{(1 + \theta)(1 + 2\theta)}$$

**Profile frequency = 1.11 x 10<sup>-8</sup>**

**Random match probability = 9.02 x 10<sup>7</sup>**



**Due to random match = 1 in 9.02 x 10<sup>7</sup> (90 million)**

Likelihood ratio: The DNA evidence indicates that it is **9.02 x 10<sup>7</sup> times more likely** that the log originated from **this specific stump** than from **any other unknown stump**



STANDARD OPERATING PROCEDURE (SOP)

## FORENSIC DNA TESTING ON PLANT SPECIES IDENTIFICATION AND WOOD TRACKING



Genetics Laboratory,  
Forest Research Institute Malaysia (FRIM)  
Version 1.3 (1 June 2018)

### SOP1: SAMPLE COLLECTION IN THE FIELD



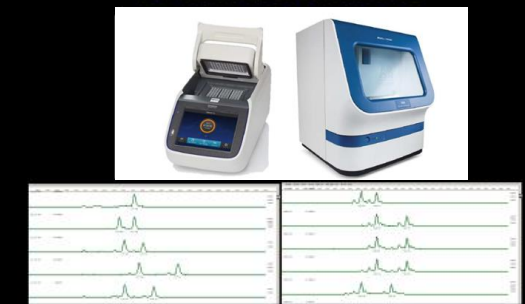
### SOP2: DNA ISOLATION AND PURIFICATION FROM CAMBIUM & WOOD



### SOP3: DNA SEQUENCING FOR SPECIES AND POPULATION IDENTIFICATION



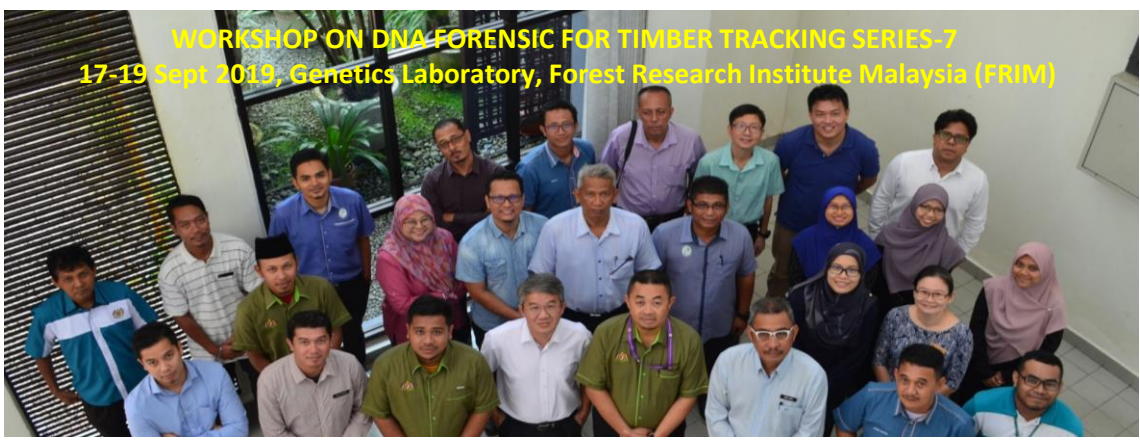
### SOP4: SHORT TANDEM REPEAT (STR) GENOTYPING FOR POPULATION AND INDIVIDUAL IDENTIFICATION



# Training to enforcement officials



# Training to enforcement officials

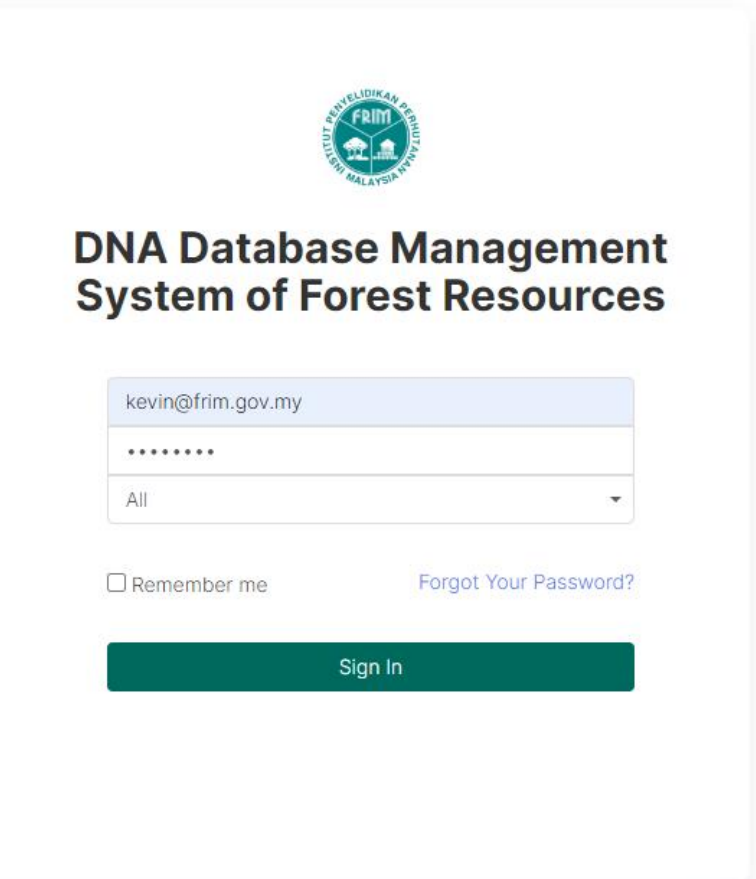



# Training to enforcement officials



# DNA Database Management System

URL: <https://DNA.frim.gov.my>





## DNA Database Management System of Forest Resources

kevin@frim.gov.my

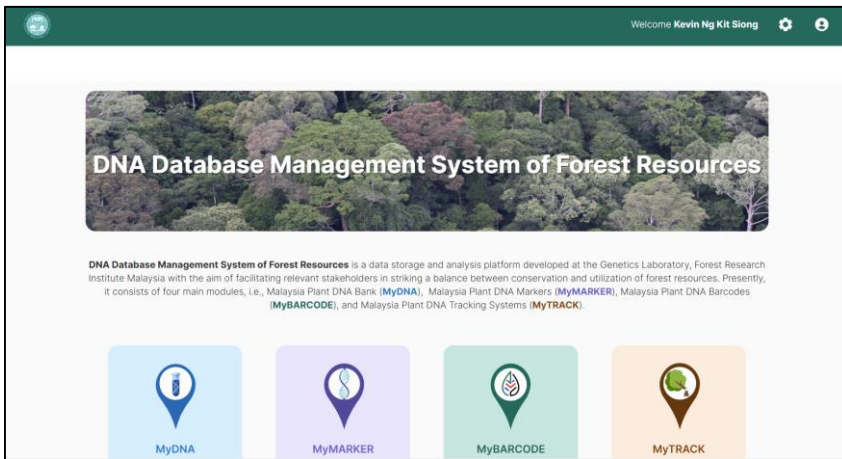
.....

All

Remember me [Forgot Your Password?](#)

**Sign In**

# DNA Database Management System

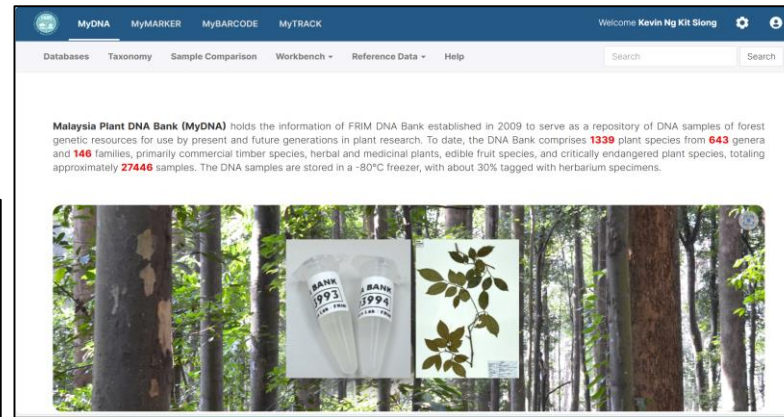


Welcome Kevin Ng Kit Siong

## DNA Database Management System of Forest Resources

DNA Database Management System of Forest Resources is a data storage and analysis platform developed at the Genetics Laboratory, Forest Research Institute Malaysia with the aim of facilitating relevant stakeholders in striking a balance between conservation and utilization of forest resources. Presently, it consists of four main modules, i.e., Malaysia Plant DNA Bank (**MyDNA**), Malaysia Plant DNA Markers (**MyMARKER**), Malaysia Plant DNA Barcodes (**MyBARCODE**), and Malaysia Plant DNA Tracking Systems (**MyTRACK**).

- MyDNA
- MyMARKER
- MyBARCODE
- MyTRACK

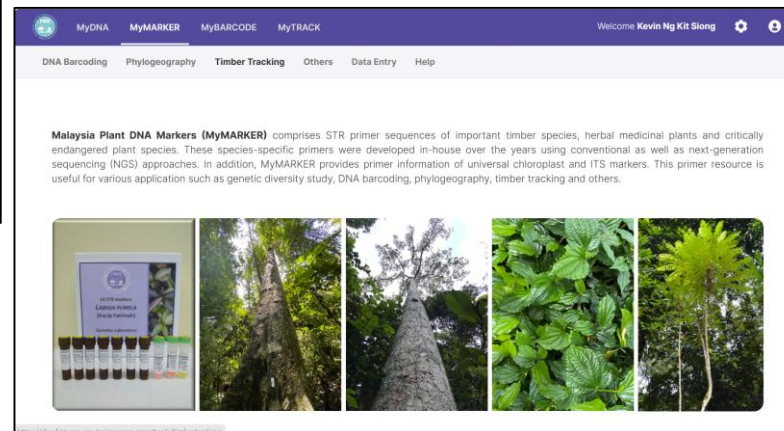



Welcome Kevin Ng Kit Siong

Databases Taxonomy Sample Comparison Workbench Reference Data Help

Search

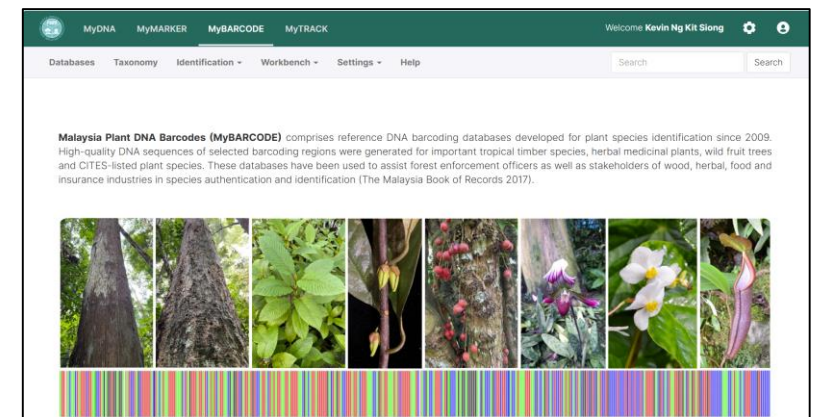

**Malaysia Plant DNA Bank (MyDNA)** holds the information of FRIM DNA Bank established in 2009 to serve as a repository of DNA samples of forest genetic resources for use by present and future generations in plant research. To date, the DNA Bank comprises **1339** plant species from **643** genera and **146** families, primarily commercial timber species, herbal and medicinal plants, edible fruit species, and critically endangered plant species, totaling approximately **27446** samples. The DNA samples are stored in a -80°C freezer, with about 30% tagged with herbarium specimens.



Welcome Kevin Ng Kit Siong

DNA Barcoding Phylogeography Timber Tracking Others Data Entry Help

**Malaysia Plant DNA Markers (MyMARKER)** comprises STR primer sequences of important timber species, herbal medicinal plants and critically endangered plant species. These species-specific primers were developed in-house over the years using conventional as well as next-generation sequencing (NGS) approaches. In addition, MyMARKER provides primer information of universal chloroplast and ITS markers. This primer resource is useful for various application such as genetic diversity study, DNA barcoding, phylogeography, timber tracking and others.

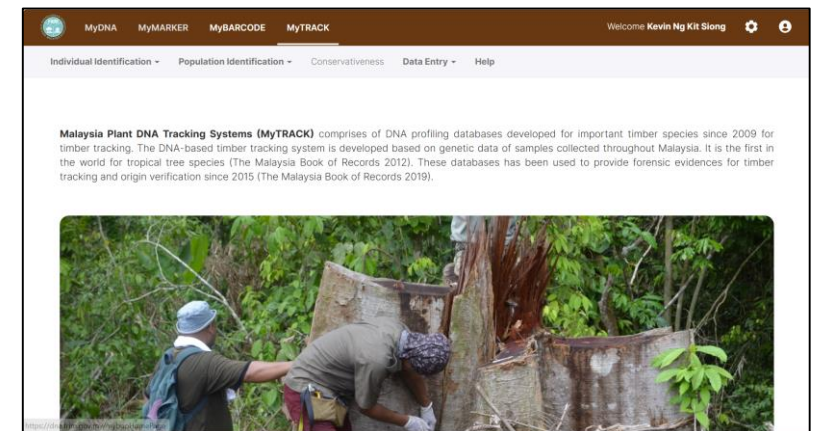



Welcome Kevin Ng Kit Siong

Databases Taxonomy Identification Workbench Settings Help

Search


**Malaysia Plant DNA Barcodes (MyBARCODE)** comprises reference DNA barcoding databases developed for plant species identification since 2009. High-quality DNA sequences of selected barcoding regions were generated for important tropical timber species, herbal medicinal plants, wild fruit trees and CITES-listed plant species. These databases have been used to assist forest enforcement officers as well as stakeholders of wood, herbal, food and insurance industries in species authentication and identification (The Malaysia Book of Records 2017).



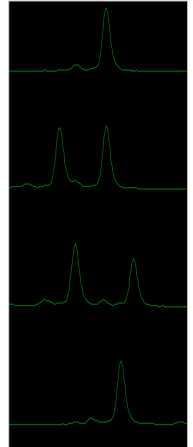
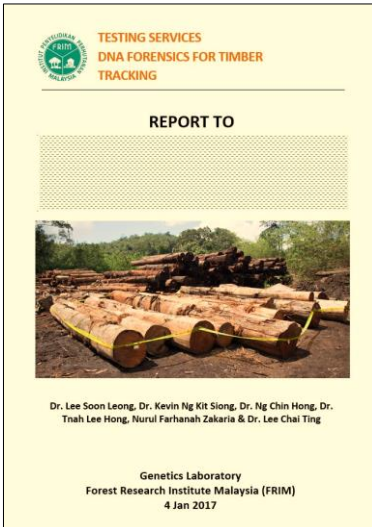
Welcome Kevin Ng Kit Siong

Individual Identification Population Identification Conservativeness Data Entry Help

**Malaysia Plant DNA Tracking Systems (MyTRACK)** comprises of DNA profiling databases developed for important timber species since 2009 for timber tracking. The DNA-based timber tracking system is developed based on genetic data of samples collected throughout Malaysia. It is the first in the world for tropical tree species (The Malaysia Book of Records 2012). These databases has been used to provide forensic evidences for timber tracking and origin verification since 2015 (The Malaysia Book of Records 2019).



To provide forensic evidences for the conviction of illegal loggers

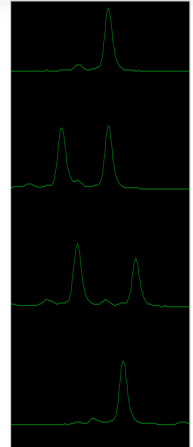


Log

100% Match

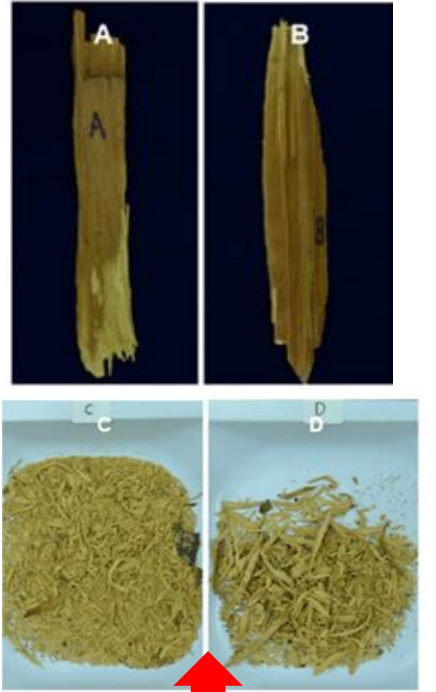
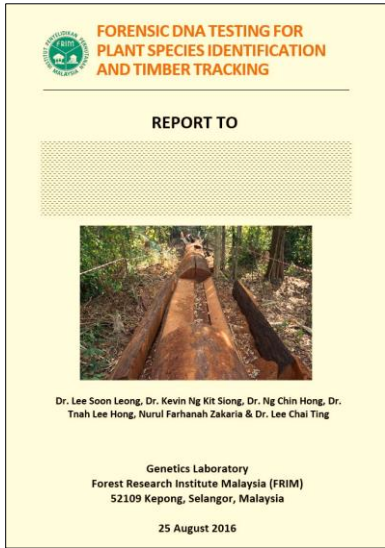
Using Individual Identification Database:

- Profile frequency =  $7.95 \times 10^{-11}$
- Random match probability = 1 in  $1.26 \times 10^{10}$
- Likelihood ratio =  $1.26 \times 10^{10}$  (1.26 billion)

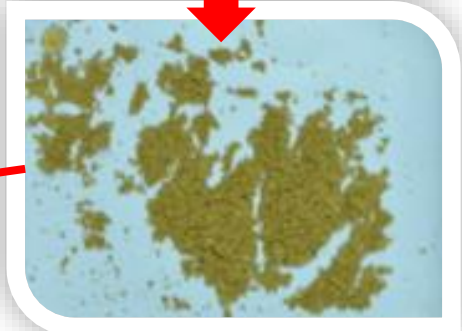


Stump

To provide forensic evidences for the conviction of illegal loggers

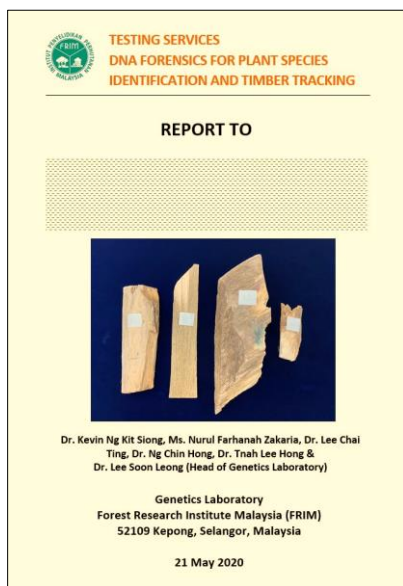
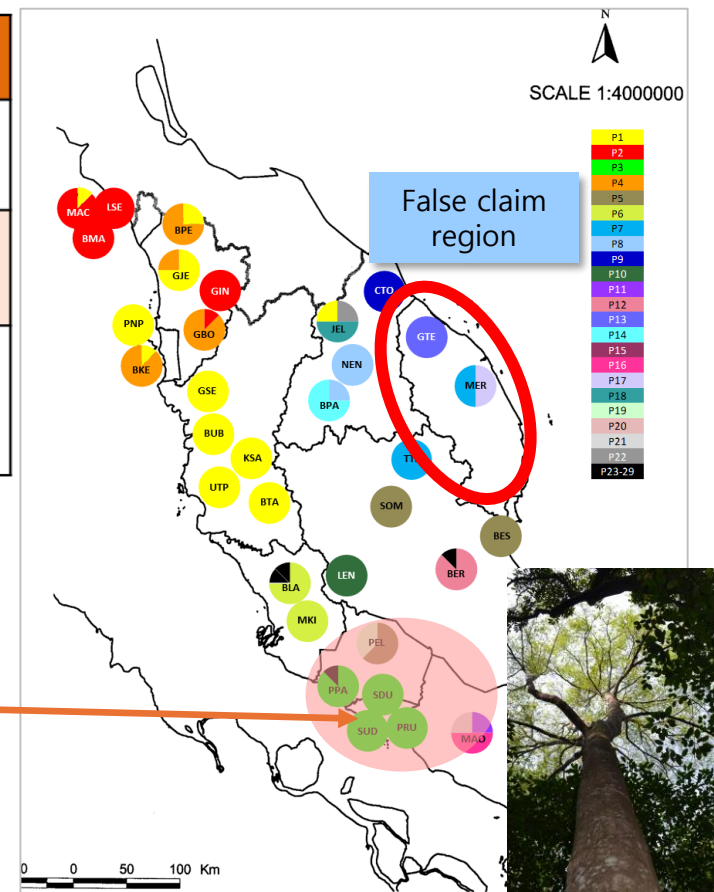


100% Match

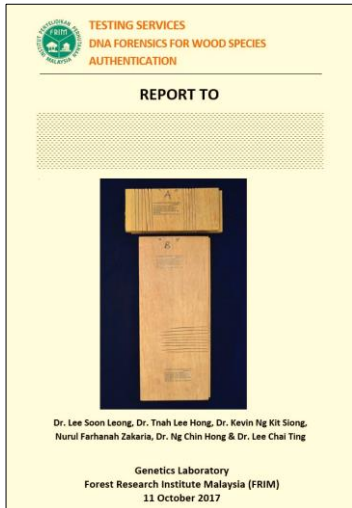


## To identify geographical origin of Agarwood

Sample ID	STR DNA profiles	Assigned population	Probability of assignment
K1	083/087; 096/104; 166/166; 103/105; 186/186; 099/099; 106/106	Paya Rumput (Melaka)	98.772%
K2	083/119; 098/104; 166/166; 103/105; 157/157; 188/188; 099/099; 108/110; 136/136	Panti (Johor)	55.805%
K4	097/100; 096/096; 170/178; 103/105; 157/157; 188/188; 099/099; 187/187; 219/219; 283/289; 112/116; 136/136	Som (Pahang)	68.667%



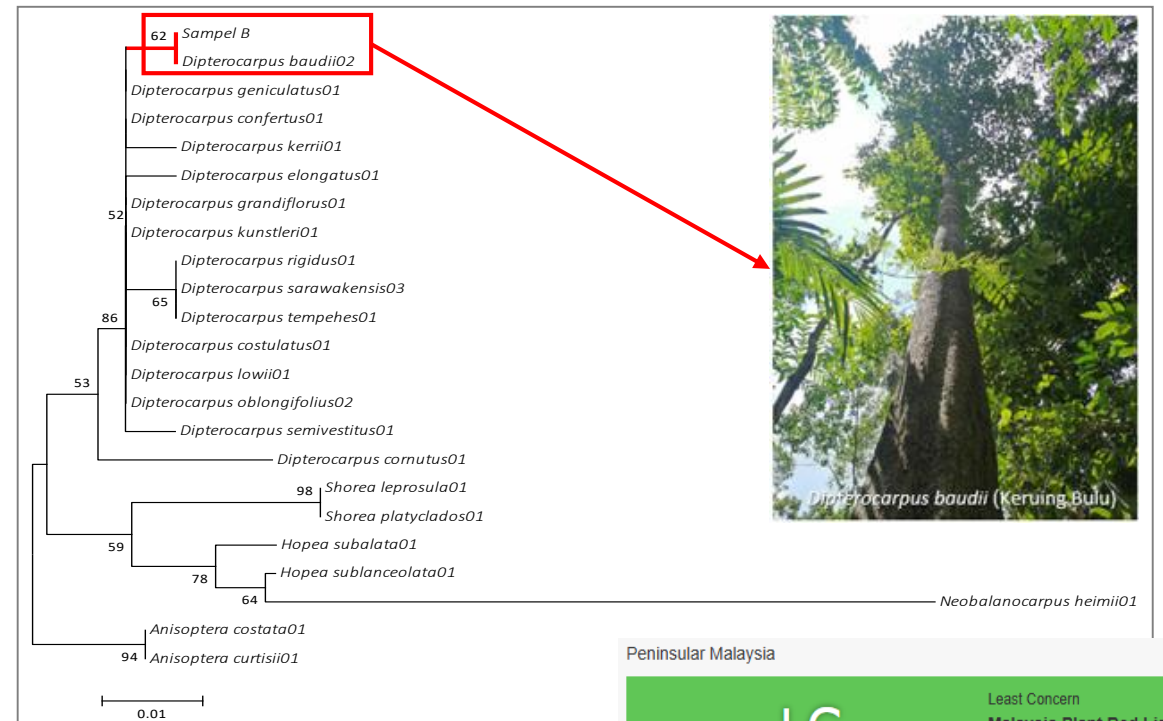
## Wood industry: Wood product identification prior export to international market



- Several species within the genus *Dipterocarpus* are listed as threatened by the IUCN Red List.



Query ID	Subject ID	% identity
Sample B	<i>Dipterocarpus baudii</i>	100.00
Sample B	<i>Dipterocarpus grandiflorus</i>	99.56
Sample B	<i>Dipterocarpus geniculatus</i>	99.56
Sample B	<i>Dipterocarpus oblongifolius</i>	99.12



Peninsular Malaysia

**LC** Least Concern  
Malaysia Plant Red List  
2021

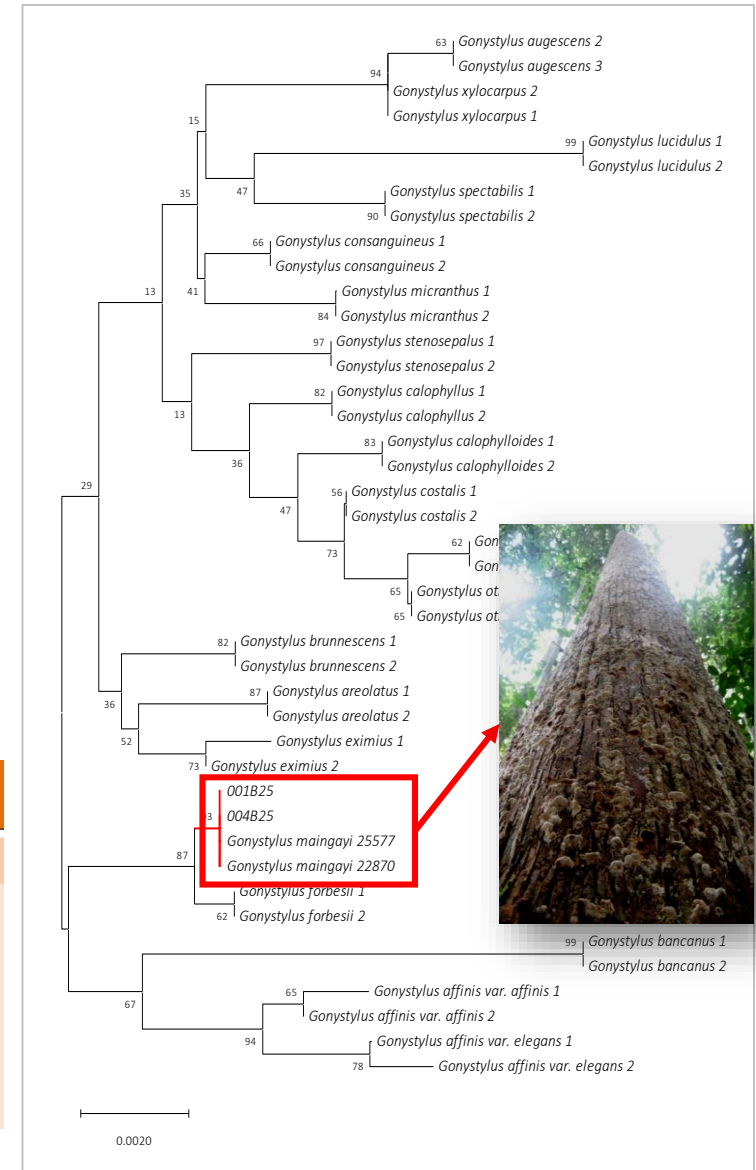
## Wood industry: Wood product identification prior export to international market



- *Gonystylus* species, commonly known as ramin, are listed in CITES Appendix II.
- International trade in Ramin is regulated and requires permits.



Query ID	Subject ID	% identity
001B25	<i>Gonystylus maingayi</i>	100.00
001B25	<i>Gonystylus forbesii</i>	98.91
001B25	<i>Gonystylus stenosepalus</i>	98.32
001B25	<i>Gonystylus eximius</i>	98.08
001B25	<i>Gonystylus brunnescens</i>	97.96
001B25	<i>Gonystylus areolatus</i>	97.96
001B25	<i>Gonystylus calophylloides</i>	97.84



## Wood industry: *Aquilaria* species identification & authentication



CONFIDENTIAL Service Code: 11 of 5

**IDENTIFICATION AND AUTHENTICATION OF PLANT SPECIES WITH DNA BARCODES**  
 GENETICS LABORATORY, FOREST RESEARCH INSTITUTE MALAYSIA (FRIM),  
 52109 KEPONG, SELANGOR, MALAYSIA.

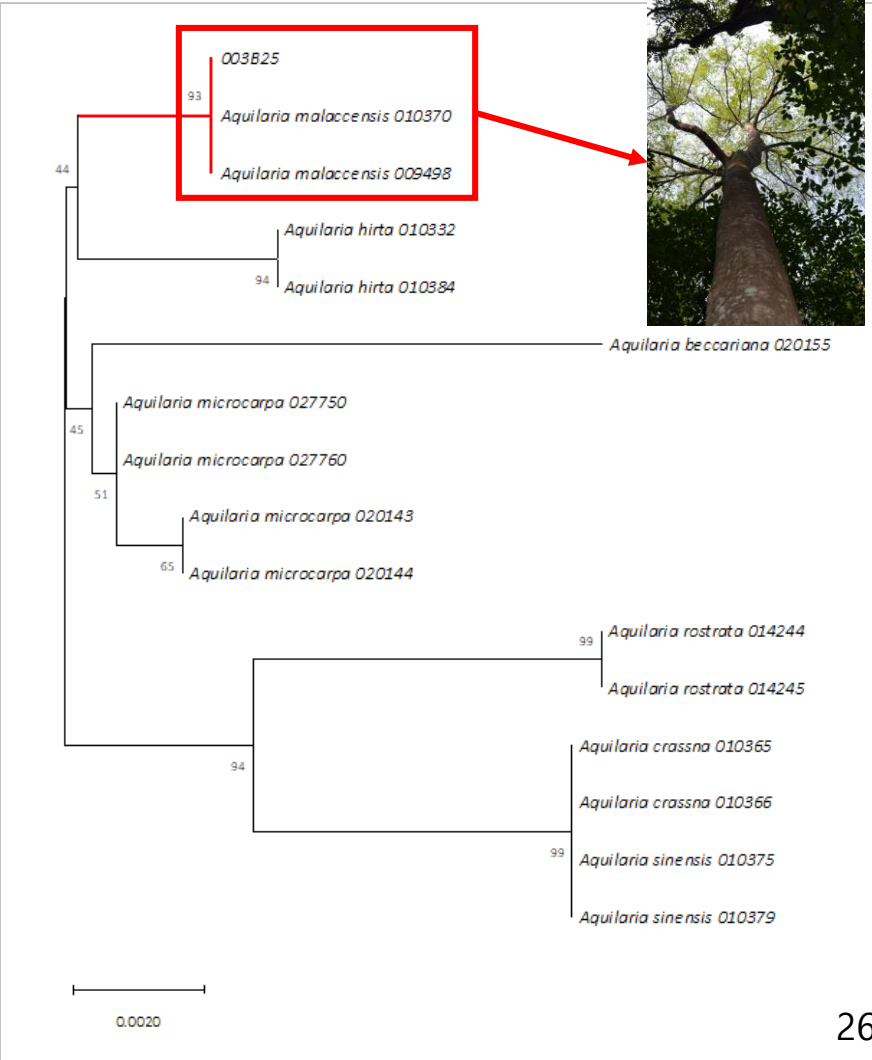
**TEST REPORT TO**

PREPARED BY: DR. TNAM LEE HONG, Research Officer, Date: 19<sup>th</sup> March 2025

APPROVED BY: DR. KEVIN NG KIT SHONG, Head of Genetics Laboratory, Date: 19<sup>th</sup> March 2025



Query ID	Subject ID	% identity	Alignment length	Mismatches	E-value	Bit score
003B25	<i>Aquilaria_malaccensis_010370</i>	100.000	996	0	0	1829
003B25	<i>Aquilaria_microcarpa_027760</i>	99.297	996	7	0	1805
003B25	<i>Aquilaria_hirta_010384</i>	99.197	996	8	0	1801
003B25	<i>Aquilaria_microcarpa_020144</i>	99.197	996	8	0	1799
003B25	<i>Aquilaria_beccariana_020155</i>	98.695	996	13	0	1773
003B25	<i>Aquilaria_sinensis_010379</i>	98.594	996	13	0	1766
003B25	<i>Aquilaria_rostrata_014245</i>	98.594	996	13	0	1766
003B25	<i>Aquilaria_crassna_010366</i>	98.594	996	13	0	1766



# Testify in the court

Defendant: Dr  
**IN THE STATE COURTS OF THE**  
 [Redacted]  
 Between  
 [Redacted]  
 And  
 [Redacted]

**AFFIDAVIT OF EVIDENCE**

I, **DR LEE SOON LEONG** (Malaysian citizen, residing at [Redacted] Kepong, Selangor, Malaysia, do affirm and swear that:

- I am the head of Genetics Laboratory, Research Institute Malaysia ("FRIM") on the behalf of the Defendant.
- Insofar as the matters deposed to hereon and otherwise suggest, they are true and correct, and are within my personal knowledge, the information and belief.
- I have been appointed by the Defendant to identify the species of timber in respect of the Defendant.
- Copies of the following are exhibited to me:

- my Report to [Redacted] for DNA Forensics for Wood Species dated 05.11.2015 (at pages 4 to 10);
- my Report to [Redacted] for DNA Forensics for Wood Species dated 03.02.2017 (at pages 11 to 16);
- my Report to [Redacted] for DNA Forensics for Wood Species dated 14.04.2017 (at pages 17 to 22); and
- my curriculum vitae (at pages 23 to 30).

5. In preparing my Reports and making this affidavit, my attention has been drawn to my obligation as an Expert Witness by the Defendant's solicitors. I confirm that the Reports are mine. I accept full responsibility for the same and in giving these Reports and making this affidavit, I accept that my duty is to the Honourable Court and overrides any obligation to the Defendant.

Affirmed by the abovenamed )  
**DR LEE SOON LEONG** )  
 at Malaysia on this - **4 MAY 2017** )  
 day of May 2017 )

Signature: [Handwritten Signature]  
**DR LEE SOON LEONG**

Before me  
 Signature: [Handwritten Signature]  
 A Notary Public

**PALAKRISHNAN A/L R. SUPPIAH**  
 NOTARY PUBLIC  
 Lot G-AB, Ground Floor, Sam Mansion  
 Jalan Akar / Jalan Tuba  
 Off Jalan Kampung Attap  
 50460 Kuala Lumpur  
 Tel: 03-22607624/5 Fax: 03-2260 6430  
 Email: palalaw49@gmail.com

**NOTARY PUBLIC**  
 PALAKRISHNAN  
 A/L R. SUPPIAH  
 PN/MKL/HQ/25/10/2007  
 Expiry Date: 30-10-2017  
 W.P. KUALA LUMPUR MALAYSIA


- 4 MAY 2017 This Affidavit on filed on behalf of the Defendant.



## MS ISO/IEC 17025: 2017

Schedule

Issue date: 4 Disember 2024  
Valid until: 20 June 2028



NO: SMM 558  
Issue 2, 4 December 2024 replacement of SMM 558 dated 3 April 2023

Page: 5 of 6


GENETICS LABORATORY (MG)

SCOPE OF TESTING: MOLECULAR

Materials/ Products Tested	Type of Test/ Properties Measured/ Range of Measurement	Standard Test Methods/ Equipment/Techniques
Plant Tissues	Identification and authentication of plant species with DNA barcodes	In-house method AK2-02 based on DNA barcoding database and DNA sequencing method published in journals:  1) Food Control, issue 95, pp.318-326, 2019 (DNA barcode database of common herbal plants in the tropics: a resource for herbal product authentication);  2) Forensic Science International: Genetics, issue 23, pp. 197-209, 2016 (Forensic timber identification: a case study of a CITES listed species, <i>Gonystylus bancanus</i> [Thymelaeaceae]);  3) Forensic Science International: Genetics, issue 57, pp. 102658, 2022 (DNA databases of a CITES listed species <i>Aquilaria malaccensis</i> [Thymelaeaceae] as the tracking tools for forensic identification and chain of custody certification); &  4) 3 Biotech, 14: 7, 2024 (DNA barcode identification of cultivated and wild tropical fruit species).

Schedule

Issue date: 4 Disember 2024  
Valid until: 20 June 2028



NO: SMM 558  
Issue 2, 4 December 2024 replacement of SMM 558 dated 3 April 2023

Page: 6 of 6

GENETICS LABORATORY (MG)

SCOPE OF TESTING: MOLECULAR

Materials/ Products Tested	Type of Test/ Properties Measured/ Range of Measurement	Standard Test Methods/ Equipment/Techniques
Plant Tissues ( <i>Continue</i> )	Wood tracking of plant species with forensic DNA	In-house method AK2-03 based on DNA profiling database and STR genotyping method published in journals:  1) Forest Ecology and Management, issue 259, pp. 1436-1446, 2010 (Forensic DNA profiling of tropical timber species in Peninsular Malaysia);  2) Forensic Science International: Genetics, issue 23, pp. 197-209, 2016 (Forensic timber identification: a case study of a CITES listed species, <i>Gonystylus bancanus</i> [Thymelaeaceae]);  3) PLoS ONE, issue 12, pp. e0176158, 2017 (Geographic origin and individual assignment of <i>Shorea platyclados</i> [Dipterocarpaceae] for forensic identification);  4) Forensic Science International: Genetics, issue 44, 102188, 2020 (A geographical traceability system for Merbau [ <i>Intsia palembanica</i> Miq], an important timber species from Peninsular Malaysia);  5) Forensic Science International: Genetics, issue 57, pp. 102658, 2022 (DNA databases of a CITES listed species <i>Aquilaria malaccensis</i> [Thymelaeaceae] as the tracking tools for forensic identification and chain of custody certification); &  6) Scientific Reports, issue 12, pp. 9546, 2022 (DNA databases of an important tropical timber tree species <i>Shorea leprosula</i> [Dipterocarpaceae] for forensic timber identification).

Scan this QR Code or visit [www.isir.gov.my/publications/index.html](http://www.isir.gov.my/publications/index.html) for the current scope of accreditation

## Wildlife forensic testing laboratory



[https://cites.org/sites/default/files/EST/CITES\\_Directory\\_of\\_forensic\\_labs\\_rev\\_January\\_2025.pdf](https://cites.org/sites/default/files/EST/CITES_Directory_of_forensic_labs_rev_January_2025.pdf)

Laboratory name and country	QA standard	Sample types analyzed	Contact name / email
<b>ASIA</b>			
Centre for Wildlife Forensics Singapore, Singapore	ISO17025	Terrestrial animal, Aquatic animal, Elephant ivory, Pangolin	Dr Anna Wong <a href="mailto:CITES@nparks.gov.sg">CITES@nparks.gov.sg</a> , <a href="mailto:anna_wong@nparks.gov.sg">anna_wong@nparks.gov.sg</a>  Dr Charlene Judith Fernandez <a href="mailto:Charlene_fernandez@nparks.gov.sg">Charlene_fernandez@nparks.gov.sg</a>
National Wildlife Forensic Laboratory Kuala Lumpur, Malaysia	ISO17025	Terrestrial animal, Aquatic animal, Rhino horn, Elephant ivory, Pangolin	Ybhg. Dato' Abdul Kadir Bin Abu <a href="mailto:kadir@wildlife.gov.my">kadir@wildlife.gov.my</a>
Forest Research Institute Malaysia (FRIM) Kepong, Malaysia	ISO9001 : 2015 MS ISO / IEC 17025 : 2017	Plant species identification and wood traceability	Dr. Lee Soon Leong <a href="mailto:leesl@frim.gov.my">leesl@frim.gov.my</a>
Research Institute of Wood Industry – Chinese Academy of Forestry Beijing, China	ISO17028	Timber and timber products	Dr. Feng Fu <a href="mailto:feng@caf.ac.cn">feng@caf.ac.cn</a> Dr. Yafang Yin <a href="mailto:yafang@caf.ac.cn">yafang@caf.ac.cn</a>
<b>EUROPE</b>			
Criminalistic Service, Guardia Civil, Madrid, Spain	ISO17025	Terrestrial animal and birds (Individual ID, parentage testing in some species; Species Identification), Aquatic animal and Plant (Specie ID, Microorganisms)	David Parra Pecharromán <a href="mailto:crim-medioambiente@guardiacivil.org">crim-medioambiente@guardiacivil.org</a>
Genomia s.r.o Plzeň, Czech Republic	ISO17025	Birds (only parentage testing of certain species)	Markéta Dajbychová <a href="mailto:marketa.dajbychova@genomia.cz">marketa.dajbychova@genomia.cz</a>
Institute of Forensic Medicine Zurich, Switzerland	ISO17025	Terrestrial animal, Aquatic animal, Elephant ivory	Nadja Morf <a href="mailto:Nadja.Morf@irm.uzh.ch">Nadja.Morf@irm.uzh.ch</a>

# Thank you

