

## REFERENCES

- Adams KL, Wendel JF (2005) Polyploid and genome evolution in plants. *Curr Opin Plant Biol* 8: 135-141.
- Adams RP, Pandey RN, Leverenz JW, Dignard N, Hoegh K, Thorfinnsson T (2003) Pan-Arctic variation in *Juniperus communis*: historical biogeography based on DNA fingerprinting. *Biochem Syst Ecol* 31: 181-192.
- Alvarez I, Wendel JF (2003) Ribosomal ITS sequences and plant phylogenetic inference. *Mol Phylogenet Evol* 29: 417-434.
- Anamthawat-Jónsson K (2001) Molecular cytogenetics of introgressive hybridization in plants. *Methods Cell Sci* 23: 134-148.
- Anamthawat-Jónsson K (2002) Hybrid introgression in *Betula*. In: *Plant Genome: Biodiversity and Evolution*, vol. 1 (Sharma AK and Sharma A, eds.) SP Publishers, Enfield, New Hampshire.
- Anamthawat-Jónsson K (2003a) Hybrid introgression in *Betula*. In: *Plant Genome: Biodiversity and Evolution*. Volume 1: Phanerogams (AK Sharma and A Sharma, eds). Science Publishers, Inc: Enfield (NH), USA; Plymouth, UK, pp. 249-265.
- Anamthawat-Jónsson K (2003b) Preparation of chromosomes from plant leaf meristems for karyotype analysis and *in situ* hybridisation. *Methods Cell Sci* 25: 91-95.
- Anamthawat-Jónsson K, Heslop-Harrison JS (1990) Centromeres, telomeres and chromatin in the interphase nucleus of cereals. *Caryologia* 43: 205-213.
- Anamthawat-Jónsson K, Heslop-Harrison JS (1995) Molecular cytogenetics of Icelandic birch species: physical mapping by *in situ* hybridisation and rDNA polymorphism. *Can J Forest Res* 25: 101-108.
- Anamthawat-Jónsson K, Heslop-Harrison JS, Schwazacher T (1996) Genomic *in situ* hybridization for whole chromosome and genome analysis. In: Clark M (ed) *In Situ Hybridization, Laboratory Companion*. Chapman & Hall, Weinheim, Germany. Chapter 1, pp. 1-23.

- Ananthawat-Jónsson K, Schwarzacher T, Leitch AR, Bennett MD, Heslop-Harrison JS (1990) Discrimination between closely related *Triticeae* species using genomic DNA as a probe. *Theor Appl Genet* 79: 721-728.
- Barnett EC (1944) Keys to the species groups of *Quercus*, *Lithocarpus* and *Castanopsis* of eastern Asia with notes on their distribution. *Trans Bot Soc Edinb* 34: 259-204.
- Bellarosa R, Simeone MC, Papini A, Schirone B (2005) Utility of ITS sequence data for phylogenetic reconstruction of Italian *Quercus* spp. *Mol Phylogenet Evol* 34: 355-370.
- Berg EE, Hamrick JL (1995) Fine-scale genetic structure of a Turkey oak forest. *Evolution* 49: 110-120.
- Blakesley D, Pakkad G, James C, torre F, Elliott S (2004) Genetic diversity of *Castanopsis acuminatissima* (Bl.) A. DC. in northern Thailand and the selection of seed trees for forest restoration. *New Forests* 27: 89-100.
- Botstein D, White RL, Skolnick M, Davis RW (1980) Construction of a genetic linkage map in man using restriction fragment length polymorphism. *Am J Hum Genet* 32: 314-331
- Briggs D, Walters SM (1997) *Plant Variation and Evolution*, 3rd edition. Cambridge University Press, Cambridge. ISBN 0521 45295 4
- Brochmann C, Breyting AK, Alsos IG, Borgen L, Grundt HH, Scheen A-C, Elven R (2004) Polyploidy in arctic plants. *Biol J Linn Soc* 82: 521-536.
- Brown GR, Carlson JE (1997) Molecular cytopgenetics of the genes encoding 18S-5.8S-26S rRNA and 5S rRNA in two species of spruce (*Picea*). *Theor Appl Genet* 95: 1-9
- Busch W, Hermann RG, Houben A, Martin R (1996) Efficient preparation of plant metaphase spreads. *Plant Mol Biol Rep* 14: 149-155.
- Canon CH, Manos PS (2003) Phylogeography of the Southeast Asian stone oaks (*Lithocarpus*). *J Biogeogr* 30: 211-226.
- Chengjiu H, Yongtian Z, Bartholomew B (1999) Fagaceae. *Flora of china* 4: 314-400.

- Chung MY, Kim K-J, Pak J-H, Park C-W, Sun B-Y, Myers ER, Chung MG (2005) Inferring establishment histories in populations of *Quercus dentate* (Fagaceae) from the analysis of spatial genetic structure. *Plant Syst Evol* 250: 231-242.
- Chung MY, Nason J, Chung MG, Kim K-J, Park C-W, Sun B-Y, Pak J-H (2002) Landscape-level spatial genetic structure in *Quercus acutissima* (Fagaceae). *Am J Bot* 89: 1229-1236.
- Creighton HB, McClintock B (1931) A correlation of cytological and genetical crossing-over in *Zea Mays*. *Proc Natl Acad Sci USA* 17: 492-497.
- Csaikl UM, Glaz I, Baliuckas V, Petit RJ, Jensen JS (2002) Chloroplast DNA variation of white oak in the Baltic countries and Poland. *Forest Ecology and Management* 156: 211-222.
- D'Emerico S, Bianco P, Medagli P, Schirone B (1995) Karyotype Analysis in *Quercus* spp. (Fagaceae). *Silvae Genetica* 44: 66-70.
- Darlington CD, Wylie AP (1955) *Chromosome Atlas of Flowering Plants*. George Allen and Unwin, London.
- Davis MB, Shaw RG (2001) Range shifts and adaptive responses to Quaternary climate change. *Science* 292: 673-679.
- Denk T, Grimm G, Stögerer K, Langer M, Hemleben V (2002) The evolutionary history of *Fagus* in western Eurasia: evidence from genes, morphology and the fossil record. *Plant Syst Evol* 232: 213-236.
- Dow BD, Ashley MV (1996) Microsatellite analysis of seed dispersal and parentage of saplings in bur oak, *Quercus macrocarpa*. *Mol Ecol* 5: 615-627.
- Dumolin-Lapegue S, Demesure B, Fineschi S, Le Corre V, Petit RJ (1997) Phylogeographic structure of white oaks throughout the European continent. *Genetics* 146: 1475-1487.
- Ellstrand NC, Whitkus RW, Rieseberg LH (1996) Distribution of spontaneous plant hybrids. *Proc Natl Acad Sci USA* 93: 5090-5093.
- Faivre-Rampant P, Jeandroz S, Lefevre F, Lemoine M, Villar M, Berville A (1992) Ribosomal DNA studies in poplars: *Populus deltoides* Bartr. and Marsh., *P.*

- nigra* L., *P. trichocarpa* Torr. and Gray, *P. maximowiczii* Henry, *P. alba* L. *Genome* 35: 733-740.
- Ferris C, Oliver RP, Davy AJ, Hewitt GM (1995) Using chloroplast DNA to trace postglacial migration routes of oaks into Britain. *Mol Ecol* 4: 731-738.
- Finkeldey R (2001) Genetic variation of oaks (*Quercus* spp.) in Switzerland. *Silvae Genetica* 50: 22-30.
- Forman LL (1964) *Trigonobalanus*, a new genus of Fagaceae. *Kew Bull* 17: 381-396.
- Fossati T, Zapelli I, Bisoffi S, Micheletti A, Vietto L, Sala F, Castiglione S (2005) Genetic relationships and clonal identity in a collection of commercially relevant poplar cultivars assessed by AFLP and SSR. *Tree Genet Genomes* 1:11-20.
- Gardner S, Sidisunthorn P and Anusarnsunthorn V (2000) *A Field Guide to Forest Trees of Northern Thailand*. Kobfai Publishing Project, Bangkok. pp. 545. ISBN 974-7798-29-8
- Gerlach WL, Bedbrook JR (1979) Cloning and characterization of ribosomal genes from wheat and barley. *Nucleic Acids Res* 7: 1869-1885.
- Gerlach WL, Dyer TA (1980) Sequence organization of the repeating units in the nucleus of wheat which contain 5S rRNA genes. *Nucleic Acids Res* 8: 4851-4865.
- Gillies ACM, Cornelius JP, Newton AC, Navarro C, Hernandez M, Wilson J (1997) Genetic variation in Costa Rican populations of the tropical timber tree *Cedrela odorata* L. (Spanish cedar), assessed using RAPD. *Mol Ecol* 6: 1133-1145.
- Gomory D, Yakovlev I, Zhelev P, Jedinakova J, Paule L (2001) Genetic differentiation of oak populations within the *Quercus robur/Quercus petraea* complex in Central and Eastern Europe. *Heredity* 86: 557-563.
- Gonzalez-Rodriguez A, Arias DM, Oyama K (2005) Genetic variation and differentiation of populations within the *Quercus affinis – Quercus laurina* (Fagaceae) complex analysed with RAPD markers. *Can J Bot* 83: 155-162.
- Guo P-G, Bai G-H, Shaner GE (2003) AFLP and STS tagging of a major QTL for Fusarium head blight resistance in wheat. *Theor Appl Genet* 106: 1011-1017.

- Hamilton MB (1999) Tropical tree gene flow and seed dispersal. *Nature* 401: 129-130.
- Hamrick JL, Godt MJW, Sherman-Broyles SL (1992) Factors influencing levels of genetic diversity in woody plant species. *New Forests* 6: 95-124.
- Hardin JW (1975) Hybridization and introgression in *Quercus alba*. *J Arnold Arboret* 56: 336-363.
- Hornero J, Gallego FJ, Martinez I, Toribio M (2001) Testing the conservation of *Quercus* spp. microsatellites in the cork oak, *Q. suber* L. *Silvae Genetica* 50: 162-167.
- Huang SSF, Hwang S-Y, Lin T-P (2002) Spatial pattern of chloroplast DNA variation of *Cyclobalanopsis glauca* in Taiwan and East Asia. *Mol Ecol* 11:2349-2358.
- Hulten MA (2002) Numbers, bands and recombination of human chromosomes: Historical anecdoted from a Swedish student. *Cytogenet Genome Res* 96: 14-19.
- Hutchinson J (1964) *The genera of flowering plants (Angiospermae)*. Clarendon Press, Oxford.
- Jeandroz S, Pugin A, Berville A (1996) Cloning and analysis of a 6.8-kb rDNA intergenic spacer region of the European ash (*Fraxinus excelsior* L.). *Theor Appl Genet* 92: 1003-1008.
- Kalendar R, Grob T, Regina M, Suoniemi A, Schulman A (1999) IRAP and REMAP: two new retrotransposon-based fingerprinting techniques. *Theor Appl Genet* 98: 704-711.
- Kanno M, Yokoyama J, Suyama Y, Ohyama M, Itoh T, Suzuki M (2004) Geographical distribution of two haplotypes of chloroplast DNA in four oak species (*Quercus*) in Japan. *J Plant Res* 117: 311-317.
- Karp A, Isaac PG, Ingram DS (1998) *Molecular Tools for Screening Biodiversity: Plants and Animals*. Chapman & Hall, London.
- Karvonen P, Szmidt AE, Savolainen O (1994) Length variation in the internal transcribed spacers of ribosomal DNA in *Picea abies* and related species. *Theor Appl Genet* 89: 969-974.

- Kato A, Vega JM, Han F, Lamb JC, Birchler JA (2005) Advances in plant chromosome identification and cytogenetic techniques. *Curr Opin Plant Biol* 8: 148-154.
- Lagercrantz U, Ellegren H, Andersson L (1993) The abundance of various polymorphic microsatellite motifs differs between plants and vertebrates. *Nucleic Acids Res* 21: 1111-1115.
- Lavania UC (2002) Chromosome diversity in population: Defining conservation units and their micro-identification through genomic *in situ* painting. *Current Science* 83: 124-127.
- Leigh F, Kalendar V, Lea V, Lee D, Donini P, Schulman AH (2003) Comparison of the utility of barley retrotransposon families for genetic analysis by molecular marker techniques. *Mol Genet Genomics* 269: 464-474.
- Leitch IJ, Bennett MD (2004) Genome downsizing in polyploidy plants. *Biol J Linn Soc* 82: 651-663.
- Leitch IJ, Bennett MD (1997) Polyploidy in angiosperms. *Trends Plant Sci* 2: 470-476.
- Lespinasse D, Grivet L, Troispoux V, Rodier-Goud M, Pinard F, Seguin M (2000) Identification of QTLs involved in the resistance to South American leaf blight (*Microcyclus ulei*) in the rubber tree. *Theor Appl Genet* 100: 975-984.
- Linde-Laursen I, Bothmer R von, Jacobsen N (1992). Relationships in the genus *Hordeum*: Giemsa C-banded karyotypes. *Hereditas* 110: 111-116.
- Loreiro J, Pinto G, Lopes T, Dolezel J, Santos C (2005) Assessment of ploidy stability of the somatic embryogenesis process in *Quercus suber* L. using flow cytometry. *Planta* 221: 815-822.
- Lu Z, Wang Y, Peng Y, Korpelainen H, Li C (2005) Genetic diversity of *Populus cathayana* Redh populations in south-western China revealed by ISSR markers. *Plant Sci* 170: 407-412.
- Löve A, Löve D (1957) Arctic polyploidy. *Proceedings of the Genetics Society of Canada* 2: 23-27.
- Mabberley DJ (1997) *The Plant Book*, 2<sup>nd</sup> edition. Cambridge University Press, Cambridge.

- Manos PS, Doyle JJ, Nixon KC (1999) Phylogeny, biogeography, and processes of molecular differentiation in *Quercus* subgenus *Quercus* (Fagaceae). *Mol Phylogenet Evol* 12: 333-349.
- Manos PS, Zhou Z, Cannon CH (2001) Systematics of Fagaceae: phylogenetic tests of reproductive trait evolution. *J Plant Sci* 162: 1361-1379.
- Mattioni C, Casasoli M, Gonzalez M, Ipinza R (2002) Comparison of ISSR and RAPD markers to characterize three Chilean *Nothofagus* species. *Theor Appl Genet* 104: 1064-1070.
- Montalvo AM, Conard SG, Conkle MT, Hodgskiss PD (1997) Population structure, genetic diversity, and clone formation in *Quercus chrysolepis* (Fagaceae). *Am J Bot* 84: 1553-1564.
- Muir G, Fleming CC, Schlötterer C (2001) Three divergent rDNA clusters predate the species divergence in *Quercus patraea* (Matt.) Liebl. and *Quercus robur* L. *Mol Biol Ecol* 18: 112-119.
- Mullis KB (1990) The unusual origin of the polymerase chain reaction. *Scientific American* 262: 56-65.
- Neves N, Delgado M, Silva M, Caperta A, Morais-Cecilio, Viegas W (2005) Ribosomal DNA heterochromatin in plants. *Cytogenet Genome Res* 109: 104-111.
- Newton AC, Allnutt TR, Gillies ACM, Lowe AJ, Ennos RA (1999) Molecular phylogeography, intraspecific variation and the conservation of tree species. *Trends Ecol Evol* 14: 140-145.
- Nixon KC and Crepet WL (1989) *Trigonobalanus* (Fagaceae): Taxonomic status and phylogenetic relationships. *Am J Bot* 76: 828-841.
- Ohri D, Ahuja MR (1990) Giemsa C-banded karyotype in *Quercus* L. (oak). *Silvae Genetica* 39: 5-6.
- Petit RJ, Pineau E, Demesure B, Bacilieri R, Ducousso A (1997) Chloroplast DNA footprints of postglacial recolonization by oaks. *Proc Natl Acad Sci USA* 94:9996-10001.
- Phengklai C (2004) Three new species and a new variety of Fagaceae from Thailand. *Thai Forest Bull (Bot)* 32: 115-122.

- Purba AR, Noyer JL, Baudouin L, Perrier X, Hamon S, Lagoda PJJ (2000) A new aspect of genetic diversity of Indonesian oil palm (*Elaeis guineensis* Jacq.) revealed by isoenzyme and AFLP markers and its consequences to breeding. *Theor Appl Genet.* 101: 956-961.
- Raina SN, Rani V (2001) GISH technology in plant genome research. *Methods Cell Sci.* 23: 83-104.
- Rieseberg LH (1997) Hybrid origins of plant species. *Annu Rev Ecol Syst* 28: 359-389.
- Rohlf FJ (1998). NTSYSpc: *Numerical taxonomy and multivariate analysis system*, version 2.1. Exeter Software: Setauket, New York.
- Santisuk T (2005) Vegetation types of Thailand. [www.dnp.go.th/botany/bkf.htm](http://www.dnp.go.th/botany/bkf.htm).
- Schaal BA, Hayworth DA, Olsen KM, Rauscher JT, Smith WA (1998) Phylogeographic studies in plants: problems and prospects. *Mol Ecol* 7: 465-474.
- Schaal BA, Olsen KM (2000) Gene genealogies and population variation in plants. *Proc Natl Acad Sci USA* 97(13): 7024-7029.
- Schierenbeck KA, Skupski M, Lieberman D, Lieberman M (1997) Population structure and genetic diversity in four tropical tree species in Costa Rica. *Mol Ecol* 6: 137-144.
- Schlotterer C (2004) The evolution of molecular markers-just a matter of fashion?. *Genetics* 5: 63-69.
- Schubert I, Fransz PF, Fuchs J, Hans de Jong J (2001) Chromosome painting in plants. *Methods Cell Sci.* 23: 57-69.
- Schwarz O (1964) *Quercus* L. In: *Flora Europaea*, vol. 1 (Tutin TG, Heywood VH, Burges NA, Valentine DH, Walters SM, Webb DA, eds.) Cambridge University Press. Pp. 61-64.
- Schwarzacher T, Heslop-Harrison P (2000) *Practical in situ Hybridization*. Bios Scientific Publishers.
- Schwarzacher T, Leitch AR, Bennett MD, Heslop-Harrison JS (1989) *In situ* hybridization of parental genomes in a wide hybrid. *Annals of Botany* 64: 315-324.



- Scoggan SJ (1978) *The Flora of Canada*, Part 3, Fagaceae. National Museum of Natural Sciences, Canada. Pp. 597-601.
- Sharma AK, Sharma A (2001) Chromosome painting-principles, strategies and scope. *Methods Cell Sci.* 23: 1-5.
- Sigurdsson V, Anamthawat-Jónsson K and Sigurgeirsson A (1995) DNA fingerprinting of *Populus trichocarpa* clones using RAPD markers. *New Forests* 10: 197-206.
- Sinclair WT, Morman JD, Ennos RA (1999) The postglacial history of Scots pine (*Pinus sylvestris* L.) in western Europe: evidence from mitochondrial DNA variation. *Mol Ecol* 8: 83-88.
- Smitinand T (1980) *Thai Plant Names* (Botanical Names – Vernacular Names). Funny Publishing Limited, Bangkok. Pp. 380.
- Soepadmo E (1972) Fagaceae. In: van Steenis CGGJ (ed) *Flora Malesiana*, ser. I, vol. 7, Noordhoff International Publishing, Leyden, the Netherlands, pp. 265-388.
- Soltis DE, Soltis PS (1999) Polyploidy: recurrent formation and genome evolution. *Tree* 14: 348-352.
- Stebbins GL (1971) *Chromosome Evolution in Higher Plants*. Addison-Wesley Publishing Company, Massachusetts, California, London, Ontario.
- Streiff R, Labbe T, Bacilieri R, Steinkellner H, Glossl J, Kremer A (1998) Within-population genetic structure in *Quercus robur* L. and *Quercus petraea* (Matt.) Liebl. assessed with isozymes and microsatellites. *Mol Ecol* 7: 317-328.
- Sumner AT, Evans HJ, Buckland BA (1971) New technique for distinguishing between human chromosomes. *Nature* 232: 31-32.
- Taberlet P, Fumagalli L, Wust-Saucy A-G, Cosson J-F (1998) Comparative phylogeography and postglacial colonization routes in Europe. *Mol Ecol* 7: 453-464.
- Tagarelli A, Piro A, Lagonia P, Tagarelli G (2003) Walter Stanborough Sutton: a hundred years after the chromosomal theory of heredity. *Chromosoma* 112: 1-5.

- Taketa S, Ando H, Takeda K, Ichii M, von Bothmer R (2005). Ancestry of American polyploid *Hordeum* species with the I genome inferred from 5S and 18S-25S rDNA. *Annals of Botany* 96: 23-33.
- Tessadori F, van Driel R, Fransz P (2004) Cytogenetics as a tool to study gene regulation. *Trends Plant Sci* 9: 147-153.
- Tilman D (2000). Causes, consequences and ethics of biodiversity. *Nature* 405:208-211.
- Tjio JH, Levan A (1956) The chromosome number of man. *Hereditas* 42: 1-6.
- Tomaru N, Takahashi M, Tsumura Y, Takahashi M, Ohba K (1998) Intraspecific variation and phylogeographic patterns of *Fagus crenata* (Fagaceae) mitochondrial DNA. *Am J Bot* 85: 629-636.
- van Tienderen PH, de Haan AA, Gerard van der Linden C, Vosman B (2002) Biodiversity assessment using markers for ecologically important traits. *Trends Ecol Evol* 17: 577-582.
- Vij SP, Sharm M, Chaudhary JD 1982 Cytogenetical investigations into some garden ornamentals III. Chromosomes in some monocot taxa. *Cytologia* 47: 649-663.
- Vos P, Hogers R, Bleeker M, Reijans M, van de Lee T, Hornes M, Frijters A, Pot J, Peleman J, Kuiper M, Zabeau M (1995) AFLP: a new technique for DNA fingerprinting. *Nucleic Acids Res* 23: 4407-4414.
- Watson JD, Crick FHC (1953) Molecular structure of nucleic acids – a structure for deoxyribose nucleic acids. *Nature* 171: 737-738.
- Waugh R, McLean K, Flavell AJ, Pearce SR, Kumar A, thomas BBT, Powell W (1997) Genetic distribution of BARE-1-like retrotransposable elements in barley genome revealed by sequence-specific amplification polymorphisms (S-SAP). *Mol Gen Genet* 253: 687-694.
- Whittemore AT, Schaal BA (1991) Interspecific gene flow in oaks. *Proc Natl Acad Sci USA* 88: 2540-2544.
- Williams JGK, Kubelik AR, Livak KJ, Rafalski JA, Tingey SV (1990) DNA polymorphisms amplified by arbitrary primers are useful as genetic markers. *Nucleic Acids Res* 18: 6531-6535.

- Yamamoto T, Shimada T, Kotobuki K, Morimoto Y, Yoshida M (1998) Genetic characterization of Asian chestnut varieties assessed by AFLP. *Breeding Science* 48: 359-363.
- Yamamoto T, Tanaka T, Kotobuki K, Matsuda N, Suzuki M, Hayashi T (2003) Characterization of simple sequence repeats in Japanese chestnut. *Journal of Horticultural Science and Biotechnology* 78: 197-203.
- Zhang D-X, Hewitt GM (2003) Nuclear DNA analyses in genetic studies of populations: practice, problems and prospects. *Mol Ecol* 12: 563-584.
- Zhang Z-Y, Chen Y-Y, Li D-Z (2005) Detection of low genetic variation in a critically endangered Chinese pine, *Pinus squamata*, using RAPD and ISSR markers. *Biochem Genet* 43: 239-249.
- Zietkiewicz E, Rafalski A, Labuda D (1994) Genome fingerprinting by simple sequence repeat (SSR)-anchored polymerase chain reaction amplification. *Genomics* 20: 176-183.
- Zoldos V, Papes D, Brown SC, Panaud O, Siljak-Yakovlev S (1998) Genome size and base composition of seven *Quercus* species: inter- and intra-population variation. *Genome* 41: 162-168.
- Zoldos V, Papes D, Cerbah M, Panaud O, Besendorfer V, Siljak-Yakovlev S (1999) Molecular-cytogenetic studies of ribosomal genes and heterochromatin reveal conserved genome organization among 11 *Quercus* species. *Theor Appl Genet* 99: 969-977.
- Zoldos V, Siljak-Yakovlev S, Papes D, Sarr A, Panaud O (2001) Representational difference analysis reveals genomic differences between *Q. robur* and *Q. suber*: implications for the study of genome evolution in the genus *Quercus*. *Mol Genet Genomics* 265: 234-241.

## **APPENDICES**

**Key to the three Fagaceae genera under study:**

*Based on vegetative and field characters*

1. Petioles not geniculate. Inner bark with ridges strongly penetrate surface of sapwood

2. Terminal buds crowded. Leaves mostly with serrate margin **1. Quercus**

2. Terminal buds solitary. Leaves with entire margin **2. Lithocarpus**

1. Petiole geniculate. Inner bark without ridges penetrate surface of sapwood

**3. Castanopsis**

*Based on acorn specimens*

1. Margin of mature cupules entire, indehiscent

2. Stigmata punctiform (early stage of acorn), terminal buds solitary

**2. Lithocarpus**

2. Stigmata capitate (early stage of acorn), terminal buds crowded

**1. Quercus**

1. Margin of mature cupules lobed or irregular lobed by dehiscent **3. Castanopsis**

*Based on flower specimens.*

1. Male flowers with present rudimentary ovary. Stamens 10-12, anthers dorsifixed. Female flowers with 10-12 staminodes, stigmata punctiform. Male and female inflorescence always erect

2. Cupule-primordia already developed before anthesis, always solitary, with distinct vertical sutures, with 2-4(-8) separate growing points, flowers.

**3. Castanopsis**

2. Cupule-primordia not developed before anthesis, solitary or in dichasial clusters, ring-shaped without vertical suture and separate growing points, enclosing 1.

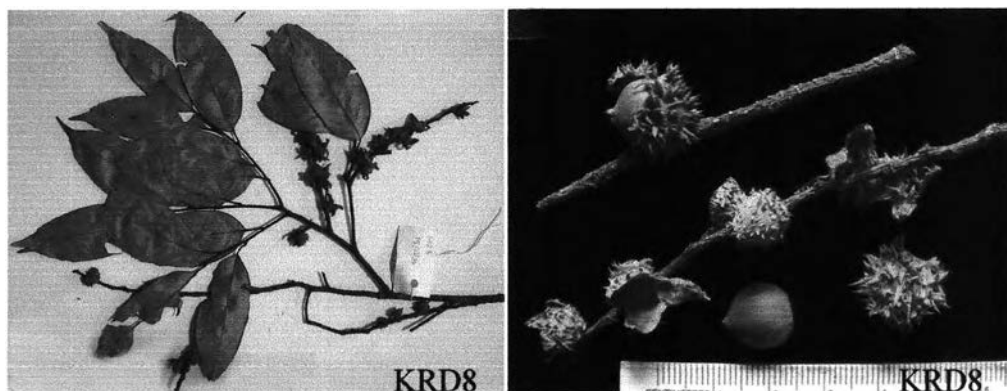
**2. Lithocarpus**

1. Male flowers without rudimentary ovary. Stamens 5-6(-9), anthers basifixed. Female flowers without staminodes (or rare 5-6 staminodes), stigmata capitate. Male inflorescence pendulous (rare sub-erect)

**1. Quercus**

### Description of each species in this study

Species: *Castanopsis acuminatissima* (Blume) A. DC.



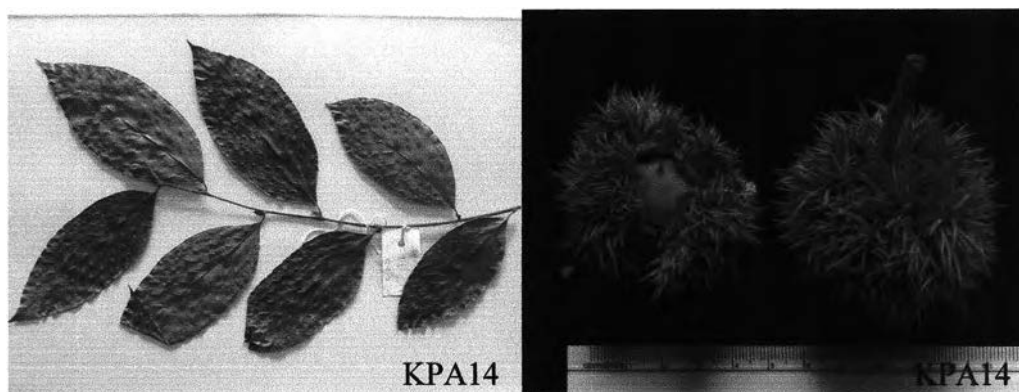
Tree, 10-40 m high, 60-250 cm girth. Lateral buds ellipsoid, ca. 1 mm long, glabrous. Twigs pubescent then glabrescent, blackish or dark brown when dry. Bark grayish brown to dark brown, densely lenticellate, flakey and longitudinal fissured. Stipules triangular, 1.5 by 1 mm.

Leaves elliptic oblong, oblong lanceolate, 5.5-13 by 1.5-4 cm. Base obtuse to slightly oblique. Apex caudate, acuminate or cuspidate. Margin serrate on the upper half. Lamina sub coriaceous, glabrous, glossy green on upper and pale on lower surface. Midrib prominent on lower and subdepressed on upper surface. Lateral nerves 8-11 pairs, conspicuous on both surfaces. Petiole 1-1.4 cm, pubescent then glabrescent.

Acorns sessile, globose or ovoid, 1-1.5 by 0.8-1.3 cm (including cupule), on erect infructescence 9-12 cm long. Cupule completely enclosed but not fused with the nut, skin sparsely with simple and curved beyond the base spines, pubescent then glabrescent, dehiscent. Nut 1 per cupule, ovoid, ca. 1 cm diameter, glabrous.



Species: *Castanopsis argentea* (Blume) A.DC.

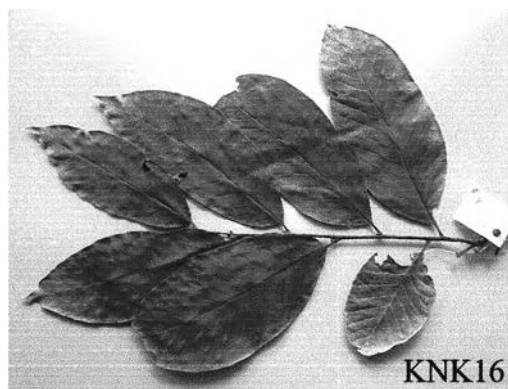


Tree, 12-30 m high, 60-200 cm girth. Lateral buds ovoid 3-4 by 2-3 mm, pubescent outer part. Twigs pubescent then glabrescent, blackish, lenticellate. Bark greyish brown, roughly scales, longitudinal furrowed. Stipules lanceolate, 3-5 by 1-1.5 mm, ciliate, pubescent outer part.

Leaves elliptic, broadly elliptic, elliptic oblong, 10-20 by 4-7 cm. Base obtuse, oblique or slightly cuneate. Apex blunted acute, rarely acuminate or cuspidate. Margin entire. Lamina subcoriaceous to coriaceous, glabrous and glossy green on upper and pubescent on lower surface. Midrib prominent on both surface. Lateral nerves 7-12 pairs, arched but not anastomosing, prominent on lower and depressed on upper surface. Scalariform veins conspicuous on lower surface. Reticulate veins conspicuous on upper surface. Petiole 1-1.5 cm, pubescent, glabrescent.

Acorns sessile, globose, 4-6 cm diameter (including cupule) on erect and woody infructescence 15-30 cm long. Cupule completely enclosed but not fused with the nut, skin densely branched with spines, till hardly seen its skin, twigs of spine erect and hairy, indehiscent. Nut 1-(3) per cupule, ovoid, 2-2.5 by 1-1.5 cm, tomentose through out scar, ca. 0.5 cm diameter.

Species: *Castanopsis armata* (Roxb.) Spach

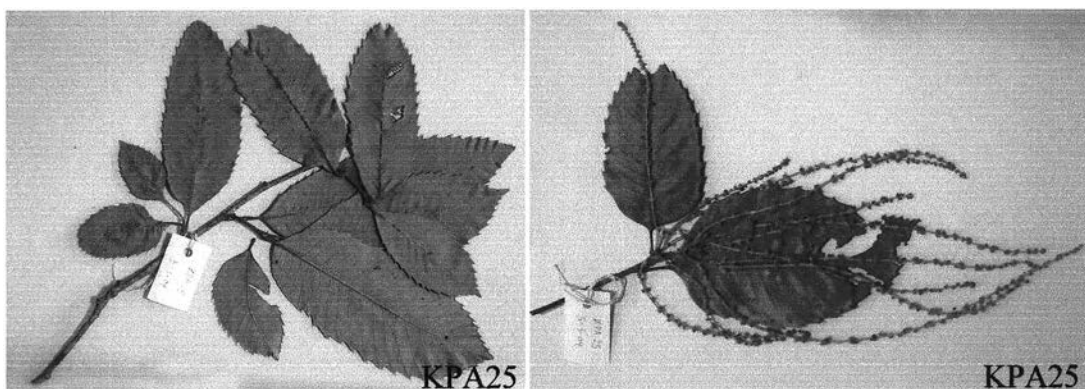


Tree, 8-20 m high, 80-180 cm girth. Terminal and lateral buds, ellipsoid or ovoid, ca. 3 by 2 mm, bracts ca. 2 by 1 mm, pubescent on outer part. Twigs pubescent then glabrous, lenticellate. Bark dark green or brown, roughly, vertically cracked, irregularly fissured.

Leaves elliptic, oblong, obovate oblong, 10-23 by 3.5-10 cm. Base acute to broadly obtuse. Apex acute, acuminate to obtuse. Margin entire. Lamina coriaceous, glabrous, dark glossy green on upper and pale on lower surface, Midrib and lateral nerves prominent on lower and depressed on upper surface. Scalariform veins dominant on lower surface. Reticulate veins indistinct. Petiole 1.5-2 by 1 mm, pubescent on outer part.



Species: *Castanopsis calathiformis* (Skan.) Rehder & Wilson



Tree, 6-20 m high, 100-200 cm girth. Terminal buds ovoid, indumentum on outer part. Twigs stout, quadrangulate, pubescent then glabrescent, sparsely lenticels. Bark brown, fissured.

Leaves obovate, oblanceolate, 14-20 by 5-9 cm. Base cuneate. Apex obtuse, broadly acute. Margin serrate. Lamina coriaceous, glabrous, glossy green on upper and pale on lower surface. Midrib and lateral nerves prominent on lower surface and depressed on upper surface. Lateral nerves 14-22 pairs, straight and protrude to the end point of serrate margin. Scalariform veins conspicuous on lower surface. Petiole slender, 1-3 cm long without gland, pubescent then glabrescent.

Male inflorescence always branched, on terminal or axillary, spikelets 4-10 cm long. Flowers white or whitish yellow, in cluster 2-3-5-flowered. Calyx 6-lobed, lobes obovate, free, ca. 1.5 by 0.5 mm, glabrous. Stamens 12, 1.5-2 mm long, bracts ovate, ca. 2 by 15 mm. glabrous. Rudimentary ovary 3-lobed, villous. Female inflorescence, spike, axillary, up to 8 cm long. Flowers not cluster, other as male flowers. Stile 3(4) ca. 1 mm long, stigmata divergent, all glabrous.

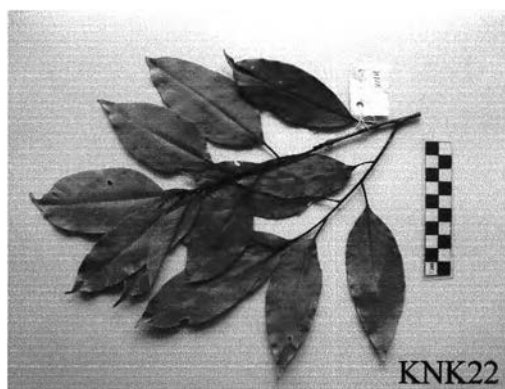
Species: *Castanopsis cerabrina* (Hickel & A. Camus) Barnett



Tree, 10-20 m high, 40-100 cm girth. Terminal buds ovoid, 4-5 by 2-3 mm. Twigs first ferruginous, glabrescent, tetra to penta angulate, lenticels. Bark grey, shallowly fissured. Stipule narrow lanceolate, 4-5 by 1.5-2 mm glabrous.

Leaves oblanceolate, 13-29 by 4-11 cm. Base cuneate. Apex acute, broadly acute to obtuse. Margin serate. Lamina coriaceous, glabrous, glossy green on upper and greenish to glaucous on lower surface. Midrib prominent on lower and slightly depressed on upper surface, pubescent then glabrescent. Lateral nerves 14-17 pairs, narrow ridge on lower and subdepressed on upper surface, glabrous. Scalariform veins conspicuous on both surfaces. Petiole 1.5-2.3 cm long, flattened at adaxial, glabrous.

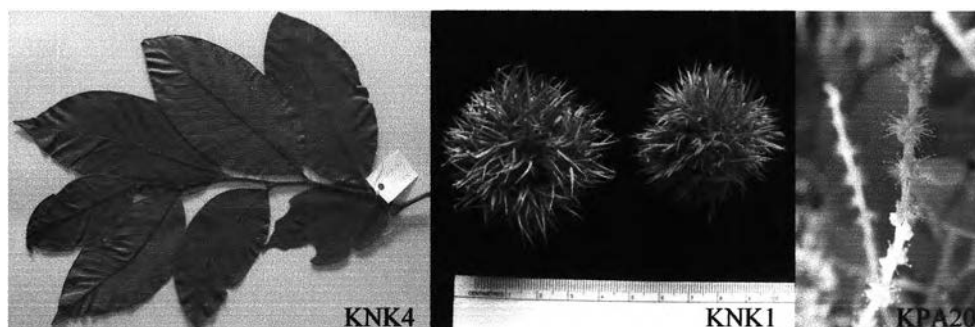
Species: *Castanopsis crassifolia* Hickel & A. Camus



Tree 5-20 m high, 50-150 cm girth. Twigs glabrous, lenticellate. Bark greenish brown, fissured.

Leaves lanceolate rarely ovate, 9-16 by 2-6 cm. Base acute, obtuse, usually equal sides. Apex acuminate, caudate. Margin entire. Lamina coriaceous, glabrous on both surfaces, dark glossy green on the upper and pale on lower surface. Midrib prominent on the lower and depressed on upper surface. Lateral nerves 6-9 pairs, arched but not anastomosing, conspicuous on both surfaces. Scalariform veins conspicuous on lower and reticulate veins conspicuous on upper surface. Petiole 0.8-1.5 cm, glabrous black when dry.

Species: *Castanopsis diversifolia* (Kurz) King & Hook.f.



Tree, 10-30 m high, 150-200 cm girth. Terminal and lateral buds ovoid, bracts 2-3 by 1-1.5 mm, pubescent on both parts. Twigs tomentose, then glabrescent. Bark brown, interval with grey patches.

Leaves elliptic, oblong, 11-22 by 5-10 cm. Base obtuse, slightly obliqued sometime. Apex acuminate. Margin entire. Lamina coriaceous or subcoriaceous, glabrous except along midrib and nerves on upper and pubescent then glabrescent on lower surface. Midrib and nerves prominent on lower and depressed on the upper surface. Lateral nerves 8-14 pairs, arched but not anastomosing. Scalariform veins conspicuous on lower surface. Reticulate veins hardly distinct. Petiole 1-1.5 cm long, tomentose then glabrescent.

Male inflorescence always branched, spikelets 5-10 cm long, bracts and bracteoles lanceolate, 4-5 by 0.5 mm, pubescent on outer part. Flowers creamy, fragrant, solitary or cluster 2-3-flowered. Calyx 6-lobed, oblong, free, ca. 1 by 0.5 mm, ciliate. Stamens 12, 1.5-2 mm long, glabrous. Rudimentary ovary ovoid, flattened top, ca. 1 mm diameter, hirsute. Female inflorescence spike, 8-15 cm long. Flowers always solitary, other as male flowers. Style 3, divergent, pilose near base. Stigmata pointed, more or less hairy.

Acorns globose, 4-6.5 cm diameter (including cupule) always solitary on erect and woody infructescence 15-20 cm long. Cupule enclosed completely except the umbonate, skin completely enclosed by the tufted erect simple spines. Nut 1 (2-3) per cupule, ovoid to ellipsoie, 1-1.5 cm diameters, glabrous except orbicular area of indumentum around umbo, scar only at base of nut.

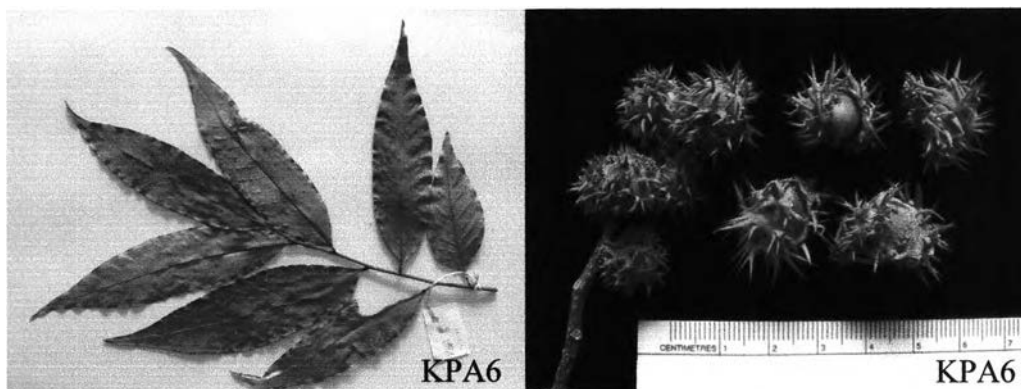
Species: *Castanopsis echinocarpa* A.DC.



Tree, 5-25 m high, 20-50 cm girth. Terminal buds, ovoid, ca. 5 by 3 mm, glabrous. Twigs first hairy then glabrescent, densely rounded lenticels. Bark blackish, greenish, shallowly fissured.

Leaves lanceolate, lanceolate oblong, 9-17 by 3-4.5 cm. Base obtuse, suboblique. Apex cuspidate, caudate. Margin entire. Lamina subcoriaceous, glabrous, glossy green on upper and glaucous greenish on lower surface. Midrib prominent on both surfaces. Lateral nerves 9-15 pairs, arched but not anastomosing, conspicuous on both surfaces. Scalariform and reticulate veins fine conspicuous on both surfaces. Petiole 1-1.5 cm, pubescent then glabrescent, blackish when dry.

Species: *Castanopsis ferox* (Roxb.) Spach

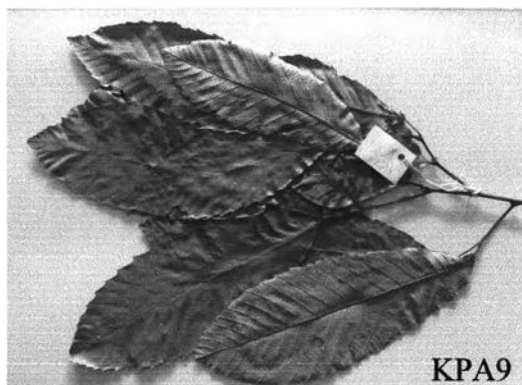


Tree, 10-30 m high, 50-150 cm girth. Twigs pubescent then glabrescent, lenticellate few.

Leaves lanceolate, lanceolate oblong, elliptic, 12-21 by 3-5.5 cm. Base slightly cuneate, obtuse, oblique. Apex acuminate, caudate. Margin entire. Lamina subcoriaceous, glabrous on both surfaces, glossy green on upper and greyish brown on lower surface. Midrib and lateral nerves sharp ridged on lower and more or less depressed on upper surface. Lateral nerves 10-18 pairs, arched but not anastomosing. Scalariform veins conspicuous on lower and subdepressed on upper surface. Reticulate veins hardly distinct. Petiole 0.5-1 cm, pubescent then glabrous, black when dry.

Acorns sessile, ovoid, 2-3 cm diameter (including cupule), often cluster 2-3-acorns, interval with solitary, on erect infructescence 15-20 cm long. Cupule enclosed completely the nut except the umbonate, skin completely enclosed by the tufted erect simple spines (except young stage only irregular diffuse sparsely throughout). Nut 1 per cupule, ovoid, 1.3-1.5 by 0.9-1 cm. usually unequal sides, closed by grey indumentum then glossy green, except the umbonate, scar ca. 1 cm diameter at base of nut only.

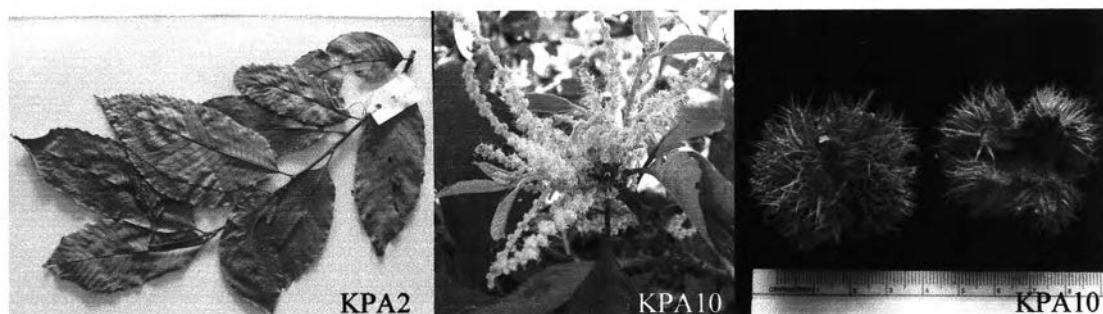
Species: *Castanopsis fissa* (Champ) Rehder & Wilson



Tree, 15-20 m high, 90-120 cm girth. Twigs with reddish hairs, glabrescent, lenticellate.

Leaves obovate, obovate elliptic, 18-25 by 6-9.5 cm. Base slightly narrowed to the base. Apex broadly acute or acute. Margin serrate. Lamina coriaceous, glossy green on upper surface, pale and tawny pubescent on lower surface. Midrib and lateral nerves prominent on lower and flattened on upper surface. Lateral nerves 14-17 pairs, straight and protrude to the end serrate of margin. Scalariform and reticulate veins hardly distinct. Petiole 1-2.5 cm, pubescent then glabrescent, usually a gland at adaxial.

Species: *Castanopsis indica* (Roxb.) A.DC.



Tree, 7-30 m high, 50-250 cm girth. Terminal buds ovoid, 5-6 by 3-4 mm, bracts pubescent on outer part. Twigs tomentose then glabrescent, lenticellate. Bark brownish or greyish, thick scaly.

Leaves oblong, ovate, slightly obovate, 10-20 by 4-10 cm. Base obtuse, equal or suboblique. Apex acute, acuminate, sometime obtuse. Margin serrate on upper half or two-third. Lamina coriaceous, glabrous except along midrib on the upper and densely pubescent on lower surface. Lateral nerves 15-21 pairs, rather straight and protended to the end of serrate margin. Sclariform veins fine distinct on lower surface. Petiole 1.5-2 cm, pubescent the glabrescent.

Male inflorescence always branched, spikelets 10-15 cm long, bracts and bracteoles triangular, ca. 1.5 by 1.5 mm, pubescent on outer part. Flower white, scented, solitary or in cluster 2-3-flowered. Calyx 6-lobed, lobes obovate, free, ca. 1 by 0.5, pubescent on outer part. Stamens 6-12, ca. 2 mm long, glabrous. Rudimentary ovary, rounded and flattened top, ca. 1 mm diameter, hirsute. Female inflorescence spike, 8-25 cm long. Flowers always solitary not in cluster, other as male flowers. Style 3, divergent, pilose at base. Stigmata pointed, blackish.

Acorns sessile, ovoid 1.5-4 cm diameters (including cupule), in cluster by its spines 2-3-acorned interval with solitary on erect infructescence 15-30 cm long. Cupule enclosed completely the nut except the umbonate, skin completely enclosed by the tufted erect simple spines. Nut 1 per cupule, conical or ovoid, 1.3-1.5 by 0.8-1.1 cm, usually curved to one longitudinal side, scar ca. 1 cm diameter at base or slightly upper.



Species: *Castanopsis tribuloides* (Sm.) A.DC.



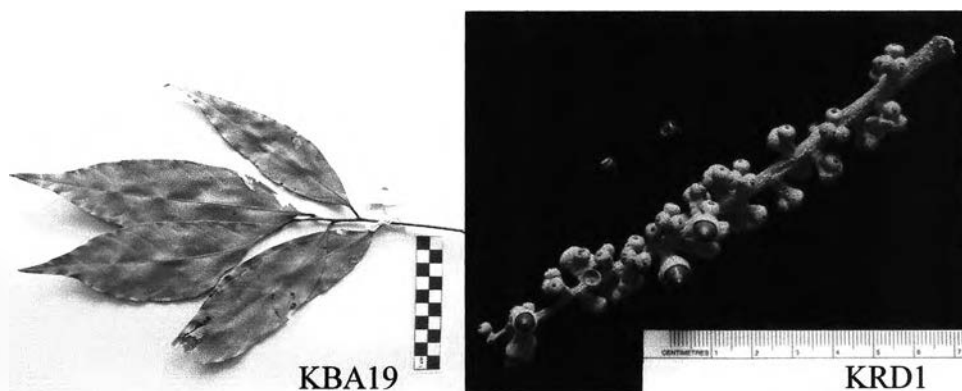
Tree, 6-40 m high, 70-150 cm girth. Terminal buds ovoid, 5-10 by 3-4 mm, outer part pubescent. Twigs greyish pubescent, glabrescent. Bark dark brown, roughly with longitudinal irregular fissured.

Leaves lanceolate, oblong, 7-21 by 3-6.5 cm. Base obtuse, oblique. Apex acuminate, acute, sometime caudate. Margin entire. Lamina coriaceous to subcoriaceous, glabrous, glossy green on upper and brownish on lower surface. Midrib and lateral nerves prominent on lower and subdepressed on upper surface. Lateral nerves 9-13 pairs, arched but not anastomosing. Other veins hardly distinct. Petiole 1-1.8 cm, glabrous, black when dry.

Male inflorescences always branched, spikelets 5-14 cm long, bracts and bracteoles triangular, ca. 1 by 1 mm, pubescent on outer part. Flowers whitish to brownish, scented, usually in cluster 2-3-flowered. Calyx 6-lobed, lobes free, obovate, 1.5-2 by 1 mm, pubescent on both sides. Stamens 12, 2.5-3 mm long, glabrous. Rudimentary ovary round and flat top, ca. 1 mm diameter, hirsute. Female inflorescence always spike, 8-15 cm long. Flower solitary not cluster, other as male flower. Style 3, divergent. Stigmata pointed.

Acorns ellipsoid, rarely ovoid, 1.5-2.5 by 1.5-2 cm (including cupule) on erect and woody infructescence, 15-20 cm long. Cupule enclosed completely except the umbo, but not fused with the nut, skin sparsely with simple spines which curls and set twisted line from base to apex. Nut 1 per cupule, 1.2-1.5 by 1-1.2 cm, conic apex.

Species: *Lithocarpus ceriferus* (Hickel & A. Camus) A. Camus



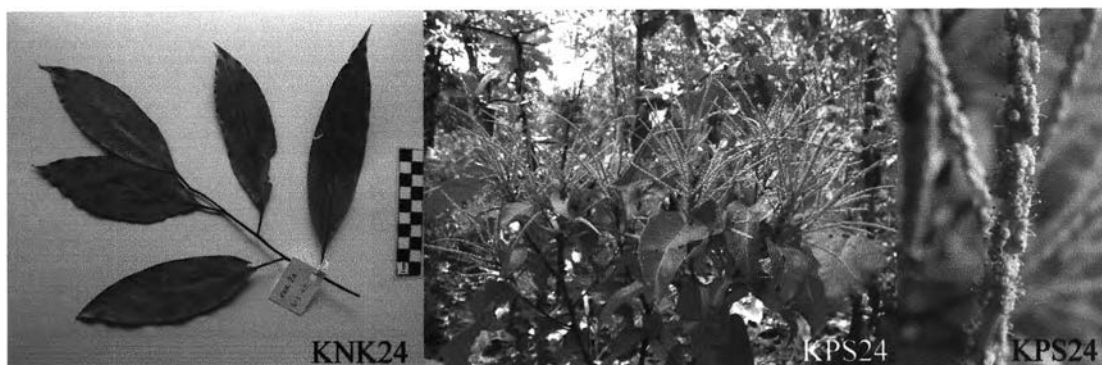
Tree, 5-25 m high, 40-110 cm girth. Bark brownish, deeply furrowed.

Leaves elliptic to elliptic-oblong, slightly oblanceolate, 10-22.5 by 3-9 cm. Base cuneate. Apex acuminate, acute. Margin entire. Lamina coriaceous, glabrous, glossy green on the upper and pale to glaucous on lower surface. Midrib and nerves prominent on upper and more or less depressed on the lower surface. Lateral nerves 9-12 pairs, arched but not anastomosing. Scalariform veins distinct or hardly distinct on both surfaces. Petiole 1-2 cm, glabrous, dark brown when dry.

Male inflorescence spike or many branches, spikes or spikelets 10-15 cm long, bracts and bracteoles ovate-acute, 2-2.5 by 0.5-1 mm, pubescent on outer part. Flowers yellowish white, always 3-5-flowered in a group. Calyx 6-lobed, broadly campanulate, 1.5-2 mm long, lobes divided to one-third to the base, pubescent on outer part. Stamens 12, 2-2.5 mm long, glabrous. Rudimentary ovary subglobose, ca. 1 mm diameter, hirsute. Female inflorescence usually spike or few branches, spikes 14-24 cm long. Flowers always in cluster 3-5-flowered, the other as male flowers. Styles 3, divergent. Stigmata pointed.

Acorns fine conical, 0.8-1 by 0.5-0.6 cm (including cupule), fruit-stalk 2-5 mm long, on erect and slender infructescence, 15-25 cm long, acorns fused adnate near base (some face), indehiscent. Cupule cup-shaped, enclosed up to half of the nut. Skin composed of alternate and grey incumentum lamentos which fused through the inner parts, except apex still free, and more or less pointed upward. Nut 1 per cupule, fine conical, ca. 9 by 6 mm, glossy brown, scar 3-4 mm diameter, at base of nut.

Species: *Lithocarpus elegans* (Blume) Harus ex Soepadmo

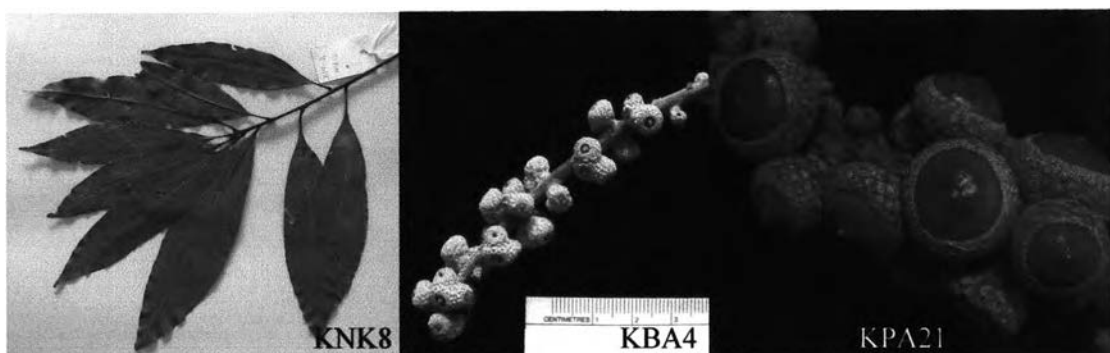


Tree, 5-25 m high, 60-150 cm girth. Terminal buds ovoid, 2-5 by 2-3 mm, bracts ovate to linear, tomentose then glabrescent. Twigs greyish pubescent then yellowish orange to dark red. Stipules ovate to linear, 3-6 by 1-2 mm.

Leaves oblong, elliptic-oblong, obovate, lanceolate, 10-22 by 3.5-9 cm. Base slightly cuneate, oblique, rare obtuse. Apex acute, acuminate, caudate, rare obtuse. Margin entire. Lamina coriaceous to subcoriaceous, pubescent then glabrescent, dull green on the upper and glaucous-green on lower surface, glossy green on the upper sometime. Midrib and nerves prominent on lower and depressed on the upper surface, usually yellowish-ping when dry.

Male inflorescence, panicle, spike, spikes or spikelets 7-20 cm long, bracts and bracteoles ovate or elliptic, 0.5-1.5 by 0.2-1 mm tomentose on outer parts. Flowers white or yellowish, 9-10-flowered in a group. Calyx 6-lobed, obconical, 0.5-1 mm long, glabrous. Rudimentary ovary subglobose, ca. 1 mm diameter, hirsute. Female inflorescence spike or few branches, spiker or spikelets 12-20 cm long. Flowers always in cluster 3-7-flowered, tho other as male flowers. Styles 3, cylindrical, ca. 1 mm long. Stigmata pointed.

Species: *Lithocarpus harmandianus* (Hickel & A. Camus) A. Camus

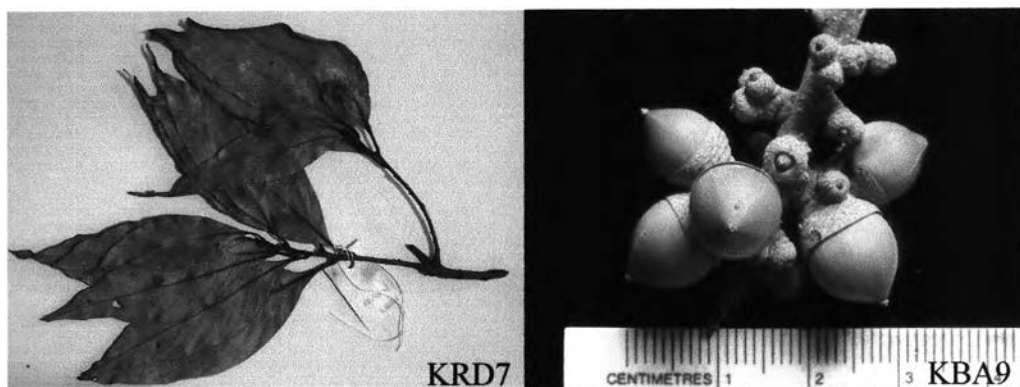


Tree, 5-20 m high, 50-150 cm girth. Twigs greyish pubescent or softly pale tawny tomentose, later minutely, lenticellate. Bark greyish.

Leaves oblong, elliptic-oblong to obovate, 11-22 by 4-10 cm. Base slightly cuneate, oblique. Apex acute, acuminate. Margin entire. Lamina coriaceous to subcoriaceous, glabrous and glossy green on the upper and grey pubescent then glabrescent except along midrib and nerves on lower surface. Midrib and nerves prominent on lower and depressed on upper surface. Lateral nerves 8-11 pairs. Scalariform veins hardly distinct. Petiole 2-3.5 cm, pubescent then glabrescent.

Acorns sessile, conical, 2-3 by 1.2-2 cm (including cupule), on erect and without sub-branch infructescence, 10-25 cm long, the latter ca. 5 mm diameter, acorns fused or addnate near base (some free), indehiscent. Cupule cup-shaped, enclosed up to 1/3 of the nut. Skin composes of alternate and greyish brown laments, which fused through the inner part completely. Nut 1 per cupule, conical 2-2.5 by 1.1-1.5 cm, dull green indumentum, glabrescent.

Species: *Lithocarpus polystachyus* (A.DC.) Rehder

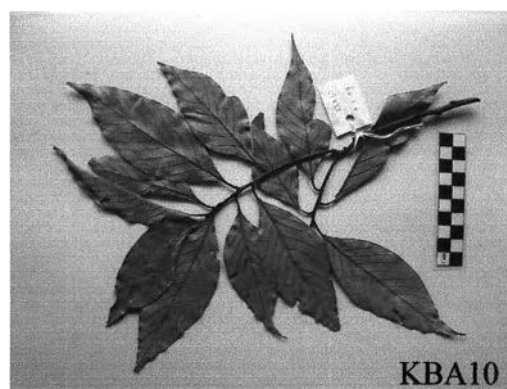


Tree, 5-20 m high, 45-100 cm girth. Twigs grey pubescent then glabrescent. Bark dark grey to brown, deeply furrowed.

Leaves oblong, ovate-lanceolate, elliptic 9-23 by 3-8 cm. Base coriaceous, subcoriaceous, glabrous, glossy green on the upper and silvery green to glaucous on lower surface. Midrib and nerves 8-10 pairs, arched but not anastomosing. Scalariform veins distinct on lower surface.

Acorns fine conical, 1.2-2.7 by 0.9-1.2 cm (including cupule), fruit-stalk 1-4 mm long, on erect and slender ifructescence, 10-30 cm long, the latter 0.4-1 cm diameter, and always distinct sub-branches, acorns fused or adnate near base (some free), indehiscent. Cupule cup-shaped, enclosed up to 1/5 to 1/3 of the nut. Skin composed of alternate and grey indumentum laments which fused throughout the inner part, apex more or less free. Nut fine conical, 1.1-2.6 by 0.7-1.2 cm, glossy brown, scar 0.5-1 mm diameters, at base of nut.

Species: *Lithocarpus recurvatus* Barnett



Tree, 5-30 m high, 40-100 cm girth. Terminal buds ovoid 5-10 by 2-3 mm, bracts lanceolate, pubescent on both sides. Twigs densely grey to brown tomentose, then glabrescent, lenticellate, dark brown when dry. Bark greyish, roughly. Stipules lanceolate, 8-10 by 2-3 mm, pubescent.

Leaves lanceolate, lanceolate oblong, 9-26 by 3.5-8.5 cm. Base slightly cuneate, obtuse. Apex acuminate, caudate. Margin entire. Lamina coriaceous, subcoriaceous, pubescent then glabrescent except along midrib and nerves on both surfaces. Midrib and nerves prominent on the upper and depressed on lower surface. Lateral nerves 10-17 pairs, arched but not anastomosing. Scalariform veins conspicuous on lower surface. Petiole 1-(2.5) cm, pubescent, then glabrescent.

Species: *Lithocarpus sootepensis* (Craib) A.Camus



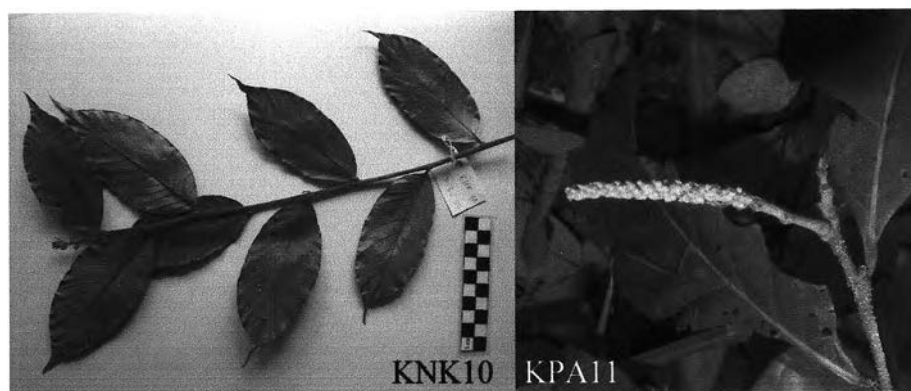
Tree, 5-20 m high, 30-145 cm girth. Twigs pubescent then glabrescent, lenticellate, blackish when dry. Bark dark brown, thick and flanky scales.

Leaves ovate, ovate oblong to obovate, 9-20 by 4-11 cm. Base obtuse, slightly cuneate. Apex caudate, acute. Margin entire. Lamina subcoriaceous to coriaceous, glabrous, glossy green on the upper and glaucous on lower surface, young leaves with black oily coated. Midrib and nerves prominent on lower surface. Petiole 1-2 cm, pubescent then glabrous.

Male inflorescences spike or branched, spikes or spikelets 10-20 cm long, bracts and bracteoles ovate-acute, ca. 2 by 1 mm, pubescent on outer part. Stamens 10-12, 2-3 mm long, glabrous. Rudimentary ovary subglobose, ca. 1 mm diameter, hirsute. Female inflorescence always spike, rare branched, spikes 10-20 cm long. Flowers solitary, rare in cluster, the other as male flowers. Styles 3, conical. Stigmata pointed.

Acorns conical to slightly obconical 1.7-2 by 1.5-1.7 (including cupule) fruit-stalk ca. 1 cm long, on erect and woody infructescence, 10-25 cm long, acorns free, indehiscent. Cupule slightly obconical, enclosed up to 1/2 of the nut. Skin composed of alternate and thin laments, which fused on the lower half, the upper free and more or less incurved apex. Nut 1 per cupule, conical to ovoid, 1.5-1.7 by 1.2-1.5 cm.

Species: *Lithocarpus vestitus* (Hickel & A. Camus) A. Camus



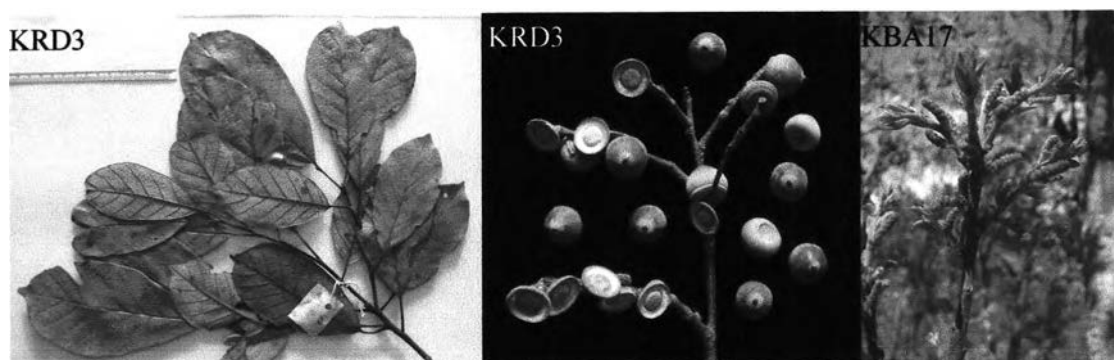
Tree, 15-30 m high, 65-180 cm girth. Twigs grey, smooth, sparsely lenticellate. Bark greenish to greyish, smooth, lenticellate.

Leaves oblong, elliptic-oblong, 10-21 by 3.5-7 cm. Base obtuse, strongly oblique, slightly cuneate. Apex acute acuminate. Margin entire. Lamina chartaceous to subcoriaceous, greyish pubescent then glabrescent, glossy green on the upper and pale on lower surface, unequal and usually curved to one side. Midrib and nerves prominent on lower and depressed on the upper surface. Lateral nerves 14-20 pairs, arched and anastomosing. Sclariform veins conspicuous on lower surface. Petiole 0.5-1 cm, pubescent then glabrescent, dark brown when dry.

Male inflorescence panicle and spike, spikes or spikelets 8-20 cm long, bracts and bracteoles ovate, 2-3 by 0.5-1 mm, pubescent on outer part. Flowers greenish white, disagreeable smell, simple or 1-3-flowered in a group. Calyx 6-lobed, campanulate, 1-1.5 mm long, lobes divided ca. 1/2 to the base, pubescent on outer part, ciliate. Stamens (10)-12, ca. 3 mm long, glabrous. Rudimentary ovary subglobose, ca. 1 mm diameter, hirsute. Female inflorescence always spike, rare few branched, spikes 8-18 cm long. Flowers in cluster, rare solitary, (1)-3 flowered, the other as male flowers. Styles 3-(4), conical then divergent. Stigmata pointed.



Species: *Quercus brandisianus* Kurz



Tree, 3-20 m high, 40-160 cm girth. Twigs tawny pubescent the glabrescent, lenticellate. Bark dark grey, greyish brown, roughly craked.

Leaves obovate, elliptic, ovate to ovate oblong, 8-19 by 4-10 cm. Base slightly coriaceous, sparsely pubescent then glabrous except along midrib and nerves on both surfaces. Midrib and lateral nerves strongly prominent on lower and subdepressed on upper surface. Lateral nerves 9-12 pairs, straight then curved near the margin. Scalariform veins fine distinct on lower and more or less depressed on the upper surface. Petiole 1-3 cm, grey pubescent then glabrescent.

Male inflorescence simple pedunculate catkins on the upper leaf-scars of young twigs, 5-15 cm long, tomentose, bracts and bracteoles scabrous on outer part. Flowers in cluster 3-4-flowered, perianth broadly campanulate, 6-lobed, ca. 2 mm long, lobes obovate 1-1.5 mm, divided to or nearly to the base, pubescent near base on outer part, ciliate. Stamens 6, 2-3 mm long, hairy near base. Female inflorescence axillary and the upper leaf-scars erect spike, 3-5 cm long, grey pubescent, each spike more than ten-flowered, free, other as male flowers. Style 3-4, cornate. Stigmata capitate.

Acorns sessile, obconical, ovoid, 1-3 by 1-2.2 cm (including cupule) on erect and woody infructescence, 2-8 cm long, acorns free, many on each infructescence. Cupule obconical-shaped, enclosed up to 1/3-1/2 from the base of nuts, limb not dilate (completely enclosed except the umbonate when young). Skin composed of grey hairy lamellae, set 5-7 annulars or lamellae. Nut 1 per cupule, conical, 1-2 by 2-2.5 cm, greyish pubescent then glabrescent.

Species: *Quercus fleuryi* Hickel & A.Camus



Tree, 8-20 m high, 60-100 cm girth. Twigs densely tomentose. Bark dark brown.

Leaves obovate, obovate oblong, oblong, 7-23 by 2.2-6 cm always whole at the end of twigs. Base obtuse, slightly cuneate. Apex broadly acute, acute, obtuse. Margin usually serrate on the upper half or one-third to apex. Lamina coriaceous, glabrous, except sparsely pubescent along midrib and nerves on the upper and pale on lower surface. Midrib and nerves prominent on lower surface. Lateral nerves 8-11 pairs. Scalariform veins conspicuous on lower surface. Petiole 1.5-2.5 cm, pubescent then glabrescent.

Species: *Quercus helferianus* A.DC.



Tree, 6-25 m high, 60-230 cm girth. Twigs densely tomentose then glabrescent, lenticellate. Bark blackish, deeply longitudinal furrowed.

Leaves oblong, elliptic oblong, 10-16 by 5-12 cm. Base obtuse, usually oblique. Apex acute, acuminate. Margin serrate on the upper half. Lamina coriaceous but brittle, pubescent then glabrescent on upper surface, except along midrib, densely velutinous on lower surface. Lateral nerves 12-16 pairs, straight and protrude to the end serrate of margin. Scalariform veins fine distinct on lower and depressed on the upper surface. Petiole 1.5-3 cm, densely tomentose.

Species: *Quercus kerrii* Craib



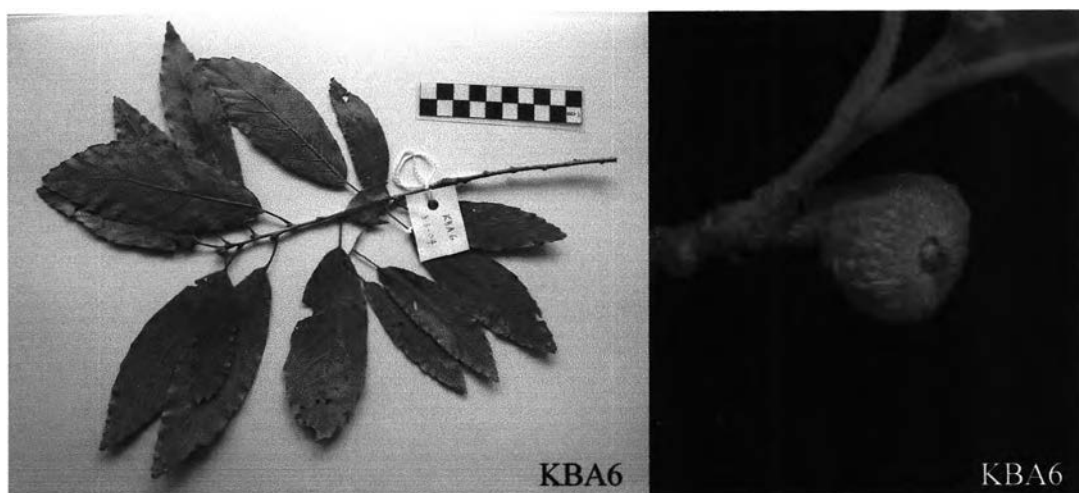
Tree, 5-40 m high, 50-150 cm girth. Terminal bud ovoid, 4-5 by 3 mm, pubescent on outer part. Twigs pubescent then glabrescent, lenticellate. Bark, blackish brown, deeply furrowed. Stipules linear, ca. 5 mm long pubescent.

Leaves oblong, ovate oblong, lanceolate, 10-24 by 3-10 cm. Base obtuse. Apex acute. Margin serrate. Lamina subcoriaceous, densely pubescent especially on lower surface, then glabrescent except along midrib and nerves on lower surface. Midrib and nerves prominent on lower and depressed on upper surface. Lateral nerves 15-17 pairs, straight protrude to the end point of serrate margin. Scalariform vein conspicuous on lower surface. Petiole 1-2 cm, pubescent then glabrescent.

Male inflorescence simple, few branches, tufted 2-5-pendulous catkins, 3-10 cm long on the upper leaf-scars or axillary of young twigs, tomentose, bracts and bracteoles, ovate-acute, ca. 3 by 1 mm, tomentose on outer part, ciliate. Flowers always in cluster 3-5-7-flowered, perianth campanulate, ca. 3 mm long, 6-(7)-lobed, lobes devided, ca. 1/2 to the base, tomentose outer part. Stamens 6-8, 2.5-3 mm long, sparsely hairs glabrous. Female inflorescence axillary and the upper leaf-scars erect spike, 3-5 cm long, tomentose, each spike many free flowers, other as male flowers. Style (3)-5, cornate. Stigmata slightly obovate.

Acorns sessile, obovoid, flatted top, 0.5-1.1 by 0.5-2.1 cm (including cupule), on erect infructescence 5-10 cm long, acorns free, 3-10 acorns in each infructescence. Cupule obconical-shaped, enclosed at same level of the top of nut. Skin compose of grey to brown hairs lamentas, set in 5-10 finess annulars or lamellae. Nut 1 per cupule, flatted to minutely retuse apex, ca. 1 by 1.5-2 cm, brown indumentum, then glabrescent.

Species: *Quercus kingianus* Craib

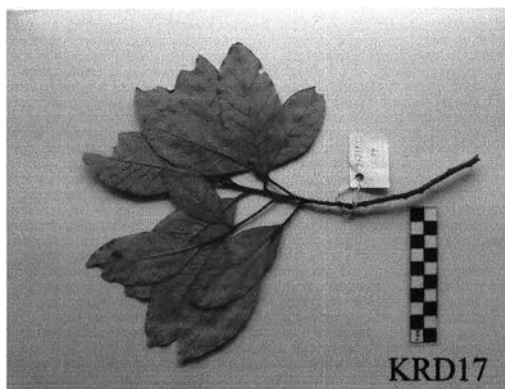


Tree, 7-30 m high, 60-200 cm girth. Twigs tomentose then glabrescent, lenticellate. Bark dark brown with greyish patches, irregularly fissured. Stipules linear lanceolate, ca. 1 by 0.2 mm, pilose.

Leaves oblong, elliptic, ovate or obovate, 8-20 by 3.5-8 cm. Base obtuse, cuneate, and more or less oblique. Apex acute, rarely obtuse. Margin serrate. Lamina subcoriaceous, pubescent then glabrescent on upper surface, densely to sparsely tomentose unless along nerves on lower surface, dark green on upper and greenish on lower surface. Midrib and lateral nerves prominent on lower and depressed on upper surface. Lateral nerves 9-14 pairs, rather straight and the end protrude to the end of serrate margin. Scalariform veins distinct on lower surface. Petiole 1-2-(4), pubescent, glabrescent.

Acorns sessile obconical in outline, 1.4-2.5 by 1.4-3.5 cm (including cupule), on erect and woody infructescence 1-4 cm long. Cupule obconical, enclosed 3/4 to 5/6 of the nut from the base. Skin composed of alternate lamellae with thick and incurved apex. Nut ovoid, ellipsoid, depressed on base and apex, 1.7-2.5 by 1.5 cm, dark brown, silky pubescent around the umbonate.

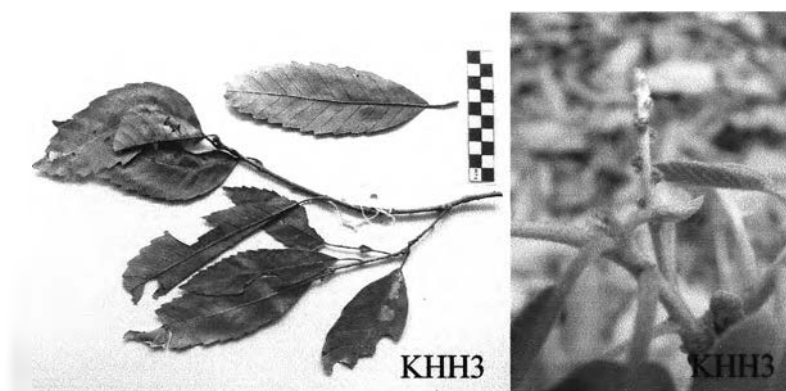
Species: *Quercus lenticellatus* Barnett



Tree, 10-40 m high, 80-250 cm girth. Terminal and axillary buds ovoid or rounded, bracts ovate, 3-4 by 1-1.5 mm, pubescent outer part. Twigs tomentose then glabrescent, lenticellate. Bark dark grey, roughly cracked.

Leaves oblanceolate, obovate, lanceolate oblong, 8-18 by 2.5-7 cm. Base slightly cuneate, suboblique. Apex broadly acute and usually minutely retuse. Margin entire to slightly serrate on the upper third to apex. Lamina subcoriaceous to coriaceous, glabrous, dull dark green on upper and greenish on lower surface. Midrib and nerves prominent on lower and depressed on the upper surface. Lateral nerves 8-10 pairs, arched but not anastomosing. Scalariform veins hardly distinct. Pitiole 1-1.5 cm, pubescent then glabrescent, reddish brown or blackish when dry.

Species: *Quercus lineatus* Blume



Tree, 10-35 m high, 100-200 cm girth. Terminal buds globose, ovoid, pubescent then glabrescent. Twigs densely pubescent then glabrous, dark grey, lenticellate. Bark brown to dark brown, smooth. Stipules linear acute, 10-15 by 1-2 mm, pubescent.

Leaves lanceolate, lanceolate oblong, 9-17 by 1.5-5 cm, not whorl at the end of twigs. Base acute, obtuse to oblique. Apex acuminate, cuspidate. Margin strongly serrate on two-third to apex. Lamina subcoriaceous, chartaceous, glabrous except along midrib and nerves on lower surface. Midrib and nerves prominent on lower and subdepressed on the upper surface. Lateral nerves 14-16 pairs, straight and the end protrude to the end of serrate margin. Scalariform veins hardly distinct. Petiole 0.8-1.5 cm, pubescent, glabrescent.

Male inflorescence simple, tufted and pendulous catkins at terminal and axillary, 2-7 cm long, tomentose, bracts and bracteoles ovate-acute, 2-3 by 0.5-1 mm, pubescent on outer part. Flower always free, in cluster 1-3-flowered, perianth broadly campanulate, 4-5-(6)-lobed, ca. 2 mm long, lobes united 1/2 to 1/3 to the base, hairy on both sides. Stamens 6-(8), 2-2.2 mm long, glabrous. Female inflorescence axillary and terminal erect spike, 1-2 cm long, tomentose, each spike 1-5-flowered, free, other as male flowers. Style (3)-4, hairy near base, divergent. Stigmata elongate, curved.

Species: *Quercus mespilifolius* Wall. ex DC.



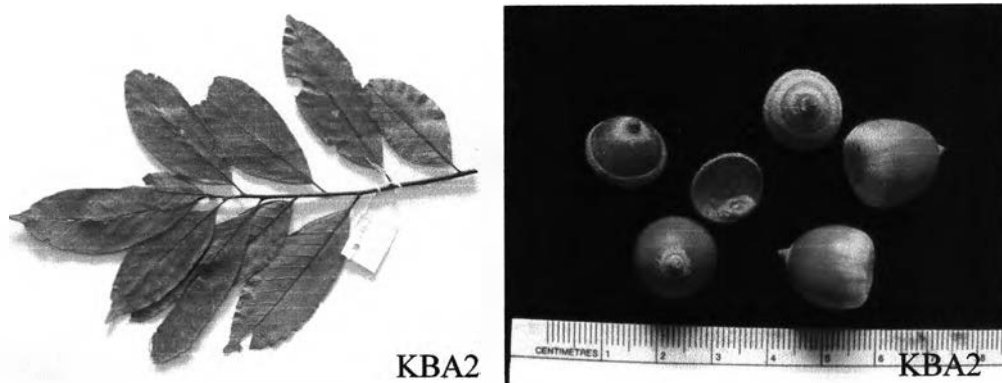
Tree, 8-20 m high, 50-130 cm girth. Twigs greenish brown hairy, then glabrescent. Bark brown, greyish brown, deeply furrowed.

Leaves oblong, la ceolate oblong, rarely elliptic, 5-28 by 2-10 cm. Base obtuse, cuneate, slightly cuneate and oblique. Apex acute, acuminate. Margin slightly serrate. Lamina coriaceous, pubescent then glabrescent except along midrib and nerves. Midrib and nerves prominent on lower and subdepressed on the upper surface. Lateral nerves 11-18 pairs, straight and the endprotrude to serrate margin. Scalariform veins conspicuous on lower surface. Petioles 1-2.5 cm, dark grey to dark brown hairy.

Acorns obovoid, strongly depressed on both tip and base, flatted top and base, flatted top, 1-2 by 1.5-3 cm (including cupule), on erect and slender infructescence, 5-9 cm long, acorn free, usually 4-10 acorns in each infructescence. Cupule saucer-shaped enclosed 1/3 to 1/2 from the base of nuts. Skin compose of dark grey hairy lamentas, set 6-12 annulars or lamellae. Nut 1 per cupule, flatted and minutely retuse apex, 0.5-1 by 1.5-2 cm, grey indumentum, glabrescent, scar at base only, 1-1.4 cm diameter.



Species: *Quercus myrsinaefolia* Blume



Tree, 9-30 m high, 40-180 cm girth. Axillary buds globose, ca. 2 mm diameter, glabrous. Twigs lenticellate, blackish when dry. Bark dark grey.

Leaves lanceolate, lanceolate oblong, usually curved to one side, 5-18 by 2-5 cm. Base cuneate, usually oblique. Apex cuspidate, caudate. Margin serrate at one third to the apex. Lamina chartaceous, glabrous, dirty blackish on upper surface when dry. Midrib prominent on lower and subdepressed on the upper surface. Lateral nerves fine and curved end to the serrate points. Scalariform veins hardly distinct. Petiole 1-3 cm, glabrous.

Acorns sessile, obovoid, ovoid, 1-1.5 by 1-1.5 cm (including cupule) on erect infructescence, 2-7 cm long, acorns free, 2-3-acorns n each infructescence. Cupule obconical-shaped, enclosed on half from the base of nuts, limb not dilate. Skin compose of greyish hairs or indumentum lamentas, set 7-9 annulars or lamellae. Nut 1 per cupule, mammilliform to conical shaped, 2-2.5 by 2-2.7 cm, sparsely silky hairy then glabrescent.

Species: *Quercus quangtriensis* Hickel & A. Camus



Tree, 10-40 m high, 100-200 cm girth. Twigs sparsely tomentose then galbrescent. Bark brown to blackish, lenticellate. Stipules linear, ca. 0.5 cm long, tomentose on both surfaces.

Leaves lanceolate, elliptic lanceolate, 6-16 by 2-4 cm, always whorl at the end of twigs. Base slightly cuneate. Apex acuminate to caudate. Margin usually serrate on the upper half or entire. Lamina subcoriaceous to chartaceous, glabrous except sparsely pubescent along midrib on lower surface, dullgreen on upper and pale on lower surface. Midrib and nerves fine distinct on lower and conspicuous of the upper surface. Lateral nerves 10-14 pairs. Scalariform veins hardly distinct. Petiole 0.5-1.5 cm, reddish tomentose near base.

Species: *Quercus rex* Hemsl.



Tree, 15-35 m high, 100-300 cm girth, usually buttress, up to 5 m high. Terminal and axillary buds ovoid, ca. 5 by 3 mm, bracts ovate-acute, hairy on outer part. Twigs tomentose then glabrescent, lenticellate. Bark dark brown, slightly fissured. Stipules linear, tomentose outer part, ciliate.

Leaves obovate, oblong, broadly elliptic 9-30 by 4-10.5 cm, usually whorl 3-4-leaves at the end of twigs. Base cuneate, acute, rarely obtuse. Apex acuminate, acute to shortly cuspidate. Margin serrate on the upper half to third to the apex or entire sometime. Lamina chartaceous to subcoriaceous, glabrous and glossy green on the upper and pubescent the glabrescent except midrib on lower surface. Midrib and nerves prominent on lower and subdepressed on the upper surface. Lateral nerves 12-16 pairs, arched but not anastomosing, end to the apex of serrate margin. Scalariform veins fine distinct on lower surface. Petiole 1-3 cm, pubescent then glabrescent.

Acorns sessile, ovoid and strongly depressed on both top and base, 1.5-2.5 by 3-4 cm (including cupule), on stout infructescence, 1-2 cm long, acorns free, usually one acorn in each infructescence. Cupule saucer-shaped, enclosed 2/3 to 4/5 from the base of nuts, limb not dilate. Skin compose of tomentose or rusty indumentum laments, the irregular apex of laments reflexed not fused with skin of cupule, set 5-7 annulars or lamellae. Nut 1 per cupule, broadly ovoid to more or less flatted, 1.5-2 by 3-3.5 cm, apex slightly convex.



## Chemical and reagents

### *DNA isolation, rDNA-RFLP, ISSR*

CTAB buffer, 500 ml; 100mM Tris base (6.06 g), 1.4 M NaCl (40.9 g), 20 mM EDTA.2H<sub>2</sub>O (3.72 g), dissolve in 400 ml distill water, adjust pH to 8.0 with conc. HCl, and make up volume to 500. Prior to use, add 2 % (w/v) CTAB, 2 % (w/v) PVP (MW 40000), and 2 % (v/v) 2-mercaptoethanol.

10xTE buffer, 500 ml; 100 mM Tris base (6.06 g) and 10 mM EDTA.2H<sub>2</sub>O (1,86 g), dissolve in 400 ml water, adjust pH to 8.0, and make up volume to 500 ml.

RNase A, 10 mg/ml; 0.05 g Ribonuclease A (bovine pancrease), dissolve in 5 ml of Tris-NaCl (10 mM Tris pH 7.5 and 15 ml NaCl), boil for 15 min to degrade DNase, allow to cool slowly to RT, dispense into aliquots and store at -20°C.

3 M sodium acetate; 408.2 g sodium acetate dissolve in 1000 ml distil water.

Depurination buffer, 0.25 M HCl; 22 ml HCl dissolve in 1000 ml distil water.

Transfer buffer, 0.4 M NaOH; 160 g NaOH dissolve in 1000 ml distil water

Primary wash buffer without urea, 4 g SDS and 25 ml of 20xSSC dissolve in water 1000 ml

### *Chromosome preparation and fluorescence in situ hybridization*

Fixative; A mixture of 1 part glacial acetic acid and 3 parts absolute ethanol.

1 M KCl, 100 ml; 7.5 g KCl dissolve in distil water 100 ml; Prior use dilute to make 75 mM solution (7.5 ml stock + 92.5 ml H<sub>2</sub>O).

1 M EDTA, 100 ml; 37.2 g EDTA dissolve in 80 ml distil water, adjust pH to 8 by NaOH (~1g), and make up volume to 100 ml.

Enzyme for leave, 10 ml; 0.5 g Cellase Onozuka R10 (Merck 102321), 0.5 ml Pectinase (Sigma, P4716) dissolve in 10 ml buffer (75 mM KCl, 7.5 mM EDTA pH 4). It is convenient to make 100–150 µl aliquots in microtubes and store at –20 °C.

10x Unlabelled nucleotide mixture; 5ul of 100mM stock of each dATP, dCTP and dGTP in of 100mM Tris.Cl, pH7.5. Store at -20C.

10x Nick translation buffer; 1 ml; 0.5 M Tris.Cl pH7.5 (0.5 ml of 1M stock), 50 mM MgCl<sub>2</sub> (0.5 ml of 100mM stock) and 0.5mg/ml bovine serum albumin (nuclease free). Filter sterilize and store at -20C.

1,4-Dithiothreitol (DTT), 100 mM; 15.5mg DTT dissolve in distil water to make 1ml. Store at -20C.

0.5 M EDTA, 100 ml; 18.6 g EDTA dissolve in 80 ml distil water, adjust pH to 8 by NaOH, and make up volume to 100 ml.

Protinase K, 500 µg/ml stock solution; 0.01 g protinase K dissolve in 20 ml protinase K buffer. Working solution 1 µg/ml, add 100 µl protinase K 500 µg/ml stock in 50 ml protinase K buffer.

Protinase K buffer, 1000 ml; 20 mM Tris (2.4 g), 2 mM CaCl<sub>2</sub> (0.29 g), dissolve in 800 ml H<sub>2</sub>O, adjust pH to 8.0 with HCl (~35drops) and make up volume to 1000 ml.

Protinase K Stop buffer, 1000 ml; 20 mM Tris (2.4 g), 2 mM CaCl<sub>2</sub> (0.29 g), 50 mM MgCl<sub>2</sub> (4.7 g), dissolve in 800 ml H<sub>2</sub>O, adjust pH to 8.0 with HCl and make up volume to 1000 ml.

RNase A, 10 mg/ml stock solution; 10 mg RNase A, dissolve in 10 ml of Tris-NaCl (10 mM Tris pH 7.5 and 15 ml NaCl), boil for 15 min to degrade DNase, allow to cool slowly to RT, dispense into aliquots and store at -20°C. Working solution 5 µg/ml, 20 µl RNase A 10 mg/ml stock solution in 40 ml 2x SSC.

20x SSC, 1000 ml; 3 M NaCl (175.4 g), 0.3 M trisodium citrate (88.2 g), dissolve in 800 ml H<sub>2</sub>O, adjust pH to 7.0 with 1N HCl (about 0.7ml) and make up volume to 1000 ml. The stock 20x SSC is diluted to make 0.1x SSC, 2x SSC and 4x SSC.

4x SSC Tween, 500 ml; mix 100 ml 20x SSC with 400 ml H<sub>2</sub>O, add 1 ml of Tween 20 and mix well.

Paraformaldehyde 4% (w/v), 500 ml; paraformaldehyde 20 g dissolve in 400 ml distilled water, in a fume hood, heat to 70–80 °C for 10 min. Add 1–2 drops of 1 M NaOH to clear the solution, adjust pH to 7 using PBS buffer, and make up volume to 500 ml, allow to cool to RT. It is convenient to make 50 ml aliquots and store at -20 °C.

Formamide; Once the bottle is opened, make aliquots and store them at -20C.

Dextran sulfate, 50% (w/v); 2.5 g dextran sulfate in 5 ml distil water, heat to 70°C to help dissolving, filter sterilize and aliquots, store at room temperature. Heating to 40C before use and pipetting with wide-bore tips is recommended.

DAPI, 1 µg/ml; Prepare 100 µg/ml stock solution of DAPI (4', 6-diamidino-2-phenylindole) in H<sub>2</sub>O. Make 1 µg/ml working solution by diluting the stock at

1:100 in McIlvaine's citrate buffer pH7 (mixing 18 ml of 0.1 M citric acid monohydrate and 82 ml of 0.21 M Na<sub>2</sub>HPO<sub>4</sub> dihydrate). Store in aliquots at -20°C.

Antifade mountant: To protect the fluorescent signal, an antifade is used to mount the preparation for microscopic examination. Recommended antifade: Vectasheild (Vector Laboratories, USA) or Citifluor AF1 (Citifluor Ltd, UK).

## Biography

Miss Ploenpit Chokchaichamnankit was born on February 23, 1975 in Chonburi, Thailand. She received bachelor degree in genetics in 1997 from the Department of Botany, Faculty of Science, Chulalongkorn University. She continued her study for master degree in genetics at the same institute in 1997 and was awarded scholarships from Biodiversity Research & Training Program (BRT). She attended the Ph.D. program in Biological Science at Chulalongkorn University in 2001 and was awarded scholarships from the University Development Committee (UDC) and The Royal Golden Jubilee (Ph.D. Program) of the Thailand Research Fund.

