AGE OF TREES IN TROPICAL RAINFORESTS ESTIMATED BY TIMING OF WOOD DECAY

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NG FSP . 2013. Age of trees in tropical rainforests estimated by timing of wood decay. The age of trees in tropical rainforests where there are no annual dry seasons cannot be obtained by counting annual growth rings because such rings do not develop. However, the decay of wood in the humid tropics appears to be related to time and this relationship may provide a method for estimating the age of trees that have hollow (decayed) cores.

Keywords: Dendrochronology, growth rings, heart-rot, sapwood

NG FSP. 2013. Anggaran usia pokok di hutan hujan tropika menggunakan tempoh pereputan kayu. Hutan hujan tropika tidak mengalami musim kering tahunan. Justeru usia pokok di hutan ini tidak dapat ditentukan dengan mengira gelang pertumbuhan tahunan kerana gelang tersebut tidak terbentuk. Bagaimanapun, pereputan kayu di kawasan tropika yang lembap nampaknya berkait dengan masa dan hubungan ini dapat diguna untuk menganggar usia pokok yang mempunyai teras lompong (reput).

INTRODUCTION

In temperate and other seasonal climates, trees can be dated by their annual growth rings. By the ring count method, giant redwood trees *Sequoia giganteum,* up to 823 cm diameter, have been dated to 3200 years old. The bistlecone pine *Pinus longaeva* is smaller but individuals have been dated to 5062 years.

In the tropics, radiocarbon dating has been applied to a single sample of a Brazil nut tree, *Bertholettia excelsa*, 233 cm diameter, grown in the Amazon (Camargo et al. 1994). The age of this tree was estimated at 440 ± 60 years. There was no mention of growth rings in the specimen. Another tree in the Amazon, *Carinata micrantha,* has been found by radiocarbon dating to be about 1400 years old (Chambers et al. 1998). There was also no mention of growth rings in this tree. This claim has been disputed by Worbes and Junk (1999) because the maximum age obtained for other tropical trees, through counting of annual rings, is only about 500 years.

In recent papers on growth rings in tropical trees, authors have asserted that growth rings are common throughout the tropics, that the 'absence of growth rings in the tropics' is an assumption on the part of Whitmore (1975) and earlier authors and that the increasing number of recent studies of trees with growth rings in the tropics has demonstrated this assumption to be a myth.

However, growth rings do not require scientific training to detect. They are self-evident and extremely important in the wood industry because they contribute to the figure, attractiveness and value of wood. The enormous timber industry based on tropical rainforests in South-East Asia does not assume that the timber it processes has no growth rings. The industry knows it for a fact. This fact is supported by the extensive collections of wood samples in the collections of forest research centres in Malaysia and Indonesia.

Growth rings, where found, are associated with tropical seasonal forests in which there is an annual pronounced dry season, while the absence of growth rings is associated with true tropical rainforests where there are no dry seasons. These two kinds of forests are different and it does not help when authors blur the distinction. Such blurring has occurred repeatedly in tropical America. For example, a paper by Bruinen and Zuidema (2006) was based on trees in a forest in Bolivia that has a distinct dry season from May till September, yet the authors called this tropical rainforest. A study in Venezuela involving tree rings was conducted in a forest with an annual dry season from about November till May (Worbes 1999). Another study, in Southern Mexico, was in two forest areas, one with an annual dry season from January till April and the other with an even longer dry season, from November till May (Bruinen et al. 2009). In Asia, forests with pronounced annual dry seasons such as these have never been recognised as rainforests.

The distinction between tropical seasonal forests and tropical rainforests should always be made clear because seasonality has profound effects on tree behaviour. In tropical rainforests, recalcitrant seeds dominate over orthodox seeds (Ng 1980) and phenological cycles are imprecise (Ng 1981). An annual dry season imposes an annual period of rest, with strong repercussions, e.g. strangling and smothering herbaceous weeds such as *Mikania* would be forced to die down annually and restart from seed, and wood-decaying fungi would be forced into dormancy. The annual shedding of leaves in the canopy would allow annual regrowth of trees to take place under equitable light conditions. In true tropical rainforests, there is no annual rest period, no annual die down of herbaceous weeds and fungi, and no annual canopy opening to give understorey trees an annual fresh start. Trees that have gained an advantage in tropical rainforests have a high probability of keeping that advantage permanently and trees that have lost the advantage have a low probability of getting it back. The biggest trees are likely to be those on the most favourable sites, growing at maximum rates without hindrance. The lack of tree rings in tropical rainforests means that the age of its biggest trees still remains a mystery.

DECAY OF WOOD AS A POSSIBLE TIMING MECHANISM IN THE HUMID TROPICS

As a tree grows it produces new wood at the periphery of its wood cylinder. This new wood is known as sapwood. Sapwood, as living wood, contains protoplasm and starch. As new layers of sapwood are produced, old layers are converted to heartwood. The process of conversion is an active metabolic process (Chattaway 1952) in which starch in the cells is used up while the cells themselves are filled up with chemicals before they die. Heartwood is dead wood but the chemicals in it make the heartwood resistant to fungal and insect attack.

In the living tree, the sapwood, though free of preservative chemicals, is quite immune to fungal and insect attack. This immunity, conferred by its life-support system, is strikingly demonstrated when a tree is struck by lightning and killed. With death, the immunity of sapwood is destroyed and the sapwood is quickly invaded by fungi and wood-boring beetles.

When a tree is cut for timber, its life-support system is similarly shut down and as a result the sapwood will decay quickly under exposed conditions. However the heartwood could have a service life of many years. In Malaysia until the mid-1900s, wood was commonly used for construction of houses and bridges. Now brick, concrete, metal and artificial materials are favoured. The durability of timbers was of practical concern when timber was the primary construction material and timbers were rated as durable, moderately durable or non-durable. It has been found through experience that the timbers with the longest service life under exposed conditions in Malaysia are chengal (*Neobalanocarpus heimii*) and belian (*Eusideroxylon zwageri*). In use, the sapwood, easily identified as a ring of lighter colour round the heartwood, is discarded. Both chengal and belian are heavy timbers with density of about 950 kg m^{-3} at 12% moisture content, and in both cases the centres of big trees are hollow. Buildings of chengal that are 100 years old are still in existence as museum pieces but they require replacement of individual pieces of wood from time to time. It would appear that chengal heartwood has a service life of about 100 years. At about this age, its chemical protection breaks down. We do not know what the chemical process of breakdown involves and why the heartwoods of different species have different levels of durability. In contrast to chengal, *Acacia mangium* in Malaysia is known to develop heart-rot at the age of about 10 years.

Since timber breaks down after a certain span of time, we have a possible timing mechanism for estimating the age of trees that have hollow cores (Figure 1). For a given species in which chemical protection is effective for X years, the band of heartwood, measured from the sapwood–heartwood boundary to the edge of the rotten core, would be X years regardless of the thickness of the heartwood band. A faster-growing tree would have a thicker band of heartwood than

Figure 1 A stack of freshly cut logs of mixed species in a Malaysian log yard showing heartwood decay

a slower-growing tree. The thickness of the heartwood band divided by X years (assumed to be constant for a given species) would give the radial growth rate of the tree. The age of the tree can be estimated from the growth rate, assuming a constant rate throughout the life of the tree. This reasoning is illustrated in Figure 2. The two assumptions, namely, constant time of chemical breakdown and constant rate of growth will require refinement, but a constant need not be an exact figure. It may incorporate a buffer range, e.g. 100 ± 25 years for time of chemical breakdown and 1 ± 0.25 cm per annum for rate of growth.

For a species with X = 100 ± 25 years, a tree with a hollow core of radius twice the width of the heartwood band would be 3X or 300 ± 75 years old, not counting the narrow band of sapwood, which would, in the case of chengal, be 1.9–5.1 cm thick (Desch 1957). Trees with a hollow core of radius twice the width of the heartwood band are almost unknown and presumably too unstable to survive.

There would be some interesting silvicultural consequences following this line of reasoning. Fast-grown trees would have thicker heartwood bands than slow-grown trees. Once a tree has reached the age when the centre begins to decay, further growth would increase the size of the hole while the thickness of the heartwood band would remain the same. The optimum rotation time for wood production or carbon sequestration for a species with wood decay time of 100 ± 25 years would be 75–125 years. For a species with wood decay time of 10 ± 2.5 years, the optimum rotation time would be 7.5–12.5 years.

Maximum growth rate for chengal has been found to be 1.63 inches girth per annum (Edwards 1930) which converts to 1.32 cm diameter per annum. Chengal commonly grows to 97 cm diameter, with the largest recorded specimen measuring 388 cm in diameter (Symington 1943). On an assumed growth rate of 1.32 cm per annum, a tree could grow to 388 cm diameter in 294 years.

TREES WITHOUT HEARTWOOD: TROPICAL SAPWOOD TREES

There is an alternative growth strategy for trees in the humid tropics, which is to maintain their entire wood body as sapwood (Ng 1986). The best known example is jelutong (*Dyera costulata*), in which trees of up to 250 cm diameter are known (Setten 1956). The timber of jelutong is white and light, with density of about 400 kg m^{-3} at 12% moisture content. Jelutong is noted for absence of heart-rot. The wood of such trees have high starch content in all parts of the woody trunk, which makes the wood very attractive to decay organisms when the tree is cut. The cut timber has no durability under exposed conditions,

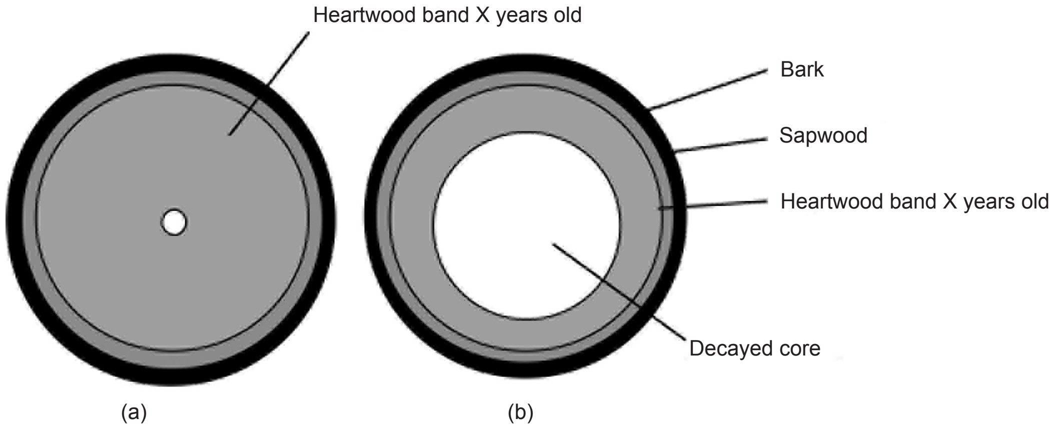

Figure 2 Relationship of sapwood to heartwood and hollow core: (a) tree at just over the age of X years when the innermost heartwood has started to decay, (b) tree with a decayed core of radius twice the width of its heartwood band, hence of age just over 3X years; the growth rate of B would be one-third that of A because its heartwood band is one-third the width of the band in A

yet living trees are relatively immune to insect and fungal attack. The bark of jelutong exudes white latex when injured. Latex also oozes from the pith in the centre of the tree and from the ray canals and ray cells that connect the pith to the bark. Latex has been shown to be a form of cytoplasm (Gomez & Moir 1979). Jelutong is the fastest growing natural forest tree in forest plots analysed by Edwards (1930), with maximum diameter growth rate of 3.4 cm per annum. At this maximum rate of growth, 250 cm diameter could be reached in 74 years.

There are many species that do not produce latex but which have uniformly pale-coloured wood lacking a boundary to distinguish sapwood from heartwood. Such trees may be sapwood trees. Any decay in the centre would then be due to death of sapwood in the centre, not to breakdown of protective chemicals.

EXPERIMENTAL STUDIES ON WOOD DECAY

At the Forest Research Institute Malaysia, tests on durability of timber have been designed as graveyard tests in which wooden pickets of defined dimensions are driven into the soil in selected areas of forests and monitored over time. These tests can easily separate non-durable timbers from durable ones but are not suitable for studying the decay process of durable timbers. For durable timbers, it would be better to monitor tree stumps after a forest has been cut and the stumps are then allowed to decay naturally. This would allow the pattern of decay to be monitored across the trunk to take into account wood of different ages from the periphery to the centre. Small pieces could be removed from time to time for laboratory analysis without interfering with the process of decay on the stump as a whole. It would be extremely challenging to establish such an experiment because the study would have to be maintained for about 100 years.

WHAT WOULD LIMIT THE SIZE OF A TROPICAL RAINFOREST TREE?

A tree with a hollow core in which the hollow core keeps increasing in diameter while the peripheral wall remains constant in thickness would eventually become unstable and collapse. The limit to the size of a tree may to a large extent be determined by the durability of its heartwood in a given growth environment. This raises the possibility that giant old trees such as the giant old redwood trees may be giants mainly because their heartwood is exceptionally durable and able to provide a stable base to support a surface layer of living tissues for several thousand years.

REFERENCES

Bruinen RJW, Lebrilja-Trejos E, Bruegel M, Perez-Garcia EA, Bongers F, Meave JA & Martinez-Romos M. 2009. The potential of tree rings for the study of forest succession in Southern Mexico. *Biotropica* 41: 186–195.

Bruinen RJW & Zuidema P. 2006. Lifetime growth patterns and age of Bolivian rainforest trees obtained by tree ring analysis. *Journal of Ecology* 94: 481–493.

Camargo PB, Trumbore S & Martinilli LA. 1994. How old are large Brasil-nut trees (*Bertholletia excelsa*) in the Amazon? *Scientia Agricoloa* 51: 389–391.

Chambers JQ, Higuchi N & Schimel JP. 1998. Ancient trees in Amazonia. *Nature* 391: 135–136.

Chattaway MM. 1952. The sapwood–heartwood transition. *Australian Forestry* 16: 25–34.

Desch HE. 1957. *Manual of Malayan Timbers*. Malayan Forest Records No 15. Forest Department, Kuala Lumpur.

Edwards JP. 1930. *Growth of Malayan Forest Trees as Shown by Sample Plot Records*. Malayan Forest Records No 9. Forest Department. Kuala Lumpur.

Gomez JB & Moir GFT. 1979. *The Ultracytology of Latex Vessels in Hevea brasiliensis*. Malaysian Rubber Research and Development Board, Kuala Lumpur.

Ng FSP. 1980. Germination ecology of Malaysian woody plants. *Malaysian Forester* 43: 406–437.

Ng FSP. 1981. Vegetative and reproductive phenology of dipterocarps. *Malaysian Forester* 44: 197–231.

Ng FSP. 1986. Tropical sapwood trees. Pp 61–67 in *Naturalia monspeliensia—Colloque International sur l'Arbe*.

Setten GGK. 1956. The largest trees recorded in Malaya. *Malayan Forester* 19: 29–32.

Symington CF. 1943. *Foresters' Manual of Dipterocarps*. Malayan Forest Records No 11. Forest Department, Kuala Lumpur.

Whitmore TC. 1975. *Tropical Rainforests of the Far East*. Clarendron Press, Oxford.

Worbes M. 1999. Annual growth rings, rainfall-dependent growth and long-term growth patterns of tropical trees from the Caparo Forest Reserve in Venezuela. *Journal of Ecology* 87: 391–403.

Worbes M & Junk WJ. 1999. How old are tropical trees? The persistence of a myth. *IAWA Journal* 20: 255–260.