Khulna University
Life Science School
Forestry and Wood Technology Discipline

Author(s): Asif Md. Galib

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Supervisor(s): S. M. Rubaiot Abdullah, Assistant Professor, Forestry and Wood Technology Discipline, Khulna University

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Determination of age and growth of *Alstonia scholaris and Leucaena leucocephala*

ASIF MD. GALIB
Student ID: 140520

FORESTRY AND WOOD TECHNOLOGY DISCIPLINE
KHULNA UNIVERSITY
KHULNA-9208

Determination of age and growth of *Alstonia scholaris* and *Leucaena leucocephala*

BY

ASIF MD. GALIB

Student ID: 140520

Forestry and Wood technology Discipline

Khulna University

Khulna - 9208

Determination of age and growth of
Alstonia scholaris and *Leucaena leucocephala*

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Supervisor

S. M. Rubaiot Abdullah
Assistant Professor
Forestry and Wood Technology Discipline
Khulna University
Khulna-9208

Prepared by

Asif Md. Galib
ID- 140520
Forestry and Wood Technology Discipline
Khulna University
Khulna-9208

APPROVAL

This is to Certify, Asif Md. Galib, ID: 140520, has prepared this thesis entitled "**Determination of age and growth of *Alstonia scholaris* and *Leucaena leucocephala***", under my direct supervision and guidance. I do here by approve the style and content of the thesis. This thesis has been prepared in partial fulfillment of the requirements for the four years professional B.Sc. (Hon's.) degree in Forestry.

09.10.18

....

S. M. Rubaiot Abdullah

Assistant Professor

Forestry and Wood Technology Discipline

Khulna University

Khulna-9208

Bangladesh

DECLARATION

I declare that, this is a result of my own and is has not been submitted or accepted for degree in any other university. I do hereby giving consent for my thesis, if accepted, to be available for photocopying and for entire library loan.

Asif Md. Galib
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Asif Md. Galib

Student ID: 140520

Forestry and Wood Technology Discipline

Khulna University

Khulna

DEDICATED

TO

MY MOTHER

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ABSTRACT

To estimate the biomass, determination of age, height, diameter, growth rate is important. For the purpose of determination age and growth rate of standing tree, three region of Khulna had been selected to collect core samples of *Alstonia scholaris* and *Leucaena leucocephala*. By using increment borer at the point of breast height, cores were collected from trees. Height of trees was also collected. Core samples were scanned and observed for checking growth ring formation. From ocular observation, no distinct growth ring was found. Microscopic observation did not confirm the demarcation of growth ring. So for this two species, age calculation by these methods is not suitable.

Key words: Age, Growth, *Alstonia scholaris*, *Leucaena leucocephala*

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CHAPTER ONE

INTRODUCTION

1.1. Introduction

Wood is the predominant source of fuel in the rural areas of Bangladesh. Generally rural people use wood as fuel for their cooking, heating and any kind of fire. By converting fuel wood to another source of fuel like charcoal or gas we can ensure the efficient use of energy. Quantity of fuelwood in a tree depends on its biomass. To estimate the biomass, determination of age, height, diameter, growth rate is important. There are too many fuel wood species in Bangladesh. Among them, *Alstonia scholaris* and *Leucaena leucocephala* are very important. *Alstonia scholaris* and *Leucaena leucocephala* are fast growing fuel wood species and available in all over the country in Bangladesh. For the converting of fuel wood, industries will be established. Industries need the successive materials to run. Sustainable production of those trees, we have to manage its plantation on sustainable basis. For sustainable management, age and growth rate is very important.

The age of a tree is the length of time elapsed since germination of the seed or budding of the sprout. Tree growth consists of elongation and thickening of roots, stems and branches. Growth causes trees to change in weight and volume and in form. Information on age is important in relation to growth and yield and as a variable in evaluating site quality. Trees undergo physiological changes as they age, including lower photosynthetic rates, decreased growth rates, shifting of carbon resources to different parts of the plant and reductions in foliar efficiency, leaf size and gas exchange rates (Ryan and Yoder 1997; Carrer and Urbinati 2004; Martínez-Vilalta et al., 2007). Generally the growth rate of tree increase upto a certain age, after that growth rate become very low. The common point of mean annual increment and current annual increment is the best time of harvest. We will know this point by determining growth rate.

Annual rings afford the best method of determining tree age in temperate regions. Here most trees grow in diameter by adding a new layer of wood each year between the old wood and bark. Formation of this layer begins at the start of the growing season and continues throughout. Woody tissue formed in the spring is more porous and lighter in colour than woody tissue formed in the summer. Thus annual growths of the tree appear on a cross sections of the stem as a series of concentric rings. A count of the number of rings on a given cross section gives the age of the tree above the cross section (Martinez-Ramos and Alvarez-Buylla 1999).

Twenty five percent of all tropical trees show growth rings. It is not necessary that will be annual. More than one growth ring may be present in a year. So for the determination of exact age of a tree it is important to know the growth ring of a tree. The knowledge of wood anatomy is necessary for the growth ring analysis.

1.2. Objectives of the study

- To determine the age of standing trees of *Alstonia scholaris* and *Leucaena leucocephala*
- To determine the growth of standing trees of *Alstonia scholaris* and *Leucaena leucocephala*

CHAPTER TWO

LITERATURE REVIEW

The description of two fuelwood species of Bangladesh; *Alstonia scholaris and Leucaena leucocephala* is given below...

2.1.1. Taxonomy of *Alstonia scholaris*

2.1.1.1. Classification

Kingdom: Plantae

Division: Magnoliophyta

Class: Eudicots

Order: Gentianales

Family: Apocynaceae

Genus: *Alstonia*

Species: *Alstonia scholaris*

2.1.1.2. Family description

Apocynaceae is a family of flowering plants that includes trees, shrubs, herbs, stem succulents, and vines, commonly known as the dogbane family, (Greek for "away from dog" since some taxa were used as dog poison). Members of the family are native to the European, Asian, African, Australian, and American tropics or subtropics, with some temperate members. The family Asclepiadaceae (now known as Asclepiadoideae) is considered a subfamily of Apocynaceae and contains 348 genera. A list of Apocynaceae genera may be found here.

Many species are tall trees found in tropical rainforests, but some grow in tropical dry (xeric) environments. Also perennial herbs from temperate zones occur. Many of these plants have milky latex, and many species are poisonous if ingested. Some genera of Apocynaceae, such as Adenium, have milky latex apart from their sap, and others, such as Pachypodium, have clear sap and no latex (Apocynaceae-wikipedia).

2.1.1.3. Species description

Alstonia scholaris is a medium to large tree to about 40 m height and 125 cm dbh. The bark is corky grey to grey-white. The boles of larger trees are strongly fluted, tapering and somewhat twisted. The outer blaze is cream to yellowish in colour with an abundant, milky exudate that flows rapidly when cut. The crown is narrow domed, deep and dense, or eventually diffuse with large spreading limbs, small in relation to size of the bole.

The leaves are in whorls of 4-8. The leaf stalks are 1-1.5 cm long, the lamina obovate to elliptical or elliptical-lanceolate, tapering towards the base, 11.5-23 cm long and 4-7.5 cm wide. The leaves are glabrous, upper surface is dark green, the lower green-white with 25–40 pairs of lateral veins on each side of the midrib and 2-6 mm apart.

The tip of the leaf is rounded or shortly pointed, tapering towards the base. The inflorescence is a much branched terminal panicle, up to 120 cm long.

The flowers are 7-10 mm long, white, cream, or green. The fruit is a pendulous, two-lobed dry-dehiscent follicle, brown or green, dry or woody, spindle-shaped, 15-32 cm long, 4-6 mm diameter, each containing numerous flat, oblong brown seeds, 4-5 mm × 0.9-1.2 mm, with a tuft of hairs 7-13 mm long at each end (Forster 1992).

2.1.2. Origin and distribution

2.1.2.1. Location of introduction

Alstonia scholaris is planted for its ornamental value in southern Florida and California, USA (Rudjiman et al., 1993). In Taiwan, the species is planted for timbers (Shen-cheng 1983).

2.1.2.2. Natural distribution

Alstonia scholaris occurs from India, Bangladesh and Sri Lanka through mainland South-East Asia and southern China throughout Malaysia, to northern Australia (Rudjiman et al., 1993).

In Bangladesh, the species occurs sporadically in the forest of Chittagong, Cox's Bazar, CHT, Dhaka-Mymensingh and also found in village shrubberies throughout the country (Das and Alam 2001).

2.1.2.3. DOCUMENTED SPECIES DISTRIBUTION

Native: Australia, Bangladesh, Brunei, Cambodia, China, India, Indonesia, Laos, Malaysia, Myanmar, Nepal, Papua New Guinea, Philippines, Solomon Islands, Sri Lanka, Thailand, Vietnam

Exotic: Taiwan, Province of China, US.

2.1.3. Habitat

2.1.3.1. Ecology

In open evergreen forests to moist deciduous forests, at 200-700 m.

In its natural range in Australia, it is a dominant canopy species found in coastal mesophyll vine forest with a canopy height of 35-42 m, in palm-dominated forests and in notophyll vine forests, associated with *Argyrodendron peralatum*, *Castanospermum australe* and *Cerapetalum sucirubrum* (Orwa et al., 2009).

2.1.3.2. Soil or edaphic condition

Soil type: Favourable soils include alluvia, basaltic red earth, yellow earth with grey-brown topsoil, stony red earth on basic volcanic soils, sandy grey earth, brown earth from a volcanic mixture of rocks and soils derived from metamorphic rocks (Orwa et al., 2009).

Alstonia scholaris is found from lowlands and foothills to uplands and in its native ranges. It occurs from near sea level to 1000 m. (Rudjiman et al., 1993).

2.1.3.3. Climatic condition

Alstonia scholaris is a species of hot humid and warm humid climatic zones with mean annual rainfall usually in the ranges of 1100-3800 mm. the mean annual temperature favourable of the species is 18-28 and the mean minimum temperature tolerable in the coolest month is 12- 22 (Hossain 2015).

2.1.4. Morphological characteristics

2.1.4.1 Fruit

Fruits are about 15-32 cm long. Seeds oblong, not acuminate or caudate at either end, about 4-5 x 0.9-1.2 mm, hairs about 7-13 mm long (Factsheet - *Alstonia scholaris*).

2.1.4.2. Flower

Flowers strongly perfumed, about 5-10 mm diam. Calyx lobes about 1.8-2.2 mm long, sparsely or densely pubescent. Corolla tube about 5-9 mm long, sparsely to densely pubescent in the throat, lobes about 1.5-4.3 mm long, sparsely to densely pubescent, with the left margins overlapping. Anthers about 0.8-0.9 x 0.3 mm (Factsheet - *Alstonia scholaris*).

2.1.4.3. Leaves

Petioles and twigs produce a milky exudate. Leaves in whorls of 4-8.Leaf blades elliptic, elliptic-lanceolate or elliptic-obovate, about 11.5-23 x 4-7.5 cm, petioles about 0.7-1.2 cm long.A small spur (or stipule) usually visible at the base of the petiole. Lateral veins about 25-40 on each side of the midrib. Intramarginal vein close to the edge of the leaf blade (Factsheet - *Alstonia scholaris*).

2.1.4.4.Bark

The bark is corky grey to grey-white (Forster 1992).

2.1.4.5. Stem

Buttresses extending well up the trunk on large trees, gradually fusing with the stem. Latex flow rapid and copious (Factsheet - *Alstonia scholaris*).

2.1.4.6. Seedlings

Cotyledons elliptic, about 7-10 x 3-4 mm. First pair of leaves ovate to elliptic, about 7-15 x 3-6 mm, margins smooth, both the upper and lower surfaces of the leaf blades glabrous. At the tenth leaf stage: leaves very pale or glaucous on the underside. Plant entirely glabrous (Factsheet - *Alstonia scholaris*).

2.1.4.7. Bole

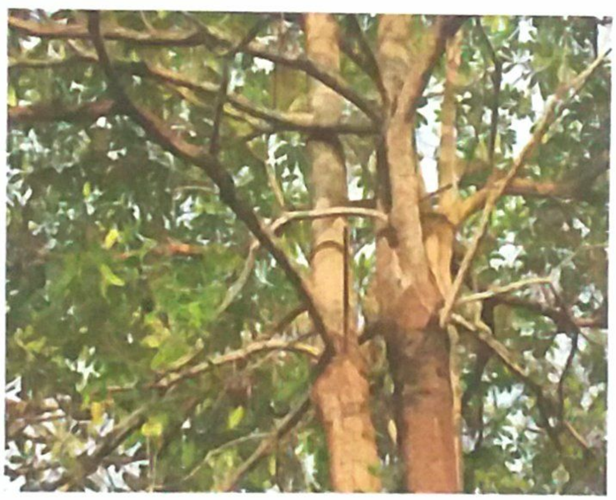
A medium to large tree to about 40 m height and 125 cm dbh. The boles of larger trees strongly fluted, tapering and somewhat twisted (Forster 1992).

2.1.4.8. Branch

The tree is evergreen with branches in whorls. Branches spreading in tiers or whorls.

Fruits and Flower

Bark



Bole

Fig 1: Morphology of *Alstonia scholaris*

2.1.5. Phenology

Alstonia scholaris is an evergreen species. The flowering period is from October-December (Boland et al., 1984). There are two flowering events each year in Sri Lanka (Joseph 1961).

In Bangladesh, mature follicles are collected in March and dry in the sun. Seed is collected after release of the hairs (Hossain 2015).

2.1.6. Regeneration

2.1.6.1. Natural regeneration

In most countries of South-East Asia, *Alstonia scholaris* is harvested selectively from natural forest with a diameter limit of 40-60 cm. seeds are wind dispersed. Natural regeneration of *Alstonia scholaris* is often scarce so enrichment planting may be employed, using the strip system (Rudjiman et al., 1993). However, sufficient opening of the canopy is essential for optimum growth of the seedlings (Hossain 2015).

2.1.6.2. Artificial regeneration

Seed production and nursery raising technique: propagation of *Alstonia scholaris* is mainly done by seeds which dehisce naturally from the mature follicles on drying. There are about 200000-300000 seeds per kg. storage life of seeds is about two months (Rudjiman et al., 1993). Germination time is about 8-10 days with an average germination percentage of 45-50. About 90% of the germinants may provide healthy and vigorous seedlings suitable for out planting. Germination starts within 12 days and continues for 3 months. Plantable of 6 mm diameter at the collar region may also be produced (Hossain 2015). .

2.1.6.3. Planting technique

Commercial plantations are established with a spacing of 2 m × 2 m at the start of the monsoon season. Young trees coppice well. Plantation areas should be cleared and burned (Hossain 2015).

2.1.7. Uses

2.1.7.1. Wood

The heartwood of *Alstonia scholaris* is cream to pale yellow in colour and may exhibit strong odour and bitter taste. The sapwood is visually indistinct from the heartwood. The air-dry density of the wood is approximately 400 kg/m^3. Wood light and soft, medium textured, somewhat lustrous and straight grained (Das and Mohiuddin 2001). The heartwood is not sufficiently durable for external use but can also be readily impregnated with preservatives. It is used for plywood, match boxes, light furniture, black boards, second grade pencils, carving and mouldings (Bootle 1983). The wood is used for making coffins in Sri Lanka, because of its lightness. It is regarded as suitable for pulp and paper production.

Alstonia scholaris is recommended as a fuelwood species in Sri Lanka and managed under short coppice rotations of 6-8 years. Due to its low density, the species makes a poor quality charcoal (Rudjiman et al., 1993).

2.1.7.2. Non-wood

The bark is used for treatment of abdominal pains, dysentery and fevers and the latex is used for neuralgia and toothache (Webb 1948). In India the bark is used to treat bowel complaints and has proved a valuable remedy for chronic diarrhoea and the advanced stages of dysentery. The active constituents are alkaloids found in the bark and latex. Tribes of northern Thailand boil the bark in water and drunk the water to combat the effects of malaria; the bark and leaves are used for a variety of ailments (Anderson 1993).

2.2.1. Taxonomy of *Leucaena leucocephala*

2.2.1.1. Classification

Kingdom: Plantae
Phylum: Spermatophyta
Subphylum: Angiospermae
Class: Dicotyledonae
Order: Fabales
Family: Fabaceae
Subfamily: Mimosoideae
Genus: Leucaena
Species: *Leucaena leucocephala*

2.2.1.2. Family description

The Fabaceae or Leguminosae, commonly known as the legume, pea, or bean family, are a large and economically important family of flowering plants. It includes trees, shrubs, and perennial or annual herbaceous plants, which are easily recognized by their fruit (legume) and their compound, stipulated leaves. Many legumes have characteristics of flowers and fruits. The family is widely distributed, and is the third-largest land plant family in terms of number of species, behind only the Orchidaceae and Asteraceae, with about 751 genera and some 19,000 known species. The five largest of the genera are Astragalus (over 3,000 species), Acacia (over 1000 species), Indigofera (around 700 species), Crotalaria (around 700 species) and Mimosa (around 500 species), which constitute about a quarter of all legume species. The ca. 19,000 known legume species amount to about 7% of flowering plant species. Fabaceae is the most common family found in tropical rainforests and in dry forests in the Americas and Africa.

Recent molecular and morphological evidence supports the fact that the Fabaceae is a single monophyletic family. This point of view has been supported not only by the degree of interrelation shown by different groups within the family compared with that found among the *Leguminosae* and their closest relations, but also by all the recent phylogenetic studies based on DNA sequences.These studies confirm that the Fabaceae are a monophyletic group that is closely related to the Polygalaceae, Surianaceae and Quillajaceae families and that they belong to the order Fabales.

Along with the cereals, some fruits and tropical roots, a number of Leguminosae have been a staple human food for millennia and their use is closely related to human evolution. The Fabaceae family includes a number of important agricultural and food plants, including *Glycine max* (soybean), Phaseolus (beans), *Pisum sativum* (pea), *Cicer arietinum* (chickpeas), *Medicago sativa* (alfalfa), *Arachis hypogaea* (peanut), *Ceratonia siliqua* (carob), and *Glycyrrhiza glabra* (liquorice). A number of species are also weedy pests in different parts of the world, including: *Cytisus scoparius* (broom), *Robinia pseudoacacia* (black locust), *Ulex europaeus* (gorse), *Pueraria lobata* (kudzu), and a number of *Lupinus* species (Fabaceae - Wikipedia).

2.2.1.3. Species Description

The genus *Leucaena* is distinguished from all other Mimosoid legumes by its hairy anthers which are easily visible with a hand lens. *Leucaena leucocephala* is distinguished from other species of *Leucaena* by its intermediate leaflets and large pods in clusters of 5-20 per flower head. It forms a small to medium-sized thornless tree 3-15 m tall and 5-50cm bole diameter. The leaves are bipinnate with an elliptic convex extrafloral nectary on the petiole, 4-9 pairs of pinnae and 13-21 pairs of leaflets per pinna. The leaflets are 9-16mm long and 2-4.5mm wide, nearly sessile and strongly asymmetric linear oblong and acute at the apex. The flowers occur in 12-21mm diameter heads, are cream-white, with ten free stamens per flower and hairy anthers. The pods occur in crowded clusters of 5-20 per flower head and are 11-19cm long and 15-21mm wide pendulous, flattened and papery, and passively dehiscent with 8-18 seeds per pod. Three subspecies are recognised, two of which - subsp. *leucocephala* and subsp. glabrata have been introduced pantropically. These two subspecies correspond to shrubby = subsp. *leucocephala* variants, sometimes referred to as the Common type, and to the more arborescent = subsp. glabrata variants, sometimes referred to as the Giant or Salvador type (Hughes 2018).

2.2.2. Origin and Distribution

2.2.2.1. History of Introduction and Spread

Although many details of the history of introduction of *L. leucocephala* across the tropics remain obscure, it is clear that the shrubby 'Common' type belonging to subsp. *leucocephala* was introduced much earlier than the 'Giant' or 'Salvador' type of subsp. glabrata. Subsp. *leucocephala* is reported to have been introduced to the Philippines aboard one of the annual Spanish government galleons that sailed between Acapulco and Manila between 1521 and 1815 (Merrill 1912). *L. leucocephala*is recorded in Blanco's 1845 Flora of the Philippines (Merrill 1918), but beyond this, the precise date of introduction is not known, although some speculate that it may have been introduced in the 1600s (Brewbaker et al., 1972; Brewbaker and Hutton 1979; Pound and Martínez-Cairo 1983). Reviewing the literature of spread in Asia, Tuda et al., (2009) suggest that introductions date back to as early as 1645 in Taiwan, approximately 1920 in continental China (Guangdong), prior to 1815 in the Philippines, prior to 1867 in Japan and during the Sukhothai Period (1238–1378) in Thailand.

By the late 1800s, subsp. *leucocephala* had spread or been introduced through much of Africa, Asia and the Pacific and it is now pantropical, recorded from the majority of tropical and subtropical countries. Invasive tendencies in the Pacific were also noted as early as 1943 in Nuie, and now it is the most prevalent invasive weed in the region and a serious problem on Tonga (PIER 2007) and the Galapagos Islands.

Subsp. *leucocephala* is an aggressive colonizer of disturbed sites and is spreading naturally It has been recorded as a weed in more than 20 countries scattered across all continents except Antarctica. All early (pre-1960) agronomic investigation, most flora treatments, and references to naturalization and weediness refer to subsp. *leucocephala*, which is pantropically distributed and much more widely naturalized than subsp. glabrata. The latter has been widely introduced outside Mexico and Central America only in the last few decades, but following active promotion of the species it is also now distributed virtually pantropically in cultivation. It is invasive in Guam, Mauritius and La Réunion (Macdonald et al., 1991). In Ghana, there are problems where the species has been introduced for alley cropping (Cobbinah 2002). Binggeli (1997) lists it as a rapidly spreading weed in India. Similarly, Ghate (1991) reports that it was introduced to the Western Ghats in India in the late 1800s and is now reported to be expanding rapidly in all habitats. Small populations of the plant exist on the Galapagos Islands, Ecuador, and whereas Mauchamp (1997) did not report the species behaving invasively, it was believed that it constituted a high risk. *L. leucocephala* is invasive in Florida, USA but not yet thought to have altered habitats (Miller et al., 2003). A record in St Louis, Missouri, USA (Missouri Botanical Garden 2007) is likely to be a protected botanical specimen. It is also considered invasive in Bermuda.

2.2.2.2. Natural Distribution

Leucaena leucocephala originally grew in the midlands of Guatemala, Honduras, El Salvadoer and southern Mexico. Several varieties were spread by pre-Columbian civilizations throughout the coastal lowlands of Central America, from northern Mexico to Nicaragua (NAS 1979).

2.2.2.3. Introduction to plantations

The species was introduced to Indonesia, Philippines, Malaysia, some countries of South East Asia, Hawaii, Northern Australia, India, Bangladesh, East and West Africa, and in the Pacific and Caribbean islands.

Leucaena leucocephala is cultivated in Bangladesh as a fast growing tree for quick afforestation programs, and also for fodder and fuelwood. It is also planted in homesteads, roadsides, office compounds etc.

2.2.3. Habitat

2.2.3.1 Ecology

L. leucocephala is essentially a tropical species requiring warm temperatures for optimum growth and with poor cold tolerance and significantly reduced growth during cool winter months in subtropical areas. For optimal growth it is therefore limited to areas 15-25 deg. north or south of the equator. *L. leucocephala* sheds its leaves even with light frosts, and heavy frost kills all above-ground growth, although trees often sprout the following summer. It grows well only in sub-humid or humid climates with moderate dry seasons of up to 6-7 months. It thrives under irrigation regimes similar to those applied to maize (i.e. over 1200 mm/year). *L. leucocephala* tolerates fast fires and can regrow after being burned to the crown by slower fires.

L. leucocephala ssp. *leucocephala* is an aggressive colonizer of ruderal sites and secondary or disturbed vegetation in many places, both in Mexico and in many parts of Asia such as the

Philippines. This has been attributed to its precocious year-round flowering and fruiting, abundant seed production, self-fertility, hard seed coat, and ability to resprout after fire or cutting. It is now naturalized and among the most prevalent invasive species in many areas such as open (often coastal) habitats, semi-natural, disturbed, degraded habitats, other ruderal sites, and occasionally, agricultural land where it has been planted as a shade tree over cacao. It is a serious problem in Tonga (Orwa et al., 2009).

2.2.3.2. Soil or edaphic condition

Leucaena does best on deep, well drained, neutral to calcareous soils; it is often found naturalised on the rocky coralline terraces of Pacific island countries. However, it grows on a wide variety of soil types including mildly acid soils (pH > 5.2). It is well adapted to clay soils and requires good levels of phosphorus and calcium for best growth.

Leucaena leucocephala thrives in elevations less than 700 meters above sea level. Natural stands are usually found in elevation below 500 m, but it is also growing up to 1350 m in Africa and 1200 m in Latin America. It grows best in areas below about 1500 m altitude and 15-25°C north or south of the equator, although it can survive over a much wider range to about 2000 m and to 30°C north or south of the equator.

2.2.3.3. Climatic condition

Temperature

Leucaena is a tropical species requiring warm temperatures (25-30°C day temperatures) for optimum growth (Brewbaker et al., 1985). At higher latitudes and at elevated tropical latitudes growth is reduced. Brewbaker et al., (1985) suggests that temperature limitations occur:

- Above 1000 m elevation within 10°C latitude of the equator, and

- Above 500 m elevation within the 10-25°C latitude zone.

Leucaena is not tolerant of even light frosts which cause leaf to be shed (Isaraseneee*et al.*, 1984). Heavy frosts will kill all above ground growth, although the crowns survive and will regrow vigorously in the following summer with multiple branches. There is some scope for breeding frost tolerance into *leucaena* Two- and three-way hybrids of *L. leucocephala* with frost tolerant *L. retusa* show promise (Brewbaker and Sorensson 1990). Kendall *et al.*, (1989) suggested that populations of *L. leucocephala* originating from more elevated sites in northeastern Mexico showed greater frost tolerance than those originating from lowland sites. Leucaena growth is strongly seasonal in the subtropics with low yields in the cool months and the majority of growth occurring in the summer months (Cooksley *et al.*, 1988). For these reasons the best opportunities for developing cool tolerant leucaenas lie with hybridisation of *L. leucocephala* with *L. diversifolia*and *L. pallida.* These latter two species can be found in elevated sites in Mexico and demonstrate cool tolerance. Hybrids of *L. diversifolia* (4x) x *L. leucocephala* averaged 4.5 m per year height increase in a 2 year period at Waimea, Hawaii at 850 m elevation and mean annual temperature 17°C (Brewbaker and Sorensson 1990).

Light

Shading reduces the growth of *leucaena* although this plant has moderate tolerance of reduced light when compared with other tree legumes (Benjamin et al., 1991). *Leucaena* seeds will germinate and establish satisfactorily under established *leucaena* hedgerows or under the weed species Lantana camara as a method of rehabilitating infested areas.

It has also been successfully grown under coconuts in Bali as a support for vanilla.

Rainfall requirements and drought tolerance

Leucaena can be found performing well in a wide range of rainfall environments from 650 to 3,000 mm. However, yields are low in dry environments and are believed to increase linearly from 800 to 1,500 mm, other factors being equal (Brewbaker et al., 1985). In Hawaii, it is naturalised on Diamond Head which receives only 300 mm p.a. In Australia the *leucaena* psyllid is much less damaging in drier areas (600-800 mm p.a.) and this is a major advantage for graziers cultivating *leucaena* in subhumid Queensland.

Leucaena is very drought tolerant even during establishment. Young seedlings have survived extended periods of dry weather and soil and plant studies have confirmed that *leucaena* exhibits better drought characteristics than a number of other tree legumes (Swasdiphanich 1992). *Leucaena* is a deep-rooted species which can extend its roots 5 m to exploit underground water (Brewbaker et al., 1972). In shallow duplex soils, roots have been observed to branch and grow laterally at only 30 cm depth due to an impermeable clay layer.

Leucaena is not tolerant of poorly drained soils, especially during seedling growth, and production can be substantially reduced during periods of waterlogging. However, once established it can survive short periods of excess moisture.

2.2.4. Morphological characteristics

2.2.4.1. Fruit

Pods flat, about 11-14 x 1.5 cm, seeds transverse. Seeds about 6-8 mm long, about 8-14 per pod.Testa with an elongated horseshoe-shaped or spathulate mark (pleurogram) on each side. Funicles filiform, long and slender. (Factsheet - *Leucaena leucocephala*).

2.2.4.2. Flower

Flowers borne in heads on paired peduncles in the leaf axils. Peduncles about 20-50 mm long. About 60-80 flowers per head. Calyx tube about 2 mm long. Stamens ten, anthers clothed in white hairs, filaments about 5-6 mm long. Ovary hairy, style about 8-9 mm long (Factsheet - *Leucaena leucocephala*).

2.2.4.3. Leaves

Leaves with (min. 4) 6-9 pairs pinnae; pinnular rachis 5-10.2 cm long, leaflets 9-16 (max. 21) mm long, 2-4.5 mm wide, 13-21 pairs per pinna, slightly asymmetric, linear-oblong to weakly elliptic, acute at tip, rounded to obtuse at base, glabrous except on margins. Leaves and leaflets fold up with heat, cold or lack of water (Orwa et al., 2009).

2.2.4.4. Bark

Bark is mid grey-brown with shallow rusty orange-brown vertical fissures; slash reddish.

2.2.4.5. Stem

Grows into a small tree but often flowers and fruits as a shrub. The younger stems are green and usually densely covered in fine greyish coloured hairs (finely pubescent). Older stems have a relatively smooth, greyish or greyish-brown, bark with numerous small raised spots (lenticels).

2.2.4.6. Seedlings

Cotyledons about 12-17 x 8-11 mm, shortly petiolate, apex rounded, base sagittate. Cotyledonary stipules very small, about 1 mm long. First leaf pinnate, second leaf bipinnate. At the tenth leaf stage: leaves bipinnate with 2-4 secondary axes, each ending in a hair-like process. Leaflets +/-sessile, about 5-13 x 1.5-4 mm, very unequal sided at the base. Stipules about 1-2 mm long (Factsheet - *Leucaena leucocephala*).

2.2.4.7. Slash

Slash salmon pink

2.2.4.8. Bole

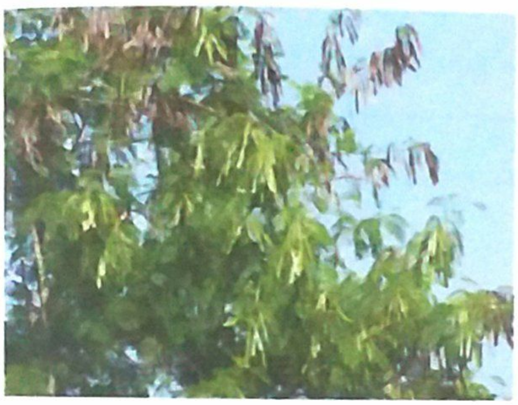
A small tree, commonly reaching 10-35 cm in bole diameter; and older trees may reach 50 cm in diameter

2.2.4.9. Branch

It has a deep taproot and is highly branched

Fruits

Flower



Leaves

Bark

Fig 2: Morphology of *Leucaena leucocephala*

2.2.5. Phenology

Leucaena leucocephala is an evergreen species with partial leaf shedding during the seasons of pod maturity. On areas where moisture is available, leaf shedding is very minimal, but in drier areas leaf (Hossain 2015).

2.2.6. Regeneration

2.2.6.1. Natural regeneration

Leucaena leucocephala can naturally regenerated by seed and coppice. The species is a prolific seeder and after harvesting exposes the seeds to sunlight that enhance the natural regeneration of the species. *Leucaena leucocephala* is an excellent coppice species after harvesting the stump may able to develop profuse coppice shoots with their established root systems. New coppice shoots of some varieties may reach up to 6 meters in 12 months. For firewood production, 2-3 coppice shoots per stump can be allowed to grow for wood production (Hossain 2015).

2.2.6.2. Artificial regeneration

Seed collection and storage: seed collection, extraction, processing and storage are very easy as the species produces seed round the year. There are between 15000-20000 seeds per kg. Clean, dry seeds can be stored for 3-4 years in a sealed container (Hossain 2015).

2.2.6.3. Nursery technique

The hard impervious seed coat of *Leucaena leucocephala* inhibits water uptake and seed requires pretreatment before sowing. Mechanical, hot water and Sulphuric acid treatments proved successful (Hawkins and Ochoa 1991). In Bangladesh, hot water treatment by soaking the seeds in water at 80°C for 3 minutes followed by washing in cold water has been most widely used. Mechanical nicking is suitable for higher germination, but is generally only efficient for small amounts of seeds. The most common methods are raising seedlings on polybags. Polybag size of 23$\times$15 cm was found suitable for production of quality seedlings in the nursery (Ferdousee et al., 2011).

Vegetative propagation through rooted stem cutting, tissue culture, grafting and air-layering are successful but have been limited to experimental programs rather than large scale commercial plantation (Brewbaker 1987; Osman 1995).

2.2.7. Uses

2.2.7.1. Wood

The *Leucaena leucocephala* wood is of medium density (0.5-0.7), with pale yellow sapwood and light reddish-brown heartwood. The wood machines easily, dries without splitting, and generally has accepted pulping characteristics. The wood is used for a wide range of products including domestic and industrial fuel, poles, posts, sawn timber, furniture, flooring, particle board and pulp (Hossain 2015).

2.2.7.2. Non-wood

Leucaena leucocephala has been for soil improvement, soil conservation and erosion control in diverse agroforestry combinations and systems including alley farming, shelterbelts or windbreaks. Leaves of *Leucaena leucocephala* are widely recognized as a valuable green manure in cropping systems. *Leucaena leucocephala* has been recognized as one of the most important tropical fodder trees. *Leucaena leucocephala* leaves have high nutritive value (high palatability, digestibility, intake and crude protein content), resulting in impressive animal production with 70-100% increases in animal live-weight gains compared with pure grass pastures (Jones 1994; Shelton and Brewbaker 1994). Unripe pods and seeds of *Leucaena leucocephala* are also used for food in Indonesia, Thailand, the Philippines and Vietnam (Hossain 2015).

2.3. Growth and Age of trees

The age of a tree is the length of time elapsed since germination of the seed or budding of the sprout. Information on age is important in relation to growth and yield and as a variable in evaluating site quality. In certain, species, branch whorls can be used to determine age. Each season's height growth starts with the bursting of the bud at the tip of the tree; this lengthens to form the leader. The circle of branchlets that grows at the base of the leader marks the height of the tree at the very start of the season's growth. This process is repeated the following year, and a new whorl appears to mark the beginning of that season's growth. A count of these branch whorls thus gives the age of the tree.

Tree growth consists of elongation and thickening of roots, stems, and branches. Growth causes trees to change in weight and volume and in form. Linear growth of all parts of a tree results from activities of the primary meristem; diameter growth from the activities of the secondary meristem, or cambium, which produces new wood and bark between the old wood and bark.

There are three methods to determinate the age of standing tree:

- Ultrasonic testing,
- 14 C dating
- Increment borer method.

An increment borer is a specialized tool used to extract a section of wood tissue from a living tree with relatively minor injury to the plant itself. The tool consists of a handle, an auger bit and a small, half circular metal tray (the core extractor) that fits into the auger bit; the last is usually manufactured from carbide steel. It is most often used by foresters, researchers and scientists to determine the age of a tree. This science is also called dendrochronology. The operation enables the user to count the rings in the core sample, to reveal the age of the tree being examined and its growth rate. After use the tool breaks down: auger bit and extractor fit within the handle, making it highly compact and easy to carry.

Effective use of an increment borer requires specialized training. Samples are taken at breast height or stump height of the tree trunk, depending on the user's objectives; during use the borer should be well lubricated, thus making it easier to use and preventing it from becoming stuck in the wood. As with any other tools, increment borers should be properly maintained to keep them in good working condition; should be thoroughly cleaned after each use and dried before storing. Sharpening kits are available and should be used regularly, hopefully before when such bits become dull.

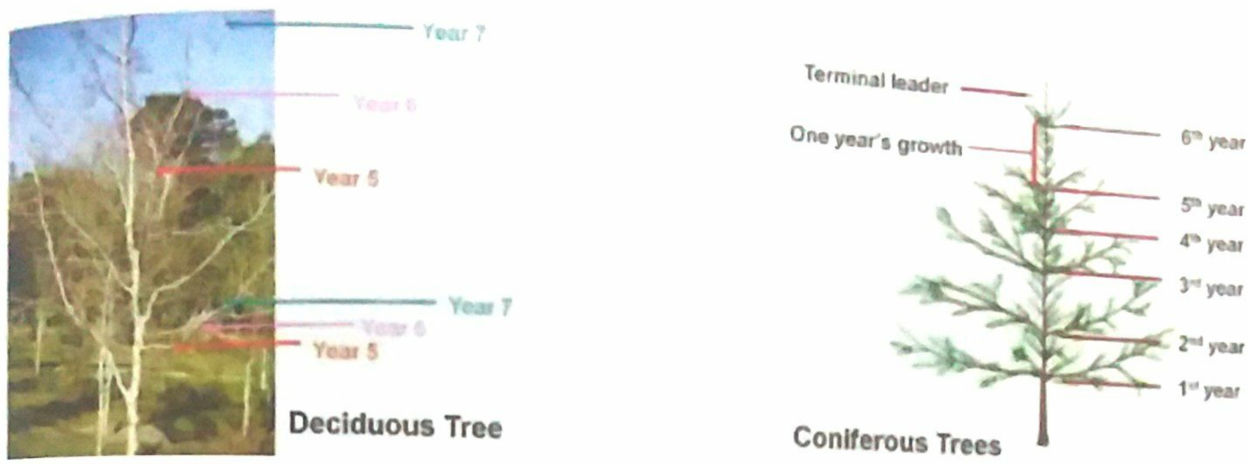


Figure- 3: Growth and Age of trees

CHAPTER THREE
MATERIALS AND METHOD

3.1. Study area

3.1.1. Location

The study was conducted at different areas of the Khulna district. The sites were selected purposively on the basis of availability of *Alstonia scholaris* and *Leucaena leucocephala*. Samples were collected from Khulna University, Krishnanagar and Fatemabag in Batiaghata. Samples were collected with special care during collection procedure because the samples were used for determination of growth ring.

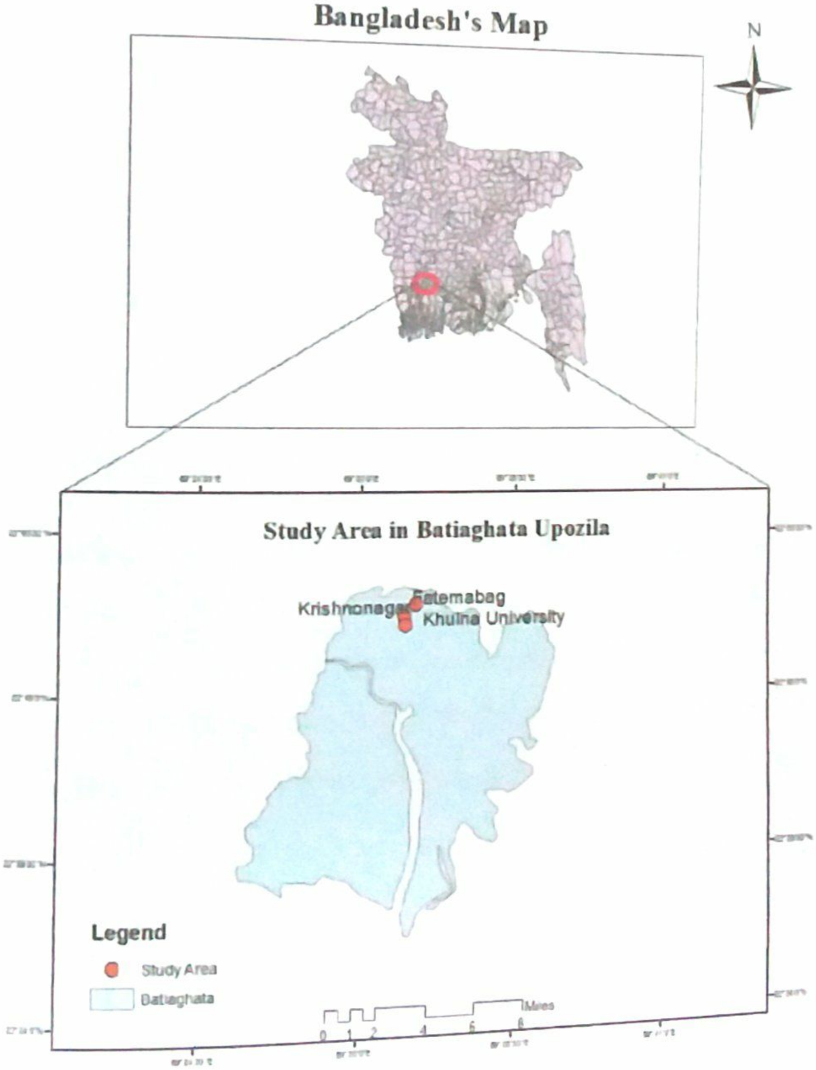


Fig 4: Location of study area

3.1.2. Climate of the study area

Khulna is humid during summer and pleasant in winter. Khulna has an annual average temperature of 26.3 °C (79.3 °F) and monthly means varying between 12.4 °C (54.3 °F) in January and 34.3 °C (93.7 °F) in May. Annual average rainfall of Khulna is 1,809.4 millimetres (71.24 in). Approximately 87% of the annual average rainfall occurs between May and October (http:// khulnacity.org).

3.2. Sample collection

Alstonia scholaris and *Leucaena leucocephala* were available in the study area. By using increment borer at the point of DBH, cores were collected from trees. Diameter at Breast Height and height of trees were also collected. DBH is measured by using diameter tape and height determination has completed by using Haga altimeter. Cores were collected very carefully with ensuring pith point. GPS location was collected for every individual tree. Every core was leveling with code by leveling tape.

3.3. Storage

Cores were stored in the plastic pipe to protect them from break down. Pipe was cut according to core size and some boxes were used for caring the core pipes.

3.4. Preparation of core for analysis

Wood stick was prepared by making a depression in the middle for attaching the core. By using glue, core has attached in the wood stick. The cores weren't give clear view, to get clear view of cores sanding has done by sanding machine and chisel. Core of *Alstonia scholaris* and *Leucaena leucocephala* were prepared for analysis. Core was observed by using hand held magnifying glass. Core was scanned and scanned picture analysis to get growth ring.

CHAPTER FOUR

RESULT AND DISCUSSION

4.1. Result

The core samples of *Alstonia scholaris* and *Leucaena leucocephala* both were sanded by sanding machine and chisel to get smooth, straight core portion. The core of *Alstonia scholaris* and *Leucaena leucocephala* both were observed by hand held lens and found diffuse pore arrangement. Then the high resolution scanned copy of core was observed (figure 4 and figure 5) no growth ring and no distinct pore arrangement were found. For better understanding, the small portion of wood of both species were taken under microscopic supervision, to observe pore density. Sliced portion of cores were zoomed in to see whether any special cell structure and demarcation line but this did not confirm any specialized. In the microscopic supervision, parenchyma cell wall thickness structure couldn't give any idea about growth ring.

Figure 5: Cores of *Alstonia scholaris*

Figure 6: Cores of *Leucaena leucocephala*

4.2. Discussion

Since the 1960s, the use of increment borers to collect core samples at breast height has become the standard method for obtaining intrinsic wood properties in standing trees. An increment core can provide a complete wood sample if it stretches from the pith to the bark and is only limited by the length of the borer and one's ability to extract an adequate core. Borer diameters range from 4 to 12 mm, with the larger diameters giving the best samples when larger quantities of wood are required (Jozsa 1988; Grissino-Mayer 2003; Williamson and Wiemann 2010). Larger-diameter borers (12 mm) cause less compaction because the area to volume ratio of the wood sample is smaller, and larger samples are easier to measure. However, larger-diameter borers require disproportionally greater expenditures of energy to extract cores, so limiting the depth of penetration to only that required to obtain an adequate sample is desirable. For most purposes, it is desirable to bore in a radial line to the pith. This is sometimes difficult because trees are not perfectly round and human operation error may cause the core to be off-center.

Increment coring is by far the most widely used sampling technique to obtain wood density information in standing trees. Knowledge of within-tree patterns has allowed the use of outer wood values for stem selection in breeding programs and for preharvest assessments (Cown 2006; Kimberley et al., 2015). Compared with the traditional destructive sampling method of cutting disks, the use of an increment borer to extract trunk tissue is considered an economically viable option to minimize the workload. In addition, increment cores allow specific biological zones (e.g., the inner 10 rings or the outer 10 rings) to be identified for study and ensure valid comparisons when properties vary with tree age. However, increment coring will always have potential to damage the trunk of the cored trees and incur some risk of negative impacts on tree health. For example, boring in a veneer-quality black cherry tree will lower the value of the butt veneer log and is therefore considered destructive. Also, bore holes can be the entrance source for decay and disease (Hart and Wargo 1965). In addition, for many applications such as tree improvement programs and large-scale wood quality studies, where potentially hundreds and even thousands of trees must be sampled for wood density information, increment coring is time consuming and expensive. A rapid field-type nondestructive method is becoming increasingly important for various research programs and forest operations.

In addition to the age–diameter model, this study also provided one further example of a subtropical species that is suitable for dendrochronological study. Climatic data from the study region indicated that rainfall patterns were strongly seasonal. The winter dry season, consisting of average monthly rainfall levels below 60 mm, followed by a regular wet season during summer and early autumn, provided conditions appropriate for annual growth ring production. Evidence from other studies has shown that similar conditions promote growth-ring production in other tropical regions (Ogden 1981; Boninsegna *et al.*, 1989; Jacoby 1989; Worbes 1995; Grau *et al.*, 2003).

The age–diameter relationship was determined by growthring counts from radial samples. The efficacy of a relationship between tree age and stem diameter is one that has been examined by many studies with varying results. Although some have indicated that a strong relationship can exist between stem diameter and tree age (e.g. Armesto *et al.*, 1992; Singer and Burgman 1999; Rozas 2003, 2004), there can be large intraspecific variation in the age–size relationship, particularly for tropical trees (Martin and Moss 1997; Worbes *et al.*, 2003; Brienen and Zuidema 2006). Although the results from our study presented a strong age–diameter relationship for the subtropical species *A. littoralis*, with little intraspecific variation, this relationship was affected by differences between both gender and site characteristics. Despite the numerous reports on tree rings in the tropics, the situation seems to be more complicated in Southeast Asia and Indian forests. While the pioneer of tropical dendrochronology, (Coster 1927), clearly demonstrated the existence of annual tree rings for many species and different climate zones on Java, recent tree ring studies in Southeast Asia seem to be restricted mainly to teak (Pumijumnong 2013). In studies of Malaysian forests, a lack of rings or the prevailing of indistinct rings are mentioned (Sass *et al.*, 1995), and the same is reported for India (Nath *et al.*, 2016), based on the interpretation of wood anatomical slides alone. In a recent study of Congo timber using wood anatomical properties, 40% of the evergreen species from moist forests were classified into the group of trees with distinct rings (Tarelkin *et al.*, 2016)

The lack of annual growth rings in the majority of tropical tree species greatly limits our understanding of the long-term dynamics of tropical forests. To address this problem, several methods have been developed to estimate the age of tropical trees from diameter growth data. These past approaches, however, suffer from two major flaws: (1) they assume a deterministic age–size relationship for a tree species, and (2) they have not been verified with independently derived age data. In this paper, I present a new approach that uses diameter growth rates, independent of tree size, that are stratified by crown class to estimate the age of individual trees. Past approaches have assumed that when present day canopy trees were juveniles they grew at rates similar to conspecifics currently in the understory. In contrast, the crown class model assumes that present-day canopy trees have grown at rates similar to conspecifics in the same crown class, irrespective of size, throughout ontogeny.

Bangladesh is a tropical country. Annual average rainfall of Bangladesh is 203 cm. In this type of tropical country, growth ring formation is not regular. Climatic condition of Bangladesh is not suitable to form growth ring. Bangladesh received about 2000 mm rainfall throughout the year. Scientists observed inter-annual parenchyma bands to determine the growth ring.

CHAPTER FIVE
CONCLUSION AND RECOMMENDATION

5.1. Conclusion

In this study, we tried to determine the age and growth of a tree. We took core samples in *Alstonia scholaris* and *Leucaena leucocephala* by increment borer. In tropical area, most of the tree species are diffuse porous and form irregular growth ring. It is very difficult to observe ring formation by core analysis. Hand lens, microscopic and scanned copy analysis were performed to determine the growth ring but found nothing significant result.

5.2. Recommendation

Inter-annual parenchyma bands observation may provide a clear idea to understand the age. For the instrumental insufficiency and shortage of time, it is not possible at this moment to do this type of analysis. So, this thesis is recommended for further research.

CHAPTER SIX

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