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Determination of age and growth of *Albizia richardiana* and *Neolamarckia cadamba*

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Determination of age and growth of *Albizia richardiana* and *Neolamarckia cadamba*

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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.

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Dedicated to my parents

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ABSTRACT

Age and growth determination ensure the maximum and sustainable benefits from forest. By knowing growth rate harvesting can be done at right time, ensuring sustainable management. To determine age and growth rate of standing tree, three region of Khulna had been selected to collect core samples of *Albizia richardiana* and *Neolamarckia cadamba.* The cores were collected by using increment borer at the point of breast height. Height and diameter at breast height were also collected for every individual. Core samples were scanned and observed for checking growth ring formation. From ocular observation, no distinct growth ring was found. Slided samples of core were also viewed under high resolution microscope to observe the pore formation and cell wall thickness deviation along the core. Diffuse pore arrangement was found throughout the core and no distinct growth ring was detected. Indistinct growth ring formation and diffuse pore could not declare a clear idea about age of the two species.

Key word: age, growth, Albizia, richardiana, Neolamarckia, cadamba

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CHAPTER ONE

INTRODUCTION

1.1. Introduction

Fuel wood refers to various forms of wood that are used as fuel for cooking, heating or to drive steam-powered engines or turbines for electricity generation. In developing country, the use of fuel wood increasing day by day. Bangladesh is a developing country and most of the area of this country is rural. 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. There are too many fuel wood species in Bangladesh. Among them, *Albizia richardiana* and *Neolamarckia cadamba* is very important. *Albizia richardiana* and *Neolamarckia cadamba* 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 (fuel wood) 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 (size) and in form (shape). 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 (Kaufmann 1996, 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 tree of *Albizia richardiana* and *Neolamarckia cadamba.*
- To determine the growth of standing tree of *Albizia richardiana* and *Neolamarckia cadamba.*

CHAPTER TWO
LITERATURE REVIEW

2.1. Species information:

Albizia richardiana and *Neolamarckia cadamba* are fast growing species and both are good for use as fuel wood. In Bangladesh, the distribution of them is all over the country and people use them huge as fuel wood. They are grown here and there and not very important species as like as other valuable timber production species.

2.2. General information of *Albizia richardiana*

Local names: Raj koroi, Belati amloki, Richardiana koroi, Gagan siris.
Scientific name: *Albizia richardiana*
Synonames: *Gagnebina richardiana* wall
(khatun, 2009)

2.2.1. Taxonomy

Classification (inaturalist.org)

Kingdom: Plantae
Subkingdom: Tracheophyta
Phylum: Magnoliophyta
Class: Magnoliopsida
Order: Fabales
Family: Fabaceae
Subfamily: Mimosoideae
Genus: Albizia
Spesies: *Albizia richardiana*

Family description

The family of Raj koroi is Fabaceae. Fabaceae has three sub families, Mimosoideae is one of them. Raj koroi stands on this subfamily. The subfamily Mimosoideae (classified as a family, Mimosaceae, by some authorities) includes 82 genera and more than 3,200 species. Like Caesalpinioideae, Mimosoideae legumes are primarily woody plants of the tropics, and the few species native to temperate parts of the world are mostly herbaceous. The majority of Mimosoideae have large leaves that are divided into secondary (compound) leaflets, and in many these leaflets are again divided (bicompound) and have a feathery, sometimes fernlike appearance. A striking exception is that of most of the Australian acacias (but not of the American kinds) mentioned above, in which the compound leaves have become modified, losing all their leaflets and appearing to be undivided, or simple. The flowers of the family are radically symmetric and are usually most easily recognized by the long stamens that extend beyond the rest of the flower. The calyx and corolla are both valvate in bud, contrasting with the usual condition in both of the other subfamilies. The petals are small and often not noticed except by close examination. Many of these plants have nodules containing the nitrogen-fixing bacterium *Rhibozium* on their roots (Berry, Isely and Turner, 2018).

2.2.2. Distribution

World distribution

Raj koroi naturally found in Central America and Carebbean countries, North America and South America (Hossain, 2015). It is native in Madagascar (khatun, 2009).

Distribution in Bangladesh

Raj koroi was introduced in Bangladesh in late nineteenth century as an avenue tree. It is planted along the roadsides, gardens and parks as an avenue tree and very common in homesteads in Patuakhali, Barguna, Bagerhat, Barisal, Jhalakhati, Madaripur and Pirojpur districts of southern Bangladesh (Biswas et al. 2010).

2.2.3. Habitat

Climatic condition

Raj koroi thrives best with a best annual rainfall of 1, 700 mm and a range of 500-3000 mm. the annual mean maximum temperature of 32 C and annual mean minimum of 21 C is favourable (Hossain, 2015).

Soil and physiography

Raj koroi prefers well-drained sandy to sandy loam soils. It is also capable of growing in poor soils (Hossain, 2015).

2.2.4. Morphology

Leaves

Leaves are bippinately compound,stipulate, stipules small, caduceus (khatun, 2009). The tree sheds leaves at the end of winter and leaves are replaced during early summer (Benthal, 1933).

Leaflets

Leaflet 60-100 pairs, llinear-falcate, sessile, acute, entire, base unequal, lower side auricled, midrib closer to upper margin, glabrous, smooth and dark green above (Hossain, 2015).

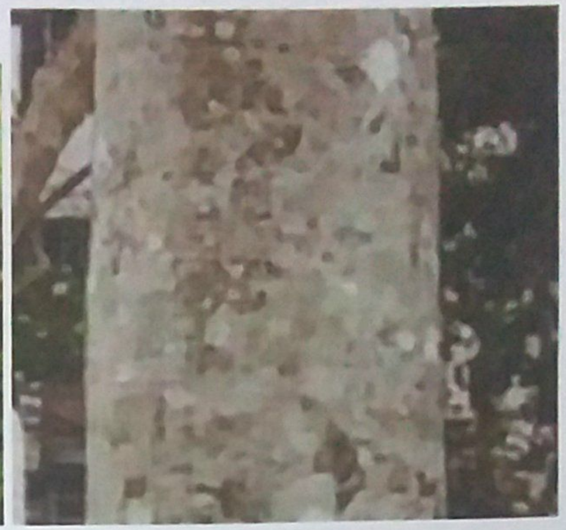
Flower

Flowers are small, greenish white, sessile (Hossain, 2015).

Fruit

Fruit a pod, c 8-10x2.0-2.3 cm, thin, flat, firm and strap-shaped, shortly beaked, dull grayish brown dehiscent (khatun, 2009).

Flower



Bark

Seed

Leaves

Figure 1: Morphology of *Albizia richardiana*

Seed

Seeds are 8-12 per pod, c 6-8 mm longoblique towars the tip near attachment with the funicle, funicle yellow and as long as seed (khatun, 2009).

Bark

Bark whitish in color. Bark is quite smooth, young trees are light in color, it become little dark with maturity.

2.2.5. Phenology

Raj koroi is an evergreen tree. Flowering in August-September and fruits became mature in January-February (Hossain, 2015).

2.2.6. Sivicultural characteristics

Raj koroi is a fast growing, evergreen, dichotomously branched, fairly drought-tolerant, light-demanding but tolerate moderate shade in the pole stage (Hossain, 2015).

Natural regeneration:

Natural regeneration of Raj koroi is limited on moist alluvial soils. Since the species is mainly planted as avenue tree, natural regeneration of Raj koroi is seldom seen in Bangladesh (Hossain, 2015).

Artificial regeneration

The fruits of Raj koroi are straw colour, about 10.8 cm long, 2 cm broad, seeds per pod about 9 (Matin and Rashid 1992). Mature seed is available in February-March. About 10000-12000 seeds are found in a kg. Seeds are light-brownish grey, elliptical in shape. Well dried seeds can be stored for 1-2 years (Hossain, 2015).

Raj koroi seeds are sown in either polybag or nursery bed in the month of March-April. Germination time is about 7-10 days with an average germination of 45-50% (Hossain, 2015). Direct sowing of seeds in the field is possible but the seedlings are infested by weeds severely. Common spacing for forest plantations is 2mx2m, but spacing varies with objectives of the plantations. Raj koroi is planted as individual trees in homestead, roadsides and also as an avenue tree in the office compounds. Once planting sites are cleared of debris by cutting and burning, pits of 30 cubic centimeters are dug before the summer season for planting out. The species is popularly planted by farmers in the homesteads of southern Bangladesh (Hossain, 2015).

2.2.7. Uses

Wood:

Wood is whitish, often without colored sap wood, hard and sustainable (Islam at al 2012). Wood is used to make boats in Barisal district of Bangladesh along with cheap furniture and fuelwood in local markets (Das and Alam 2001). The pulp yield of Raj koroi was comparable to other hardwood species widely used in pulp and paper mills of Bangladesh (Biswas et al. 2012). Raj koroi wood needs seasoning and preservative treatments for making the furnitures durable. The treatment is made by 10% borax-boric acid solution (Hossain, 2015).

Non woods:

Widely planted occur along the roadsides, gardens and parks as an avenue tree for its beautiful foliage and dichotomous branching habit. It is a good fodder (Hossain, 2015).

2.3. General description of *Neolamarckia cadamba*

Local names: kadam, bul kadam

Scientific name: *Neolamarckia cadamba*

English name: Common bur-flower tree

Synonames: *Anthocephalus chinensis* (Lamk), A. rich. *Ex* Walp., *Anthocephalus cadamba* (Roxb). Miq. *Anthocephalus indicus* A. Rich.

(Hossain, 2015)

2.3.1. Taxonomy

Classification

Kingdom: plantae

Order: Gentianales

Family: Rubiaceae

Subfamily: Cinchonoideae

Genus: Neolamarckia

Species: *Neolamarckia cadamba*

Family description:

Rubiaceae, the madder family of the Rubiales order of flowering plants, consisting of 660 genera with more than 11,000 species of herbs, shrubs, and trees, distributed primarily in tropical areas of the world. Members of the family have leaves opposite each other with stipules or in whorls, unbroken leaf margins, and leaflike appendages at the base of the leafstalks. The leaves usually are large and evergreen in tropical species, deciduous in temperate species, and needlelike or scalelike in desert species. The plants may bear a single flower or many small flowers clustered together. Economically important products of the family Rubiaceae include quinine, which is derived from the bark of *Cinchona* species; coffee, from the seeds of *Coffea* species; ipecac, obtained from the roots of *Psychotria ipecacuanha*; and gambier, a substance that is used in tanning, from *Uncaria gambir*. Some trees in the family provide useful timber. Common madder (*Rubia tinctorum*) was formerly cultivated for the red dye obtained from its roots (alizarin); the roots of crosswort (*Crucianella*) also contain a red dye once used in medicines.Plants in the genus *Myrmecodia* have swollen stems with hollow areas that are inhabited by ants. Ants also inhabit the hollow stem segments in the genera *Nauclea*, *Duroia*, and *Hydnophytum*. Two familiar genera of low herbaceous plants native to temperate areas are *Galium* (bedstraw, or cleavers), with small flowers and square stems, and *Mitchella* (partridgeberry), with twin four-petaled flowers borne at the end of each stem.

2.3.2. Distribution:

World distribution:

Its natural range extends from India, Bangladesh, Malay Peninsula, Nepal, Sri Lanka, Vietnam, Mayanmar, Indonesia, Australia, Papua New Guinea, The Philippines and China (Hossain, 2015).

Distribution in Bangladesh

In Bangladesh, it occurs almost throughout the country (Khatun, 2009).

2.3.3. Habitat

Climate:

Kadam can grow in a wide range of rainfall conditions (150-5000 mm /year) with or without pronounced dry seasons. It grows best in sub-tropical moist forests. Mean annual temperature in its native habitat ranges from 3.3-37.7 C (Hossain, 2015).

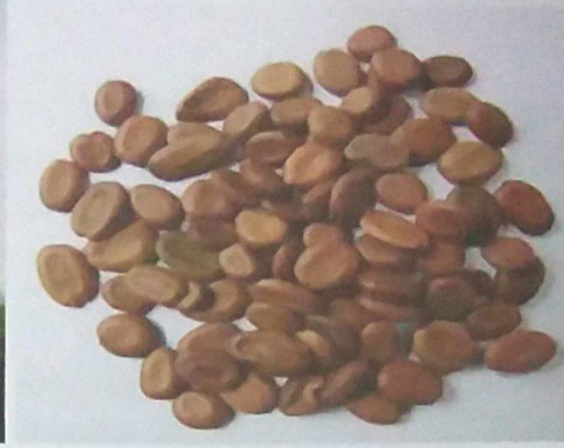
Soil and physiography:

Kadam grows well in deep, moist, well drained loams and on alluvial soils with high fertility from 0-1000 m avobe mean sea level. It also occurs in clays and clay loams derived from sedimentary shales, sandstones and mudstones. It does not grow well in dry, heavy textured or nutrient poor soils (Fox 1971).

2.3.4. Morphology:

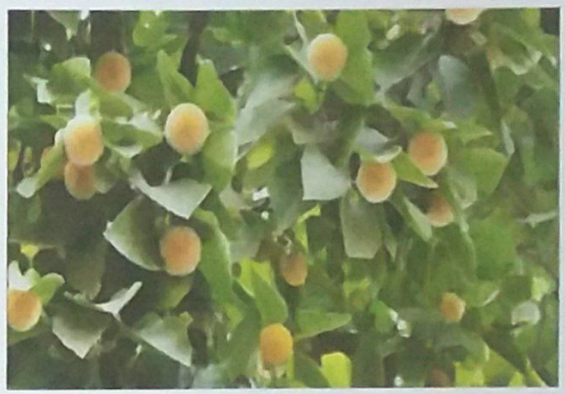
A small or medium-sized tree and is up to 30m tall. Leaves stipulate and petiolate, stipules broadly elliptic to obovate, petoles c 5 mm long, thick glabrous, lamina elliptic to elliptic-oblong or orbicular, 5-30 x 3-15 cm, apex obtuse, base rounded, axils with domatia. Inflorescence a head Flowering axes 1-3, up to 8 cm long, hypanthium up to 1.5 mm long. Calyx tube angled, lobes 5. Corolla is funnel-shaped, tube up to 7 mm long, throat glabrous, lobeslobes deltoid to elliptic, 2-3 mm long, outside densely sericious. Anthers are 5, up to 2 mm long. Styles filiform, stigmasclavate, ovary 2 called. Fruiting heads up to 35 mm in diameter, fruitless 8-10 mm long, crowned by the calyx remnants. Flowering and Fruiting: August-May (Rahman and Das, 2009).

Full tree (Neolamarckia cadamba)

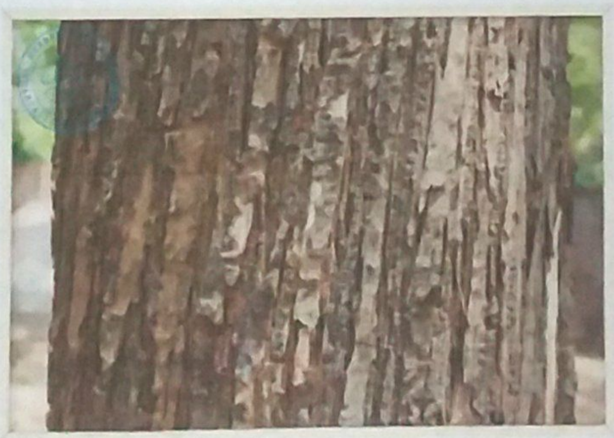


seed

Leaves



Flowers



Bark

Figure 2: Morphology of *Neolamarckia cadamba*

2.3.5. Phenology:

Kadam is a fast growing deciduous tree species. Tree becomes leafless or nearly where leaves fall during hot season. Flowering generally begins at 4 to 5 years. The flowering season runs from May-July. Fruits begin to mature or ripen from January-February (Hossain, 2015).

2.3.6. Silvicultural characteristics:

Kadam is a light-demanding species, but at the early stage prefers partial shade. On good sites, the growth is vigorous and rapid. It is a pioneer species common to old logging sites. It can tolerate wind, has the ability to self-prune, and is suited to coppicing. Young saplings are subject to damage by deer and cattle (Hossain, 2015).

Natural regeneration

Natural regeneration is successful if there are seed producing trees followed by clearing the soil at the time of seed ripening. Dispersal of seeds occurs while the fruits are still on the tree and after they have fallen by ants and other animals. Plantation established from nursery seedlings are less successful than natural regeneration, which is possibly related to local site conditions (Hossain, 2015).

Artificial regenaration

Kadam can be propagated by seed, nursery-grown seedlings, stumps and stem cuttings. The mature fruits are yellow-orange and each fruit contains approximately 8000 seeds. Fruits are readily eaten by ants, cattle and other animals, so, seeds should be collected immediately after the fruits falls. Ripen fruits should be soaked in water until they rot. After maceration by hand, the resultant slurry should be spread on newspapers to dry in a warm condition. Kadam seeds are very small and there are approximately 20000 seeds per gram (Pollard 1969). Seeds can be stored for up to 2 years in cool conditions and for 3-6 months in dry, airtight containers in shaded areas (Hossain, 2015).

The seeds should be sown in germination tray or nursery bed directly. Water must be provided by placing the tray in a bucket, so that the thin mass of seeds should not be dislodges. Germination occurs in 7-14 days (Pollard 1969). Seedlings grown in germination tray need to be pricking out when the seedlings are 3-4 cm in height. The seedlings should be watered regularly for 3-4 months or until seedlings reach about 30-45 cm tall (Hossain, 2015).

Kadam can be planted bare rooted without a significant loss of growth. Stump plants having about 1-2 cm collar diameter give good results. Planting at 3m x 3m or 4m x 4m spacing is recommended depending on the end uses. A close spacing of 2 m x 2m is needed to produce relatively straight bole timbers. First thinning should be done to 5-6 years old plantations (Hossain, 2015).

2.3.7. Management, growth and yield:

Kadam is treated as a "miracle" or "wonder tree" because of its fast growth rate. The tree forms buttresses under flooded conditions, but in well drained areas, it does not. About 60-80% of its straight cylindrical bole is nranchless. Average tree height is about 15-30 m, and tree diameter at maturity ranges from 30-60 cm. Average height growth ranges from 1.8-3.0 m per year during the first 5 years, slowing down to 0.2-09 m per year after 25 years (Hossain, 2015).

Rotations in plantations may vary from 4-7 years according to site location and end-products (Soerianegara and lemmens 1993). Volume increment ranges from 12-30 cubic meter/ha/year during the first 12 years of growth and volume increases almost linearly with age. High production yields of 50 cubic meter/year have been reported in the Philippines (CABI 2005). Usual production is 10-40 cubic meter per year (Hensleigh and Holaway 1988).

2.3.8. Pest and diseases:

Arthroschista hilaralis is an insect which defoliates the leaves of kadam trees. The fungi *Cercospora* sp, *Alternaria* sp and *Cladosporium* sp. cause irregular shaped dark brown or black spots, sometimes with a distinct yellow edge, on leaves. Baksha (2008) recorded 9 pests on kadam in Bangladesh (Hossain, 2015).

2.3.9. Uses

Wood:

Wood white to yellowish white or creamy white with yellowish cast on the longitudinal surface> wood moderately hard and moderately heavy, straight grained, somewhat lustrous, medium coarse textured (Das and Mohiuddin 2001).

Its density is 209-465 (560) kg/ cubic meter at 15% moisture content (Soerianegara and Lammens 1993). With proper treatment it can be used as a material for making tea-chests, packing cases, shuttering, ceiling boards, toys, yokes, carvings, boxes, wooden shoes, matches, pencils, chopsticks, veneer and plywood. It is also a good source of charcoal. It is suitable formaking canoes and cheap furniture. Most important use of kadam is for pulp, producing low and medium-quality paper. The pulp is sometimes mixed with other long-fibre material (Soerianegara and Lammens 1993).

Non-wood:

Kadam is used as a plantation crop for commertial purposes and its wood has a wide range of commertial uses. Because of its spreading crown and large leaves, it is a suitable species for windbreas in agroforestry systems. It is also used an an ornamental tree. kadam leaves are used as a fodder for cattle. The fruits and flowers are edible and the leaves are occasionally used as plates. The bark, when dried, has medicinal properties and is used to relieve fever and as a tonic. The bark of the roots also provides a yellow dye and an important essential oil (Hossain, 2015).

2.4. Growth and age of tree

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.[1] 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.

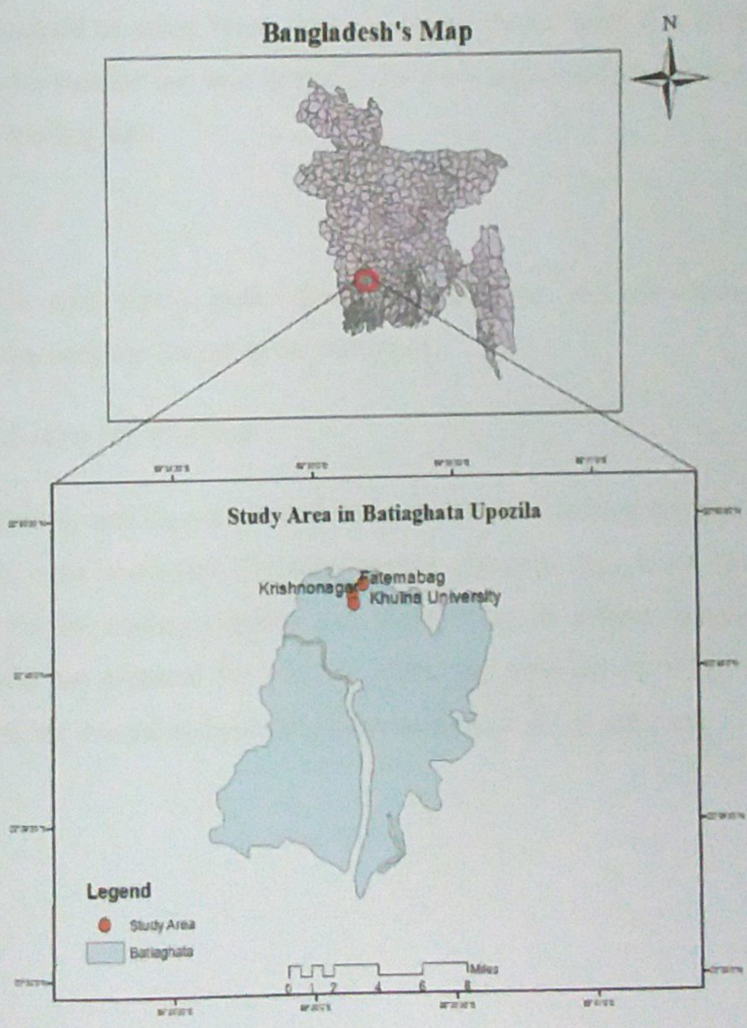
CHAPTER THREE

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 *Albizia richardiana and Neolamarckia cadamba.* Samples were collected from Khulna University Fatemabag and Krishnanagar in Batiaghata. Samples were collected with special care during collection procedure because the samples were used for determination of growth ring.



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 milimetres (71.24 in). Approximately 87% of the annual average rainfall occurs between May and October.

3.2. Sample collection

Albizia richardiana and *Neolamarckia cadamba* are available in the study area. By using increment borer at the point of DBH, cores are collected from trees. Diameter at Breast Height and height of trees are also collected. DBH is measured by using diameter tape and height determination has completed by using Haga altimeter. Cores are collected very carefully with ensuring pith point. GPS location has been 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 use 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 *Albizia richardiana* and *Neolamarckia cadamba* has prepared for analysis. Core was observed by using hand held magnifying glass. Core has scanned and scanned picture analysis to get growth ring.

CHAPTER FOUR
RESULT AND DISCUSSION

4.1. Result

The core of *Albizia richardiana* and *Neolamarckia cadamba* both were observed by Hand held lens. Diffuse pore arrangement was formed throughout the core and no growth ring was detected. Then the high resolution scanned copy of core was observed diffuse pore arrangement (figure 4 and figure 5) and no growth ring was found. For better understand, the small portion of wood of both species were taken under microscopic supervision, no growth ring and diffuse porous vessel density was found again. Cells were zoomed in to see close view by microscopic supervision, any special cell structure and demarcation line weren't found in the cell structure. In the microscopic supervision parenchyma cell wall thickness structure couldn't give any idea about growth ring.

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 (Armesto *et al.* 1992). 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; Azim and Okada, 2014), 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 (Tarekin 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 presentday 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 interannual parenchyma bands to determine the growth ring.

Figure 4: Core of *Neolamarckia cadamba*

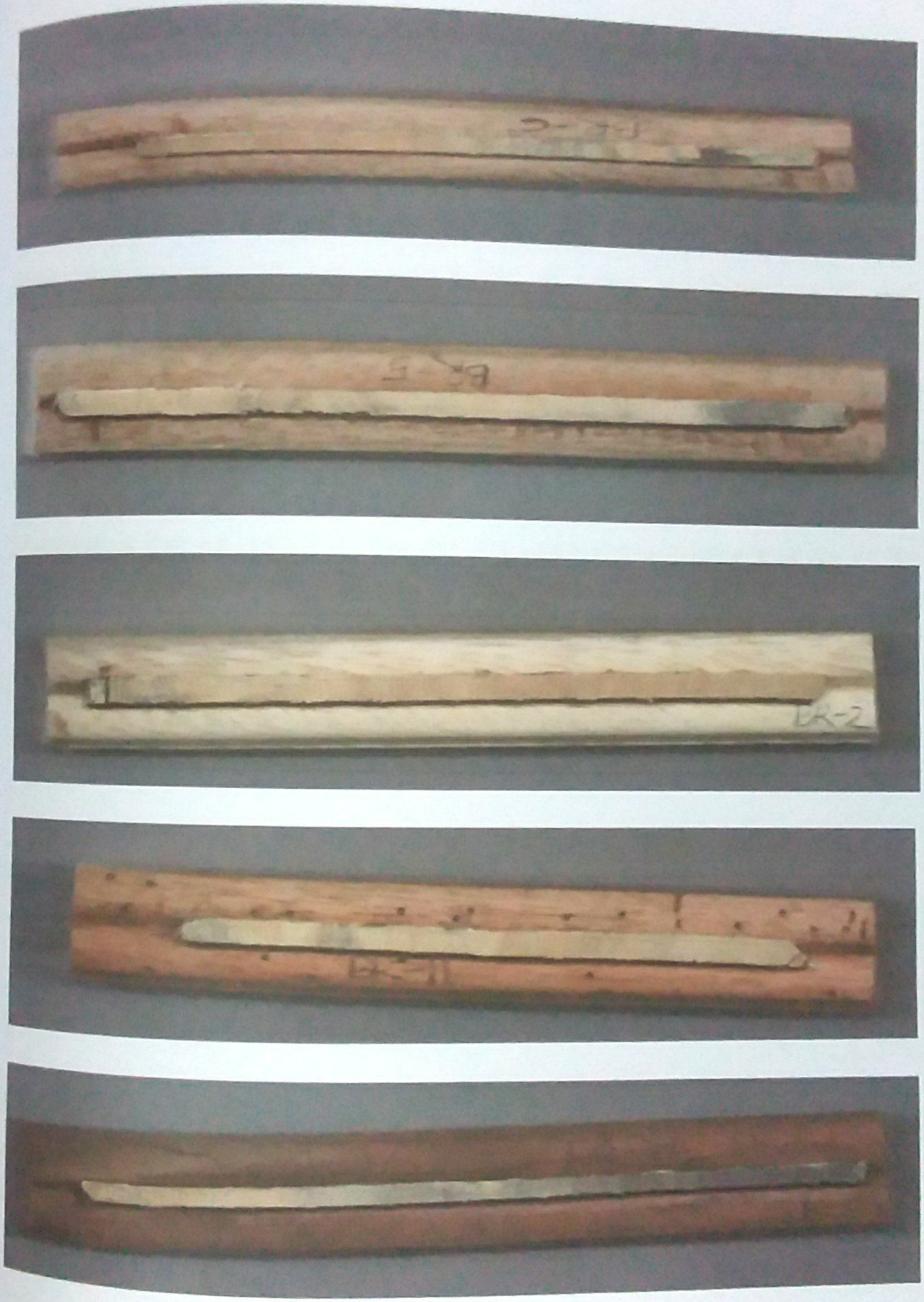


Figure 5: Core of *Albizia richardiana*

CHAPTER FIVE
CONCLUSION AND RECOMENDATION

5.1. Conclusion

Collected cores by increment borer are observed to see growth ring formation. But, in subtropical country formation of growth rings are not regular. As a result growth rings analysis can't determine the age. *Albizia richardiana* and *Neolamarckia cadamba* both are showed diffuse pore. Growth rings observation and pore analysis both are failed to determine age of *Albizia richardiana* and *Neolamarckia cadamba.*

5.2. Recommendation

Interannual parenchyma bands observation may give a clear idea to determinate the age. For the lack of instruments and time it is not possible at this moment to this type of analysis. So, this thesis is recommended for further research.

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