Leaflet No.2/84-85

Government of the Union of Myanmar
Ministry of Forestry
Forest Department
Forest Research Institute

Study on the Substitution of Burmese Species in Place of Imported Wooden Shuttles

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February 1985

ပြည်ပမှတင်သွင်းရသော စက်ယက္ကန်းသုံး သစ်သားလွန်းများအား မြန်မာသစ်များဖြင့်အစားထိုး၍ လွန်းများပြုလုပ်အသုံးချနိုင်ရန်လေ့လာခြင်း

ဦးစိုးမြင့်သိမ်း၊ M.Sc. (GDR)၊ အကြီးတန်းသုတေသနမှူး
ဦးသိန်းကြွယ်၊ M.Sc. (Rgn.)၊ သုတေသနမှူး
သစ်တောသုတေသနဌာန၊ ရေဆင်း။

စာတမ်းအကျဉ်းချုပ်

ပြည်တွင်းတွင် တပ်ဆင်အသုံးချနေသော ဂျပန်နိုင်ငံလုပ်၊ စက်ယက္ကန်းစင်များအတွက် ပြည်ပမှ ဂျပန်လုပ် သစ်သားလွန်းအိမ်များကို မှာယူတင်သွင်းနေရပါသည်။ ထိုတင်သွင်းရသော စက်ယက္ကန်းသုံး လွန်းအိမ်များကို ပြည်တွင်းရှိ မြန်မာသစ် (၈)မျိုးဖြင့် ပြုလုပ်သောသစ်သားလွန်းအိမ်များဖြင့် အစားထိုး စမ်းသပ်ခဲ့ပါသည်။ လွန်းပြုလုပ် စမ်းသပ်ခဲ့သော သစ်မျိုးများမှာ ဂျုတ်၊ တရော်၊ သပြေ၊ ဒဟတ်၊ ဖျောက်ဆိတ်၊ ရုံး၊ သစ်စိမ့်နှင့် နှောတို့ ဖြစ်ပါသည်။ စမ်းသပ်သစ်မျိုးတို့အား သစ်အင်္ဂါဗေဒလေ့လာခြင်း၊ သစ်ဂုဏ်သတ္တိလေ့လာခြင်းများ ပြုလုပ်ပြီး ပြည်ပမှ တင်သွင်းသော လွန်းအိမ်များနှင့် ပုံစံတူပြုလုပ်၍ မိတ္ထီလာ၊ သဲတော၊ ဝမ်းတွင်းမြို့နယ်များရှိ ပုကလိကပိုင် ဂျပန်ပြည်လုပ် စက်ယက္ကန်းများတွင် စင်တင် သုတေသနဆောင်ရွက်ပါသည်။ စမ်းသပ်လွန်းသစ်(၈)မျိုးတို့၏ အလုပ်ခွင်အတွင်း အသုံးချခံနိုင်ရည် စွမ်းအားများအပေါ်မူတည်၍ အဆင့်ခွဲပါသည်။ ယခုစမ်းသပ်ချက်အရ ရရှိသည့်အဖြေမှာ (၁) ဂျုတ်သား (၂) တရော်သား (၃) ဒဟတ်သား (၄) သပြေသားတို့မှာ အစားထိုးသုံးစွဲရန် အတွက် အသင့်တော်ဆုံး ဖြစ်ကြပါသည်။ ဆက်လက်၍ အခြားသင့်တော်မည့် သစ်မျိုးတို့ဖြင့် စမ်းသပ်ဦးမည် ဖြစ်ပါသည်။

Study on the Substitution of Burmese Species in Place of Imported Wooden Shuttles

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Abstract

Wooden shuttles are used in power looms imported from Japan. This investigation sought to substitute shuttles made from Burmese woods for possible cost-savings. Evaluation of the anatomical and mechanical properties of known Burmese species were reviewed and eight species selected for use in shuttles. Results of these first tests indicated that Gyok (*Diospyros montana* Roxb.), Tayaw (*Grewia taliaefolia* Vahl.), Dahat (*Tectona hamiltoniana* Wall.) and Thabye (*Syzygium cumini* Linn.) in that order, were suitable for making shuttles at a substantially lower cost than Japanese-made shuttles.

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1. Introduction

Wooden shuttles are used in textile machines imported from Japan. This paper described an investigation of possible substitution of Burmese species for the wooden portions of the shuttles in the power looms. The purpose of the investigation was to determine the suitability of Burmese woods and the possible cost benefits to be gained from their use.

2. Literature Review

Examination of the anatomical and mechanical properties of Burmese species of wood described by the Forest Research Institute, Yezin was made. Those species with the characteristics suitable for the purposed use sought. From this examination eight species were selected for further testing: Gyok (*Diospyros montana* Roxb.), Tayaw (*Grewia taliaefolia* Vahl.), Dahat (*Tectona hamiltoniana* Wall.), Thabye (*Syzygium cumini* Linn. Skeels; syn.-*Eugenia jambolana* Lank.), Hnaw (*Adina cordifolia* Hook.f.), Yon (*Anogeissus acuminata* Wall.), Thitsein (*Terminalia belerica* Roxb.), Pyaukseik (*Holoptelea integrifolia* Planch.). There being no published data on the working qualities of Burmese woods in such use, it was decided to conduct tests of them.

3. Materials and Methods

Specimens of the eight species to be tested were collected from Tetkone, Yamethin, Pyinmana and Pagan-Nyaung Oo Township, Mandalay Division and all were authenticated both from botanical material as well as structural analysis.

The anatomical structures of the species were determined. Microscopic sections of the wood samples were prepared according to the method given by Jeffery (Johnsen). Photomicrographs of each species were prepared showing (A) Transverse, (B) Tangential longitudinal and, (C) Radial Longitudinal sections at an overall magnification of 83 X. The photomicrophotographs were made using an Olympus Vanox model Universal Microscope.

Sample logs were collected from mature trees of good quality. The logs were cut into scantlings of 2" x 2" x 6'. These were then air-drying to reduce the moisture content to 10-15%. The wood specimens for use as shuttles were graded according to the Malayan Grading rules and desired samples were selected.

The wood specimens were then made into shuttles by manually local carpenters. The interior parts of metallic tongues, shuttle tips and porcelain shuttle eyes were obtained from discarded Japanese-made wooden shuttles. One hundred and fifty shuttles were prepared for each species.

The shuttles were used on Japanese looms of 4 types-Harada, Herano, Iwama and Suzuki. During weaving time when a defect appeared which required the shuttle to be rejected, the time or removal was recorded and the total weaving time noted. The test was continued for 900 hours. The service life for the shuttles of a species group were classified into seven classes of working time as shown in Table 1.

Following this first test, four species were selected for additional testing. Again one hundred and fifty shuttles were made and the service life determined as before. Observations on condition and operations were recorded.

4. Observations

1. Anatomical

The eight species selected displayed the following characteristics and are illustrated in Plates III- X.

a. Gyok (*Diospyros montana* Roxb.)

Family – Ebenaceae

Habit and Distribution

A moderate size tree attaining 9.0-21.0 m in height and 0.9-2.4 m in girth. It is commonly found growing in plain forest and in rocky hill in parts of the dry zone.

General characteristics of the wood

Yellowish brown to greyish brown, dull to lustrous, with smooth feel without characteristics order or taste, moderately heavy (sp. gravity approx. 0.66) straight-grained, very fine and even-textured hard.

Structure of the wood

Fibres: Libriform fibre, non-septate, individual fibres 420-1216 μ in length, 16-21 μ in diameter and cell walls 3-5 μ thick, interfibre pits fairly numerous, bordered, minute and slit-like aperture.

Vessel elements: Growth rings inconspicuous, not distinct to the naked eye; vessel very small to extremely small, number per sq mm. 12-38; evenly distributed; pores distribution mainly solitary medium thick-walled, tangential diameter ranges from 37.0-85.5 μ, perforation plates simple, end wall truncate or nearly horizontal, length of vessel elements ranges from 187-604.5 μ, truncate or tailed on the ends, tyloses absent.

Vascular rays: Not distinct to the naked eye, appearing narrow lines with hand lens extremely closely spaced; number per mm. ranges from 16-28 heterogeneous type 1, uniseriate, bi to triseriate mostly uniseriate, 1-3 cells wide, the height of uniseriate rays ranges from 59.5-612.0μ: the height of multiseriate rays ranges from 280.5-1402.5μ; pitting between ray cells and contiguous parenchyma cells small and fewer in number, ripple mark absent, non-storied.

Xylem parenchyma: Sparse paratracheal parenchyma, restricted to a few cells which are mostly contiguous to the tangential wall of the vessels; metatracheal parenchyma very abundant which are diffused through the fibrous tracts; pitting between xylem parenchyma cells are few in number and small in size.

Working qualities: It is not difficult to work and planes to a smooth hard surface.

b. Tayaw (*Grewia tiliafolia* Vahl.)

Family – Tiliaceae

Habit and Distribution

A moderate to large tree with a straight, fairly cylindrical stem which attains 12-18 m in height and 0.9-1.5 m in girth. It is commonly found growing in plains and mixed deciduous forests of the Upper Burma.

General characteristics of the wood

Sapwood pale yellowish white to brownish grey with age, heartwood reddish brown to brown with darken streaks; dull with smooth feel, odour resembling of new leather, without distinct taste, moderately heavy (sp.gr. approx. 0.72) straight-grained or sometimes wavy grained in radial plane medium-textured; fairly hard.

Structure of the wood

Fibres: Non-libriform to libriform, non-septate, individual fibres 320-1620μ in length, 19-22 μ in diameter and cell walls 3-6μ thick, interfibre pits sparse, minute, slit-like.

Vessels elements: Growth rings distinct to the naked eye; vessels medium size to large number per sq mm. 3-6; quite evenly distributed, but larger in the inner portion of the ring; pore distribution solitary, in multiples or clusters; oval or polygonal in cross sections medium thick-walled; tangential diameter ranges from 230-270 μ; perforation plate simple, end walls nearly horizontal; length of vessels elements ranges from 160-350 μ truncate or rarely abruptly short tailed on one end; tyloses abundant.

Vascular rays: Visible to the naked eye, fairly closely spaced; number per mm. ranges from 5-11; heterogeneous type IIA, uniseriate to triseriate; mostly triseriate; 1-3 cells wide, the height of uniseriate rays ranges from 80-165μ; the height of multiseriate rays ranges from 170-230μ; pitting between ray cells and other parenchyma cell small in size and fewer in number; high wing absent, reddish brown organic infiltration present; ripple marks present; storied wood.

Xylem parenchyma: Abundant paratracheal parenchyma which are restricted to the immediate vicinity of the vessels; metatracheal parenchyma abundant in tangential bands mostly uniseriate lines formed; terminal parenchyma forming a sharply defined and contiguous lines 1-4 seriate; pitting between xylem parenchyma cells few in number and small in size.

Working qualities: The wood is easy to saw and worked up very easily, both on machine and by hand.

c. Dahat (*Tectona hamiltoniana* Wall.),

Family – Verbenaceae

Habit and Distribution

A moderate size tree attaining 13.5-21.0 m in height and 1.5-1.8 m in girth. It is commonly found growing in plain forests and rocky hills in the dry zone.

General characteristics of the wood

Sapwood light greyish brown triated with faint lines; heartwood light to dark brown dull to lustrous, with smooth feel; without characteristic odour or taste; moderately heavy (sp.gravity approx 0.70) straight-grained; fine and even-textured; hard and tough.

Structure of the wood

Fibres: Libriform, medium coarse, septate, for individual fibres 480-1460 µ in length; 35-43 µ in diameter and cell walls 2-6 µ thick; interfibre pits numerous, simple slit-like, steeply oblique orifice.

Vessel elements: Growth rings distinct, visible to the naked eye, but inconspicuous; vessels small to very small and extremely small, not distinct to the naked eye, number per sq mm. 32-42; close and evenly distributed, pore distribution mostly solitary and occurs in radial multiples of up to 2-5 extremely fine straight, vessel not distinct to the naked eye along the grain; oval or circular in cross section; medium thick walled, tangential diameter ranges from 126-140 µ, spiral thickening observed perforation plate sample, nearly horizontal to oblique; length of vessel elements ranges from 156-360 µ; truncate sometimes tailed at the ends, tyloses occasionally observed in the heartwood plugging some vessels which are brownish yellow or reddish brown in colour and gum abundant in the heartwood.

Vascular rays: Not distinct to the naked eye, closely spaced; number per mm. ranges from 6-10 heterogeneous type IIA, uniseriate, to tetraseriate mostly triseriate, 1-4 cells wide, the height of uniseriate rays ranges from 110.5-340.0µ: the height of multiseriate rays ranges from 120.0-769.2µ; pitting between rays cells and other parenchyma cells small in size and fewer in number, crystals absent, ripple marks present, storied wood.

Xylem parenchyma: Paratracheal parenchyma relatively sparse, confined to occasional cells contiguous to the vessels and forming a sheath; metatracheal parenchyma extremely sparse, pitting between xylem parenchyma cells few in number and small in size.

Working qualities : It was without much difficulty and works to an exceptional dense, smooth surface.

d. Thabye (*Syzygium cumini* Linn.) Syn. (*Eugenia jambolam* Lamk.)

Family – Myrtaceae

Habit and Distribution

A large tree attaining a height of up to 18-24 m and girth of 3-3.7 m. Fairly straight cylindrical boles of 15 m is found. It occurs in dry and fairly moist forests at attitude up to 1050m.

General characteristics of the wood

Pale reddish grey to brownish grey, sometimes with faint darker streaks, heartwood not distinct; dull to lustrous with rough feel, without distinct odour or taste; moderately heavy (sp.gr. approx. 0.67), more or less irregular-grained and frequently interlock grained in narrow bands or wavy grained in the radial plane, medium-coarse textured, fairly hard and strong.

Structure of the wood

Fibres: Semi-libriform, coarse, non-septate, rarely septate, individual fibres 1400-3150 µ in length; 35-43 µ in diameter and cell walls 4-8 µ thick, interfibre pits sparse, largely confined to radial wall,minute, slit-like, with steeply oblique orifice.

Vessel elements : Growth rings scarcely distinct; vessel large to medium size or small, the orifices of the largest vessels visible to the naked eye; number per sq mm. ranges from 7-12; fairly evenly distributed; pore occurs solitary or in radial multiples; oval, pentagonal or polygonal in cross section; medium thick-walled; tangential diameter ranges from 230-250 µ; perforation plate simple, end walls nearly horizontal or oblique; length of vessel elements ranges from 240-1550 µ; truncate or abruptly or attenuate tailed on one or both ends; tyloses present.

Vascular rays: Not visible to the naked eye, fairly closely spaced; number per mm. ranges from 9-14; heterogeneous type I, uniseriate to pentaseriate; mostly biseriate to pentaseriate, of 1-5 cells wide, the height of uniseriate rays ranges from 95-1040µ; the height of multiseriate rays range from 250-2310µ; pitting between ray cells and other parenchyma cells small in size and few in number; reddish brown gummy deposits present; ripple marks not present; non-storied wood.

Xylem parenchyma: Paratracheal parenchyma relatively sparse; paratracheal zonate parenchyma to form more or less continuos, wavy, 2-3 seriate; metatracheal bands 1-5 cells wide fairly abundant; pitting between xylem parenchyma cells few in number and small in size.

Working qualities: It is not extremely difficult to saw and works fairly easily by hand and on machine.

e. Hnaw (*Adina cordifolia* Hook.f. syn. Nauclea *cordifolia* Willd.)

Family – Rubiaceae

Habit and distribution

A very large tree attaining a height of 34m and a girth of 1.5-3 m; but only under favourable conditions it attains large dimensions. It occurs in the deciduous forests in the plains and lower hills forests all over Burma.

General characteristics of the wood

Pale yellowish, becoming reddish brown with age, quite lustrous, with fairly smooth feel; sapwood yelowish white rather thick, grading gradually into the heartwood; without distinct odour or taste; light to moderately heavy (sp.gr. approx. 0.65), fairly straight grained interlocked grained or occasional spiraled grained; fine and even textured; fairly hard.

Structure of the wood

Fibres: Non-libriform; fibres and fibre tracheal coarse, non-septate, 840-2265 µ in length and 34-40 µ in diameter and cell walls 4-7 µ thick; interfibre pits numerous bordered with round or elliptical; steeply oblique orifices.

Vessel elements: Growth rings present but inconspicuous, vessel small to very small; number per sq. mm. 41-75; quite evenly distributed; pores solitary or occurs in radial multiples, pore circulars as seen in cross section; medium thin-walled, tangential diameter 60-75 µ; perforation plate simple, nearly horizontal to oblique; length of vessels elements ranges from 450-1500 µ; truncate or abruptly or gradually on one or both ends; tyloses absent.

Vascular rays: Not distinct to the naked eye, very closely spaced, number per mm. 14-22; heterogeneous type I, uniseriate to biseriate; mostly biseriate, 1-2 cells wide; the height of uniseriate rays ranges from 100-3000µ; the height of multiseriate rays range from 110-2020µ; pitting between ray cells and other parenchyma cell small in size and many in number; ripple mark absent; non-storied wood.

Xylem parenchyma: Sparse**,** apotracheal parenchyma diffuse and scattered, pitting between parenchyma cells small in size and few or many in number.

Working qualities: It saws with ease, and polishes well and retains its colour.

f. Yon (*Anogeissus acuminata* Wall.)

Family – Combretaceae

Habit and distribution

A large deciduous tree attaining a height of 25.5-30m and a girth of 2.4-2.7 m with straight cylindrical bole of 9 m which is frequently found. It is commonly found growing in the moist mixed deciduous forests throughout Burma.

General characteristics of the wood

Sapwood light whitish grey to pale greenish grey often with light grey bands, turning light greyish brown with age; heartwood chocolate brown; small; lustrous, with smooth feel, without distinct odour or taste; moderately heavy to heavy (sp.gr. approx. 0.80), fairly straight grained to irregularly interlocked grained; medium fine textured; fairly hard.

Structure of the wood

Fibres: Libriform, very fine, occasionally septate; for individual fibres 340-1600 μ in length and 16-19 μ in diameter and all walls 3-6 μ thick; interfibre pits sparse, slit-like, nearly vertical orifice.

Vessel elements: Growth rings present but inconspicuous; vessels medium sized to small or very small; number per sq mm. ranges from 13-40; quite evenly distributed; pore distribution solitary, with occasion and radial multiples; oval in cross section; medium thick-walled; tangential diameter ranges from 150-175 μ; perforation plates simple; end walls nearly horizontal to oblique; length of vessel elements ranges from 175-600 μ truncated or tailed at the ends; tyloses absent.

Vascular rays: Not distinct to the naked eyes and appearing fine under hand lens, very closely spaced, number per mm. ranges from 15-18; heterogeneous type III, uniseriate to triseriate, mostly uniseriate to biseriate, 1-3 cells wides; the heighest uniseriate ranges from 160-480 μ; the height of the multiseriate rays ranges from 220-650μ; pitting between rays cells and other parenchyma cells small in size and few in number; marginal upright cells absent; ripple marks absent; non-storied wood.

Xylem parenchyma: Paratracheal parenchyma abundant; paratracheal zonate parenchyma and uniting two several adjacent group of vessels never forming definite tangential bands; terminal parenchyma inconspicuous; sometimes interrupted; undulate; metatracheal parenchyma fairly abundant, scattered through the tracts of dense fibrous tissue, pits to xylem parenchyma cells few in number and small in size.

Working qualities: It is a hard and tough timber to saw. It works with care to a shiny, lustrous surface giving the timber a pleasing appearance.

g. Thitsein (*Terminalia belerica* Roxb.)

Family – Combretaceae

Habit and distribution

A large tree attains 18-24 m in height and 1.8-2.0m in girth. It is commonly found in hills and plains of upper mixed deciduous forests and semi-evergreen forests.

General characteristics of the wood

Yellowish grey; heartwood lacking; lustrous, with rough feel; without distinct odour or taste; light to moderately heavy (sp.gr. approx. 0.57-0.75), fairly straight grained and sometimes wavy grained in the radial plane, very course textured fairly strong and tough.

Structure of the wood

Fibres: Non-libriform to semi-libriform fibres; almost all are fibre tracheal; medium fine; non-septate; individual fibres 490-2296 µ in length and 24-26 µ in diameter and use walls 3-6 µ thick; interfibre pits sparse; minute; slit-like; nearly vertical orifice.

Vessel elements: Growth rings fairly distinct under hand lens, extremely large to medium sized; number per sq mm. ranges from 5-15; evenly distributed; pore distribution solitary occurs in radial multiples, elliptical, oval or angular in cross section; thin-walled, tangential diameter ranges from 45-50µ; perforation plates simple, nearly horizontal to oblique; length of vessels elements 225-600 µ; truncate or tailed on the ends; tyloses absent.

Vascular rays: Not distinct to the naked eyes, appearing extremely fine with hand lens, closely spaced, number per mm ranges from 10-15; heterogeneous type II A, uniseriate to pentaseriate; mostly triseriate to tetraseriate, 1-5cells wide; the height of uniseriate ray 100-605µ and that of multiseriate rays 120-900µ; pitting between ray cells and contiguous parenchyma cells small in size and few in number; marginal upright cells absent; ripple marks absent; non-storied.

Xylem parenchyma: Abundant, paratracheal parenchyma vesticentric, alliform of confluent; terminal parenchyma forming a narrow; 1-3 seriate bands; metatracheal parenchyma sparse; pitting between xylem parenchyma cells larger in size and few in number.

Working qualities: The timber is easy to saw and machine, but difficult to bring a good surface.

h. Pyaukseik (*Holoptelea integrifolia* Planch.).

Family – Ulmaceae

Habit and distribution

A large tree attaining a height of 18-21m and a girth of 1.8-2.1m. It is found scattered in the open forests of upper and lower Burma at an altitude up to 600m.

General characteristics of the wood

Uniformly light yellow becoming light yellowish grey with age, lustrous when first exposed; with an offensive odour when fresh which disappears as the timber seasons, without distinct taste; light to moderately heavy (sp.gr. approx 0.63), interlocked grained; medium and quite even textured; fairly hard.

Structure of the wood

Fibres: Semi-libriform to libriform medium fine, non-septate for individual fibres 720-1260µ in length; 28-30 µ in diameter and cell walls 2-4 µ thick; interfibre pits abundant, slit- like, steeply vertical orifice.

Vessels elements: Growth rings distinct to the naked eye but relatively inconspicuous, vessel large sized to small; number per sq mm. 9-15; quite evenly distributed; pore distribution solitary or in multiples, broadly oval in cross section; medium thick -walled, tangential diameter ranges from 170-185 µ; perforation plate simple with end walls nearly horizontal or oblique; length of vessel element ranges from 210-320 µ; truncate or abruptly or attenuately tailed at the ends; tyloses occasionally present.

Vascular rays: Not distinct to the naked eye, fairly spaced, number per mm. ranges from 7-11; heterogeneous type II A, uniseriate to tetraseriate; mostly biseriate to triseriate, 1-4 cells wide; the height of uniseriate rays ranges from 90-125µ; and that of the multiseriate rays from 175-240µ; pitting between ray cells and contiguous parenchyma cells small in size and fewer in number; ripple marks present; storied wood.

Xylem parenchyma: Paratracheal parenchyma fairly abundant, forming 1-3 seriate; paratracheal zonate parenchyma to form concentric, wavy; continuous bands; extending across the rays; metatracheal parenchyma extremely sparse, scattered, in the fibrous tissues pitting between xylem parenchyma cells few and the size of pits is small.

Working qualities: It saws without difficulty and machines well, but does not turn to as clean a finish as the best turnery woods.

2. Technical

The percent of shuttles in service by species at the end of each working class is shown in Table 2 and illustrated in Plate I.

Shuttles of Hnaw, Thitsein, and Pyaukseik were rejected because of loose shuttle tips, shuttle tongues and cracking on the side surfaces of the shuttles. Yon rarely displayed the

above defect but after 300 working hours the shuttle surfaces became rough and fibrous which damaged the yarn. The shuttles hat to be repaired to make them smooth again.

Based on the above observations the test of the service life was made of four remaining species, Gyok, Tayaw, Dahat and Thabye. The results of this test are shown in Table 3 and illustrated in Plate II.

4. Discussions and Conclusions

The four species, Gyok, Tayaw, Dahat and Thabye in that order of preference were found to be satisfactory for use in shuttles on power looms. It is the authors opinion that if wooden shuttles were made from these species using new non-wood parts, there would be a substantial savings of foreign exchange. It was also their opinion that the use of kiln-dried wood should increase the service life through less defect from cracks in the wood.

Further tests of suitability of these species should be made using kiln-dried material and new non-wood parts. Investigations of other species of woods for suitability for this use also should continue to determine the best suited species for use in the manufacture of power loom shuttles.

Table 1. Classification of Shuttle Service Life

Class	Working Time (hrs)	
	From	To
A	0	150
B	151	300
C	301	450
D	451	600
E	601	750
F	751	900

Table 2. Total Service Life Percent by Classes for eight species

Wood Species	Percent shuttles in service at end of service class					
	A	B	C	D	E	F
Gyok	100.0	97.3	94.0	88.0	81.3	62.7
Tayaw	98.7	91.3	80.7	70.7	62.7	48.0
Dahat	97.3	91.3	78.0	66.7	57.3	44.3
Thabye	94.7	86.7	68.7	62.0	51.3	39.3
Hnaw	90.7	62.0	22.7	13.3	6.7	
Yon	86.7	57.4	15.4	6.7	2.7	
Thitsein	60.7	8.7				
Pyaukseik	62.0	6.7				

Table 3. Total Service Life Percent by Classes for four species

Wood Species	Class					
	A %	B %	C %	D %	E %	F %
Gyok	100.0	100.0	98.0	95.0	86.5	68.0
Tayaw	98.5	94.0	85.0	75.5	64.0	50.5
Dahat	96.5	87.5	79.5	66.5	57.0	45.5
Thabye	92.5	85.5	71.5	57.0	48.5	39.0

PLATE I

PERCENT SHUTTLE WORKING LIFE OVER WORKING HOURS FOR EIGHT SPECIES

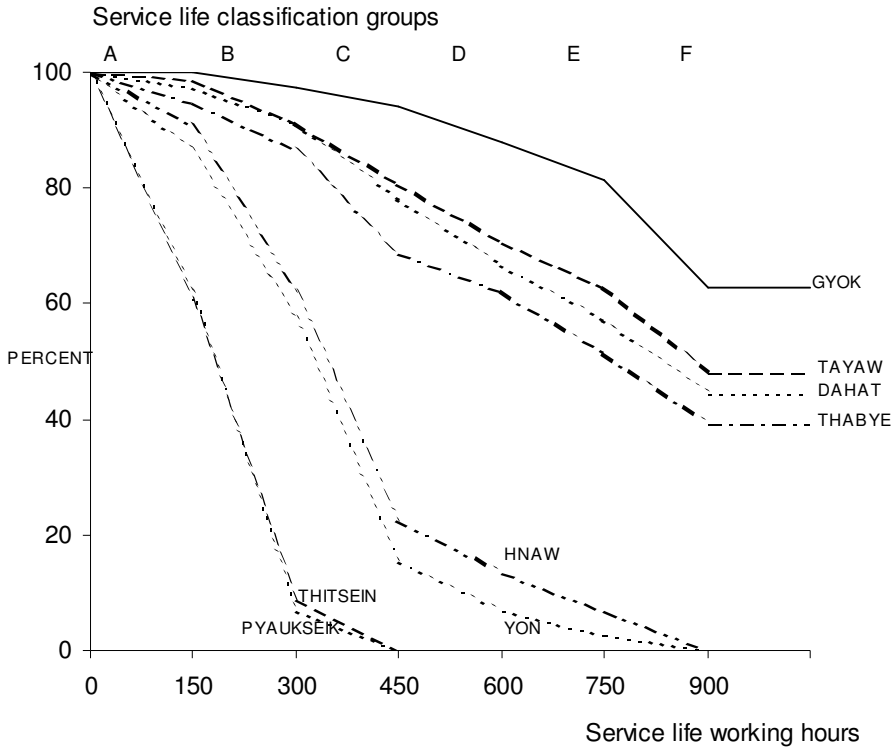


PLATE II

PERCENT SHUTTLE WORKING LIFE OVER WORKING HOURS FOR FOUR SPECIES

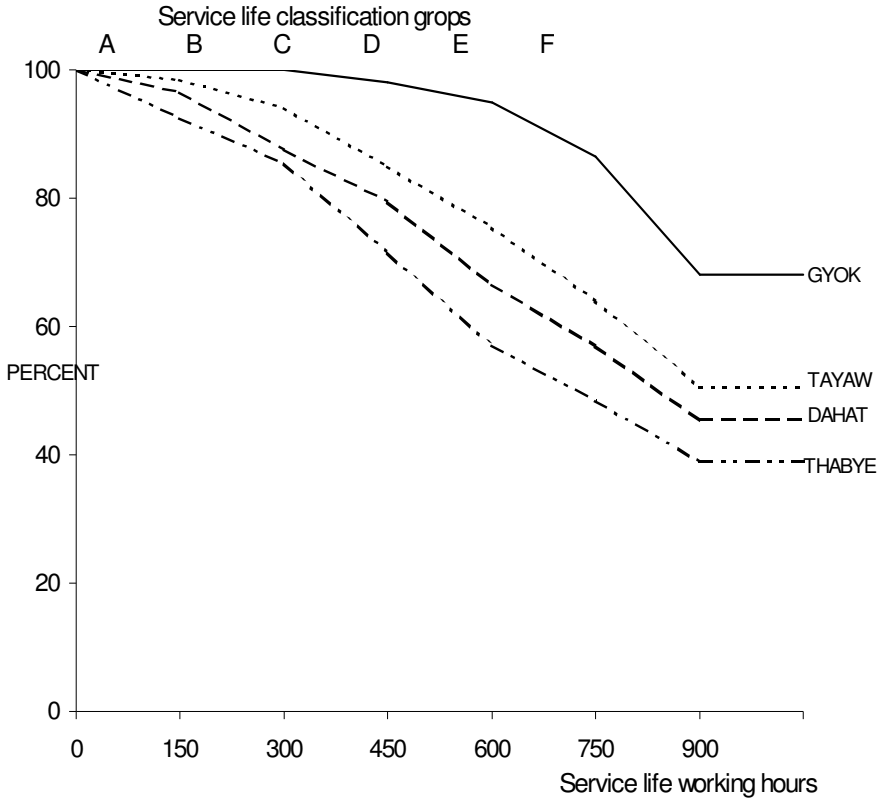


PLATE III

Diospyros montana Roxb. (Gyok)

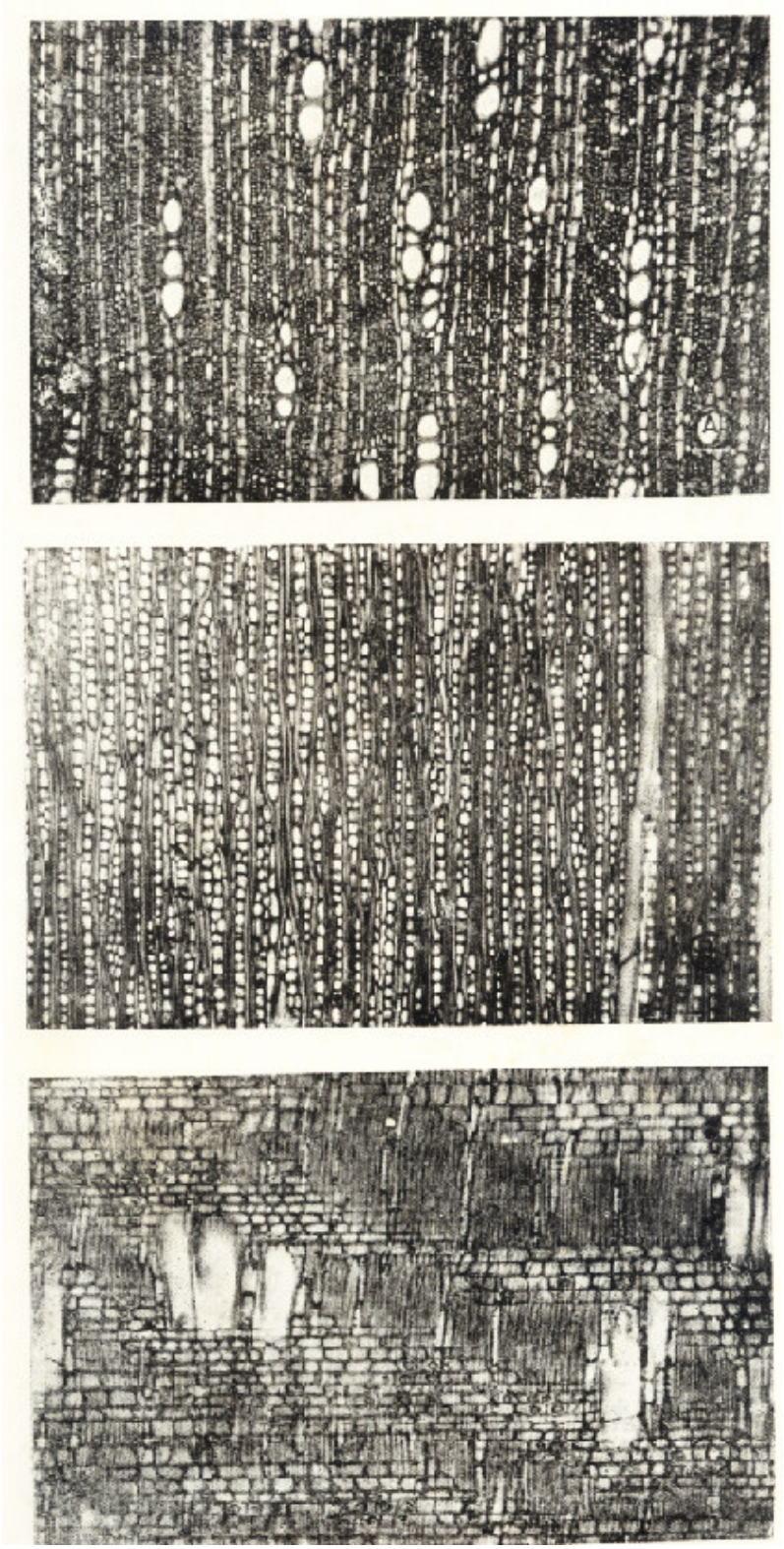


PLATE IV

Grewia tiliaefolia Vahl. (Tayaw)

PLATE V

Tectona hamiltoniana Wall. (Dahat)

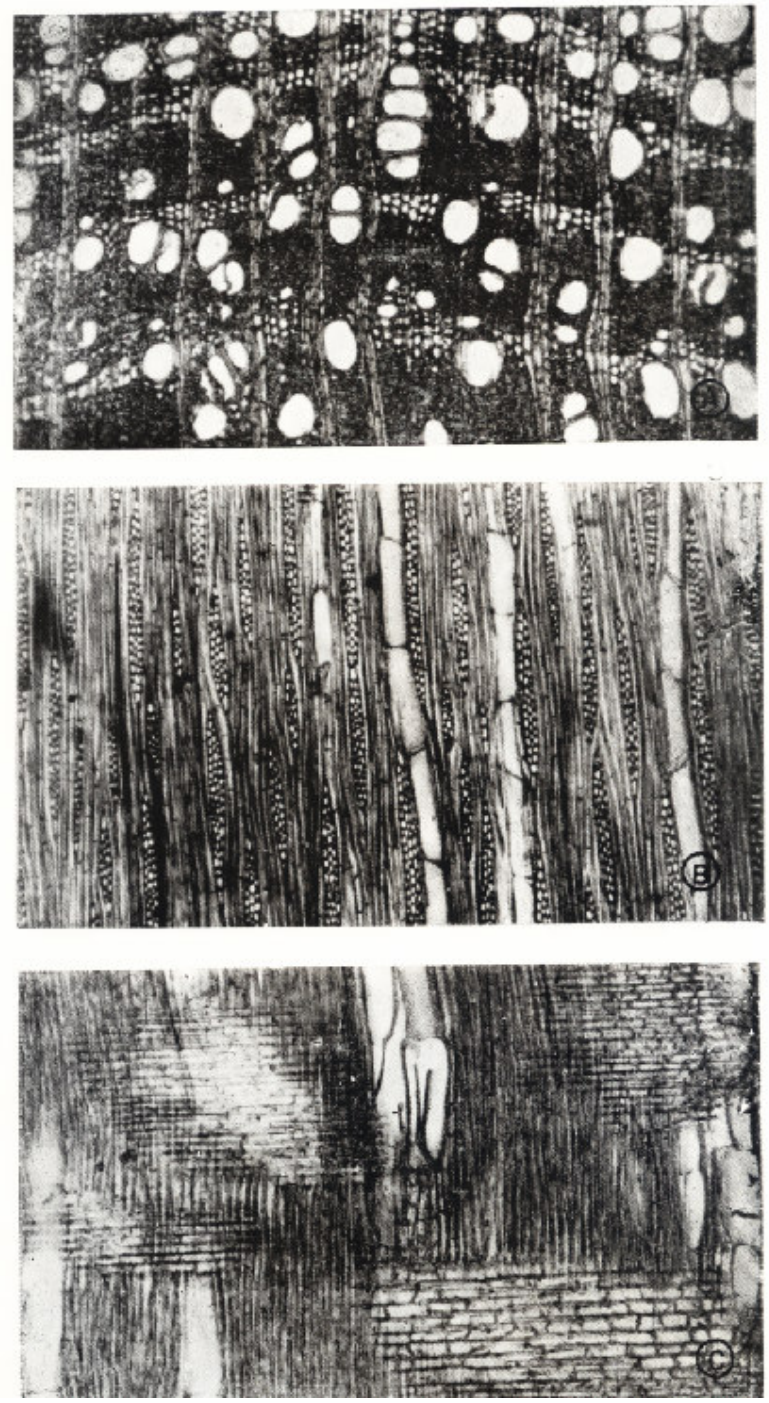


PLATE VI

Syzygium cumini Linn. (Thabye)

PLATE VII

Adina cordifolia Hook.f. (Hnaw)

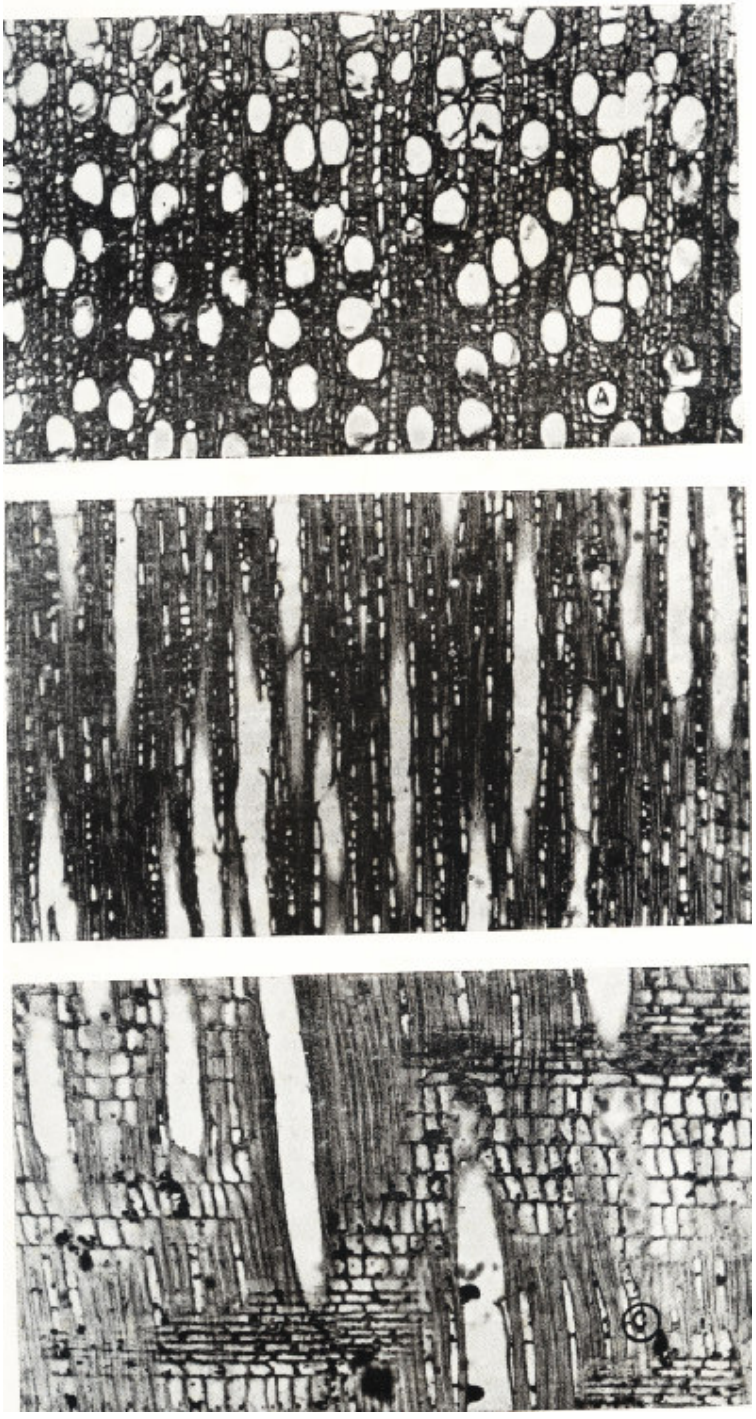


PLATE VIII

Anogeissus acuminata Wall. (Yon)

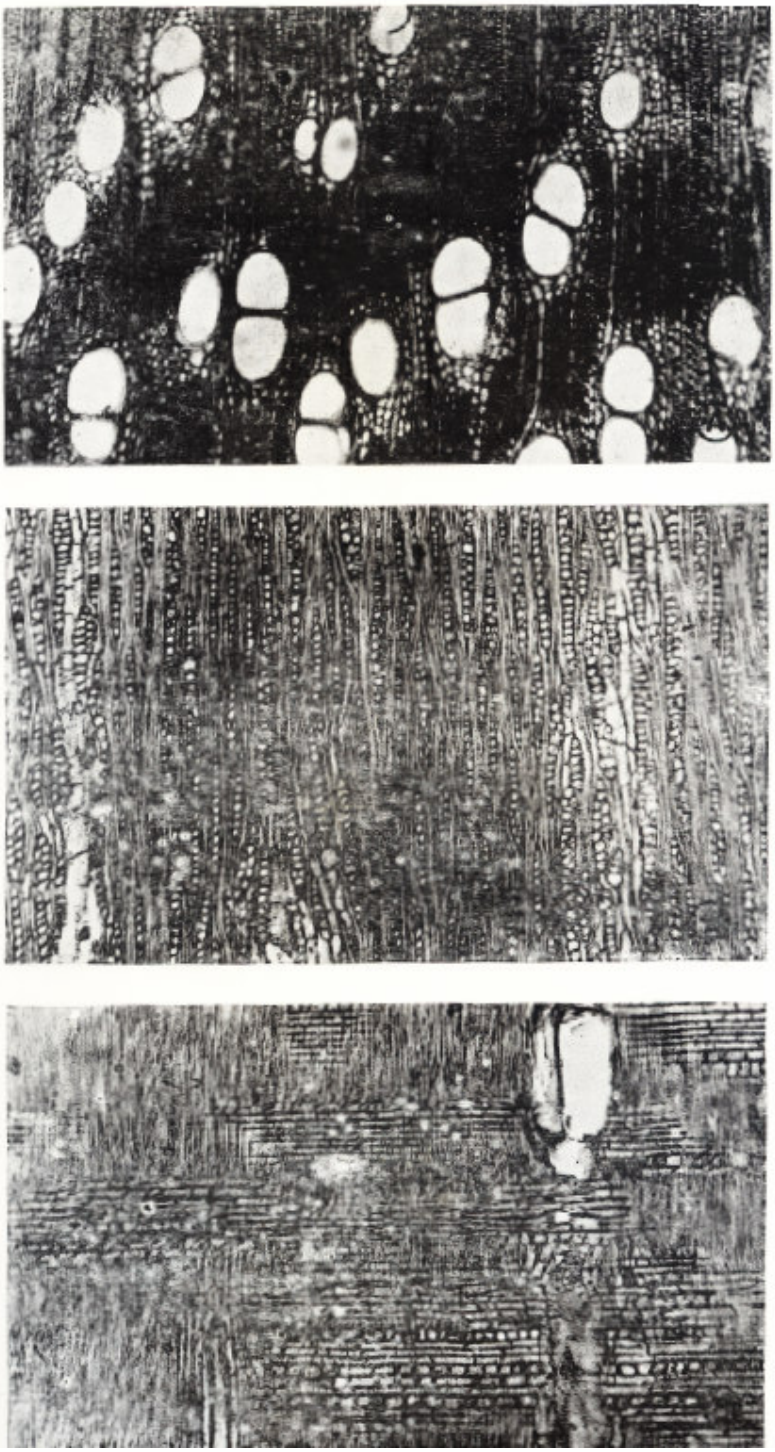


PLATE IX

Terminalia belerica Roxb. (Thitsein)

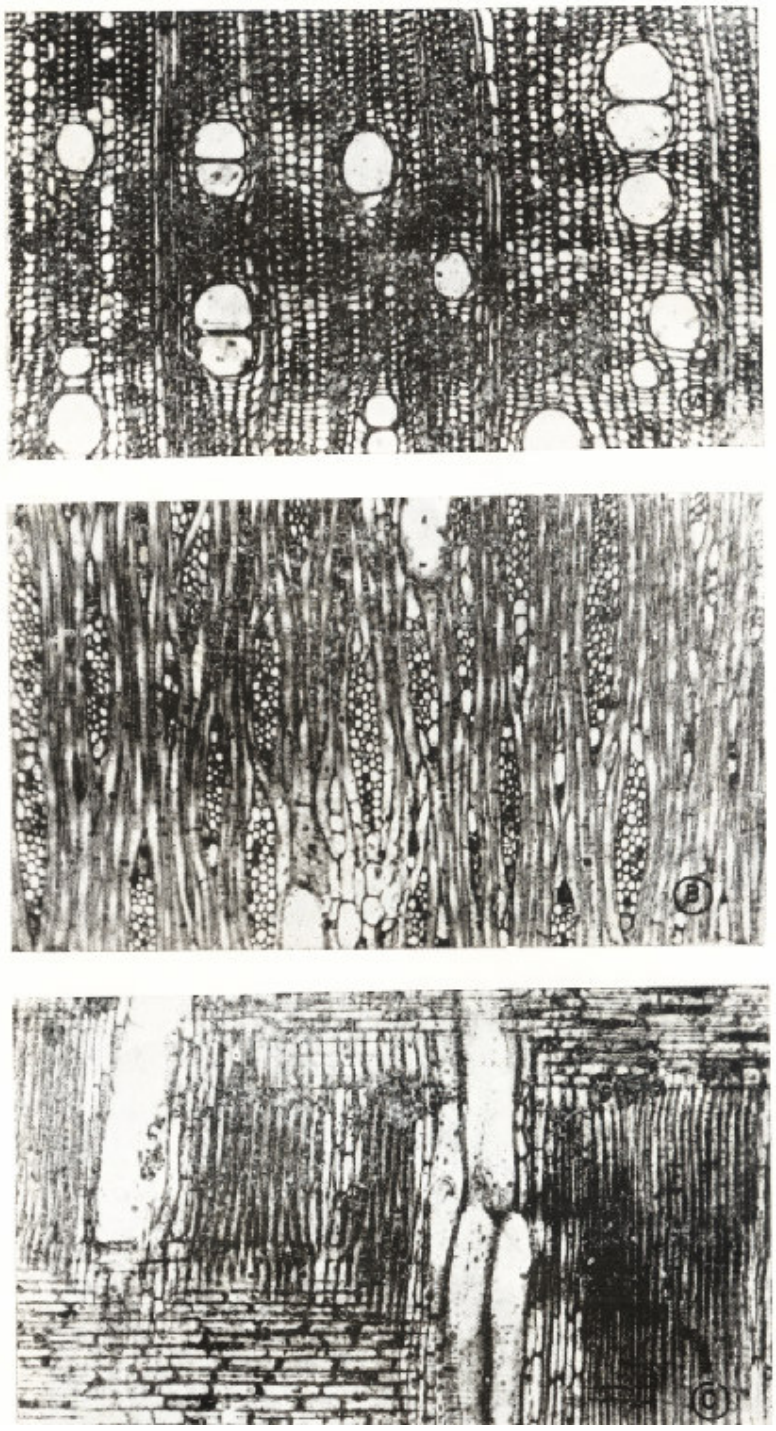


PLATE X

Holoptelea integrifolia Planch. (Pyaukseik)

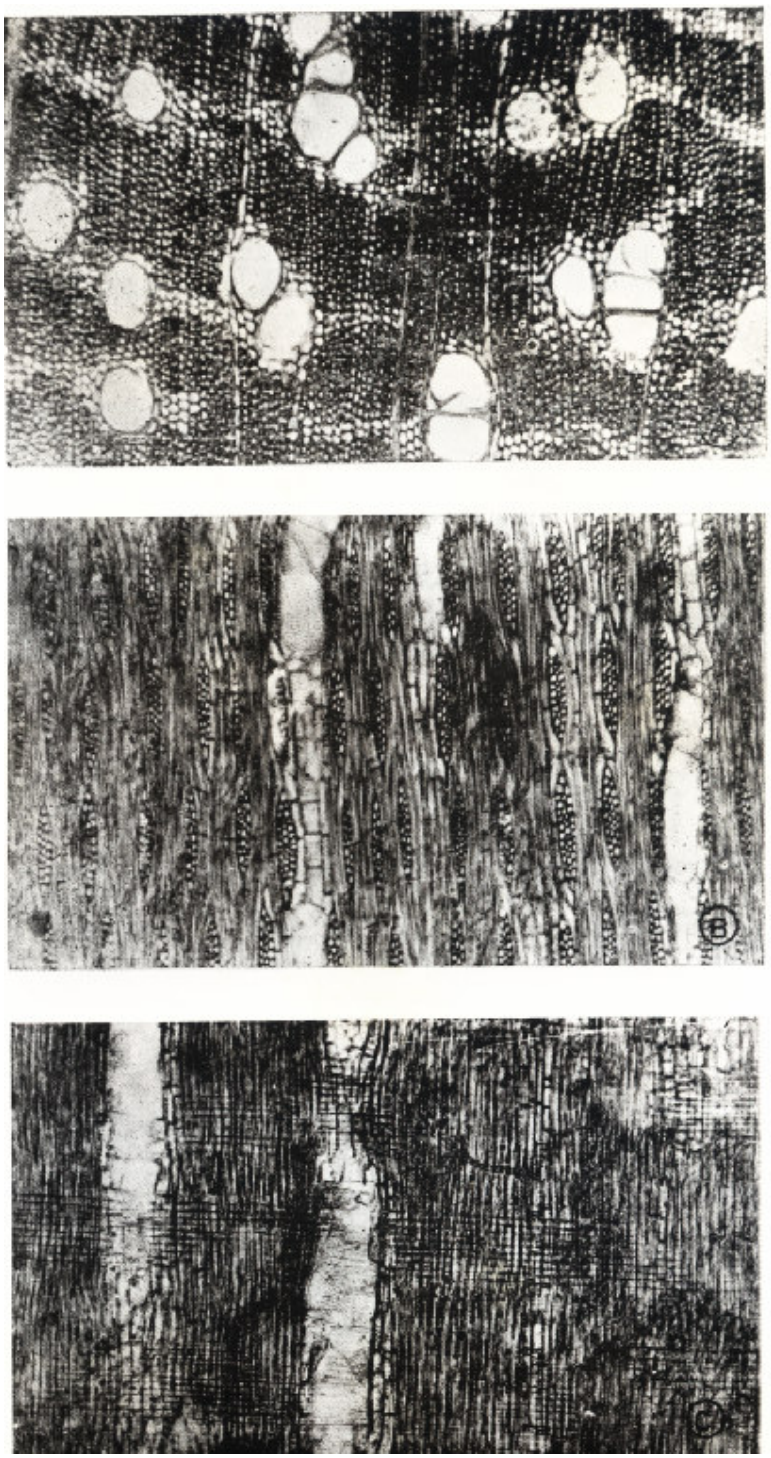
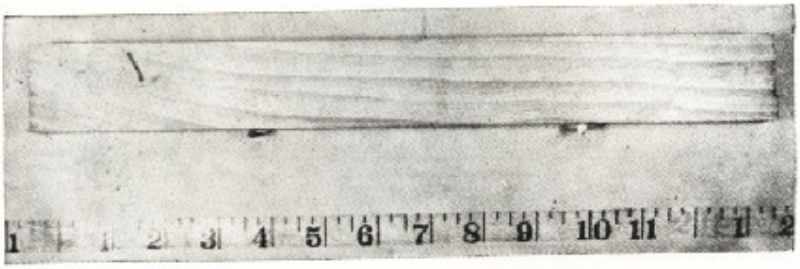
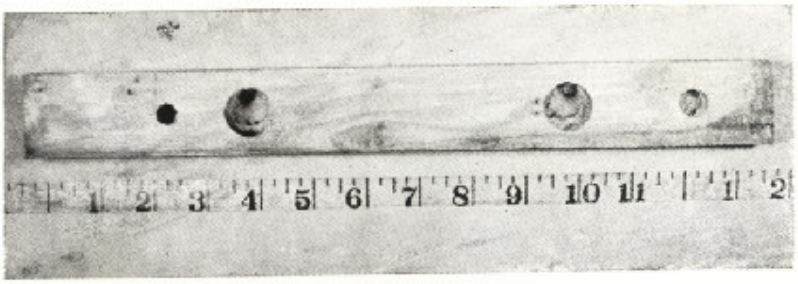


PLATE XI

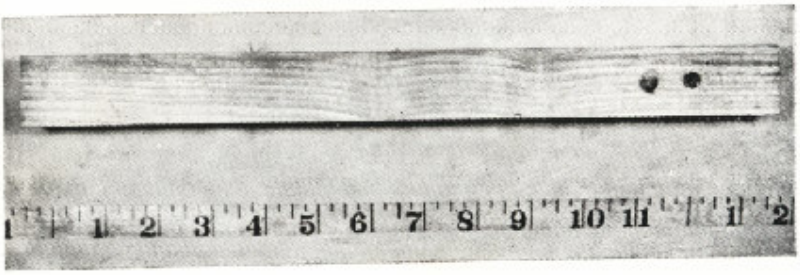
Stages involved in the production of shuttles



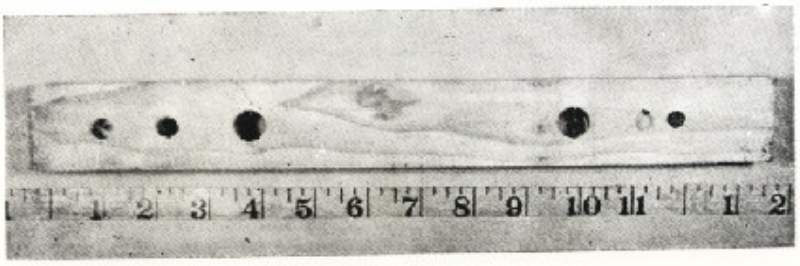
XI/A



XI/B



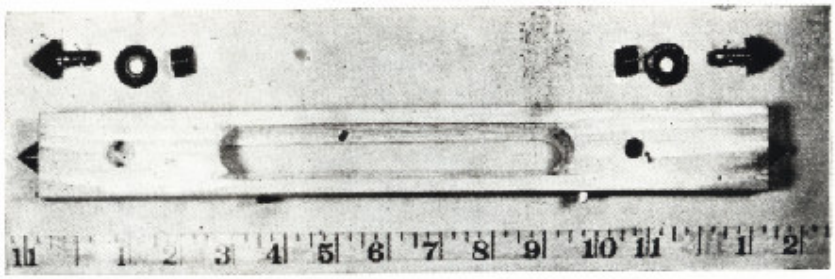
XI/C



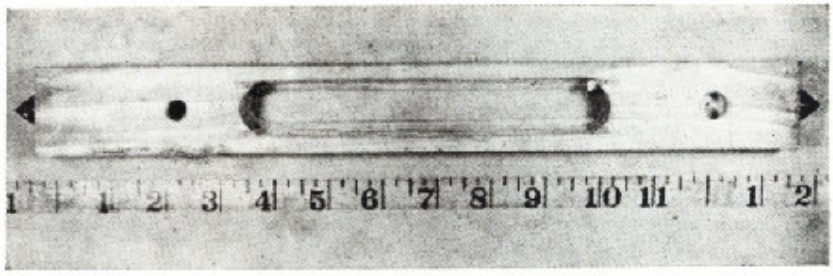
XI/D

PLATE XII

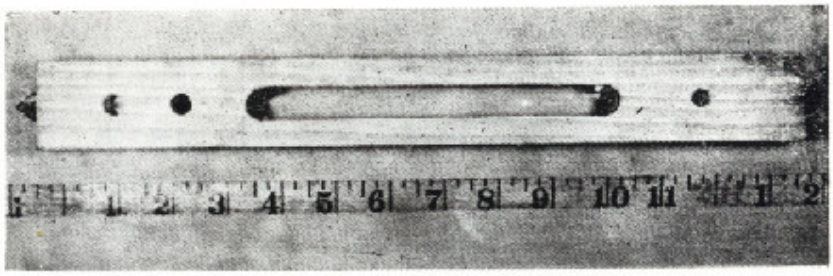
Stages involved in the production of shuttles



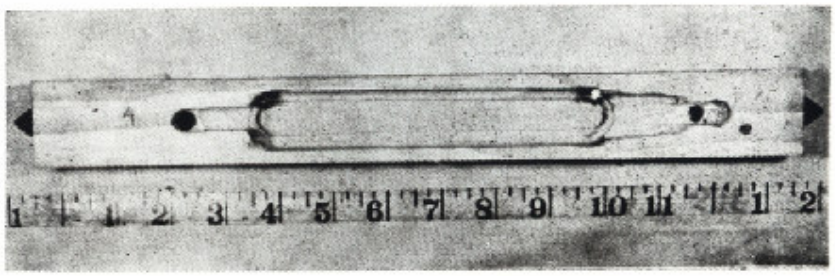
XII/A



XII/B



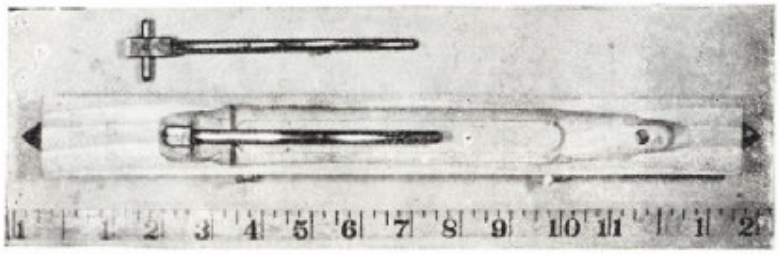
XII/C



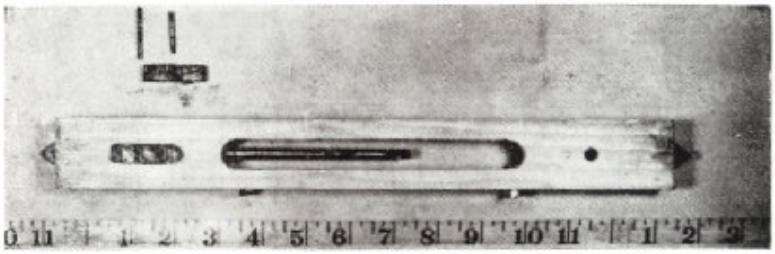
XII/D

PLATE XIII

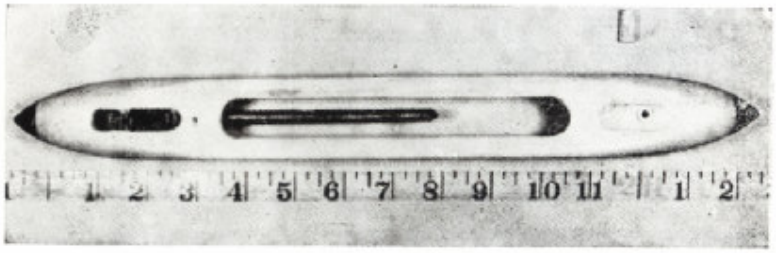
Stages involved in the production of shuttles.



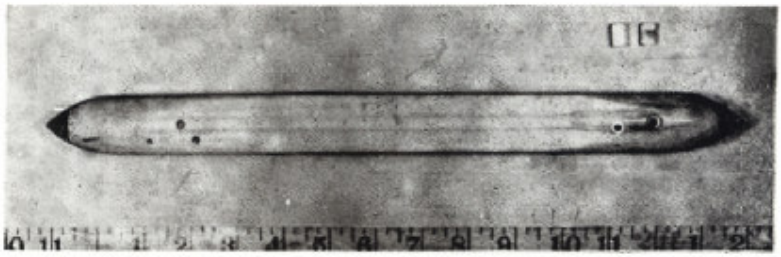
XIII/A



XIII/B



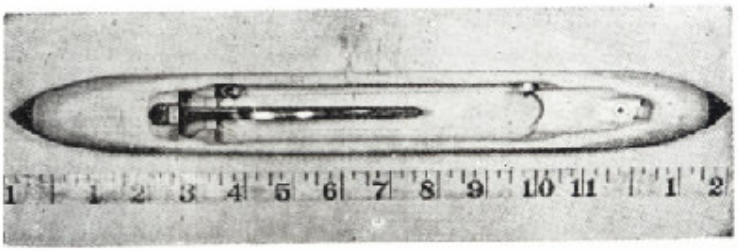
XIII/C Bottom view of a shuttle.



XIII/D Side view of a shuttle.

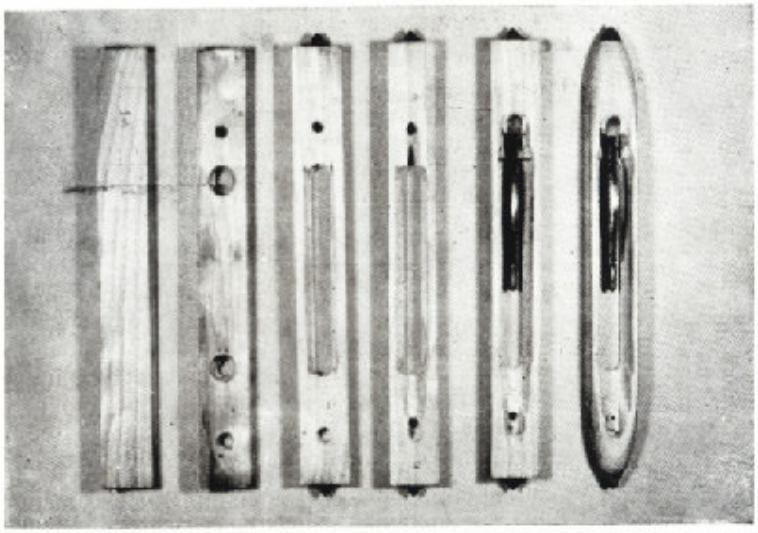
PLATE XIV

Top view of a shuttle



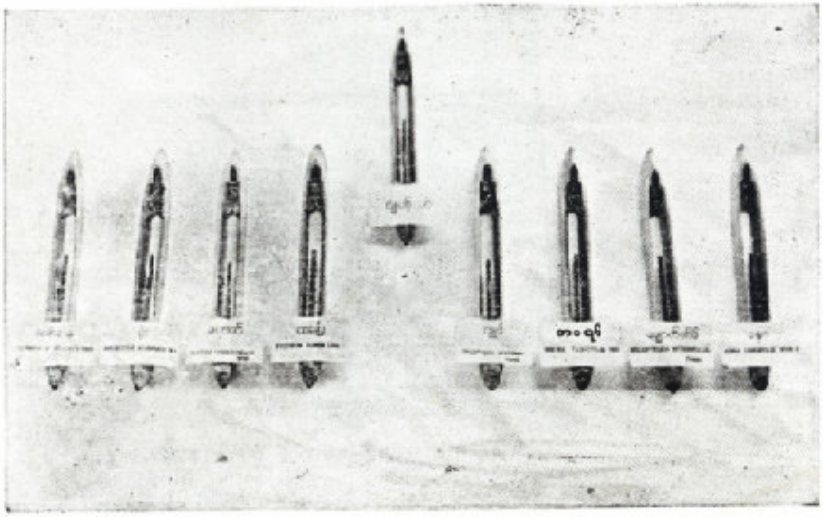
XIV/A

Stages involved in production of shuttles



XIV/B

Comparison of Japanese and Burmese wooden shuttles.



XIV/C

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