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Experimental Study on Properties of Some Lesser Used Seasoned Timber Species in Myanmar

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ABSTRACT
This study investigates the properties of four lesser used seasoned timber species in Myanmar: Inn (Dipterocarpus tuberculatus Roxb.), Kanyin (Dipterocarpus turbinatus), Thit-Sein (Terminalia bellirica Roxb.) and Yamane (Gmelina arborea Roxb.). The experiments are tested according to American Standard Methods of Testing Small Clear Specimens of Timber (ASTM D 143-09). The moisture content is examined in the kiln dried condition. The mechanical properties are done to measure the bending strength, compressive strength parallel to grain, compressive strength perpendicular to grain, and tensile strength perpendicular to grain and shear strength of each species of timber. In addition, the density and moisture content of timber are also measured for physical properties. Total 600 specimens (30 specimens for each test and species) are measured in this study. The results from experiments are also adjusted to 12% moisture content.

Keywords: *Physical and mechanical properties of local seasoned timber species, ASTM D 143-09, Kiln dried condition, 12% moisture content*

I. INTRODUCTION
Myanmar is a country with a long history of scientific forest management and possessing valuable natural forest resources. Over half of the country is covered with natural forests. So, forest products are the biggest sources of foreign income.

Wood is different from other construction materials because it grows naturally. Its mechanical properties largely depend on the species, age, location, climate and humidity. Related to its physical properties, wood has different colors and odors. In addition, its unit weight, strength, density moisture content, and other characteristics are also different. The ability of wood to resist loads depends on a number of factors, including the type, direction, and duration of loading; ambient conditions of moisture content and temperature. The strength properties of wood are of importance in structural design. They are measure of the ability of wood to resist externally applied force which tends to alter its shape, size or result in any other deformation. Mechanical properties determine the applicability of wood in structure as well as many other uses where resistance to bending, compression, tension, shear and other effect of external force is required.

In Myanmar, more than 100 wood species are available to the prospective user. Efficient use of our nation's timber resource is a vital concern. Markets must be developed for lesser known timber species. The use of lesser known timber species is equally appropriate in civil and structural applications. The utilization of lesser used timber species in Myanmar will solve the crisis of demand and supply of timber.

The objective of this experimental study is to investigate the strength properties of timbers selected from four lesser used seasoned timber species in Myanmar.

II. EXPERIMENTAL PROGRAMME
A. Materials
In this study, four lesser used seasoned timber species are selected. They are Inn, Kanyin, Thit-Sein, and Yemane.

B. Drying the Collected Timbers to an Average Moisture Content by Kiln Seasoning Method

The strength of timber increases with a decrease of moisture content below the fiber saturation point which is approximately 30% moisture content. Above this point, the strength of timber does not alter with any farther increase of moisture. To obtain comparative strength values of different timber species, it is necessary to test timber at above 30% moisture content which is green or saturated condition, or at standard moisture content below this value. The specimens are targeted for drying to an average moisture content of 12%.

In kiln drying, higher temperatures and faster air circulation are used to increase drying rate considerably. Specific kiln schedules have been developed to control temperature and relative humidity in accordance with the moisture content within the wood, thus minimizing shrinkage-caused defects. Firstly, the collected timbers in this study are air-dried to average 100% moisture content for 120 hours before heating the kiln. Time-based kiln schedule is given in Table 1.

Table1. Time-Based Kiln Schedule for (3 in. thick) Collected Timbers, Dried to Average 12% MC Day

Day	Time (hr)	Temperature(°C)		Avg. Equilibrium MC %
		Dry-Bulb	Wet-Bulb	
1	0 -24	<50	<45	85
2	24 -48	50	45	70
3	48 -72	50	45	65
4	72 -96	50	42	50
5	96 -120	50	42	45
6	120-144	50	40	40
7	144-168	50	43	35.5
8	168-192	50	42	30
9	192-216	52	45	25
10	216-240	53	43	20
11	240-264	53	43	18.5
12	264-288	53	43	18.3
13	288-312	53	40	18
14	312-336	50	40	16
15	336-360	50	45	15
16	360-384	50	40	14
17	384-408	53	47	13
18	408-432	54	48	≤12

(a) Trebel Universal Testing Machine

(b)Shimadzu Autograph Universal Testing Machine

Figure1. Testing machine

In this study the following strength properties were investigated:

1. Moisture content, specific gravity, density and bending strength
2. Compressive strength parallel to grain,
3. Compressive strength perpendicular to grain
4. Tensile strength perpendicular to grain and
5. Shear strength

1. Static bending strength test

The Trebel Universal Testing Machine (see Figure 1.(a)) set up with two supports and the four point-loading device as shown in the Figure 2. The species were broken on a four point's fixture shown in this figure.

(a) Preparation specimen (2in. ×2in. × 30 in., span length = 28 in.)

(b)Failure specimens

(c) Simple grain tension tension failure (Kanyin)

(d) Cross grain failure (Kanyin)

(e) Splintering tension failure (Yemane)

(f) Brash tension failure (Yemane)

(g)Horizontal shear failure (Thit-Sein)

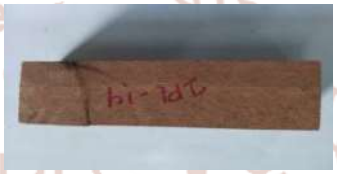
Figure 2. Static bending test

2. Compressive strength parallel to grain test

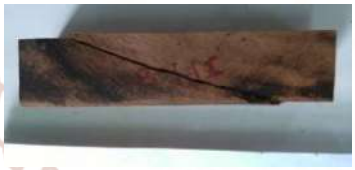
In this test, the compressive strength is measured by applying the force parallel to the grain, as shown in Figure 3.

(a)Expermental set-up (2 in. ×2 in. × 8 in.)

(b) Failure specimens



(c) Crushing failure (Inn)

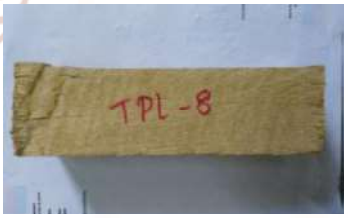


(d)Shearing failure(Inn)

(e)Splitting failure (Thit-Sein)

(f) Wedge split failure (Thit-Sein)

(g) Compression parallel to grain failure (Inn)

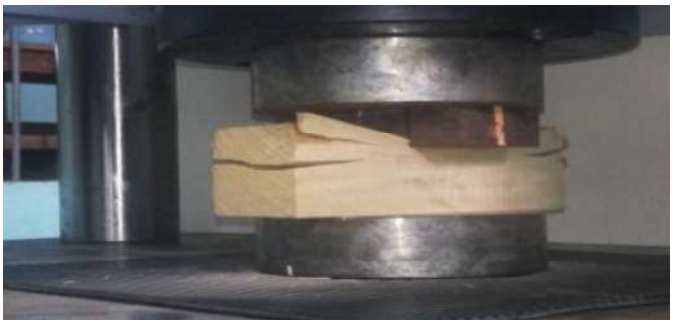


(h)End-rolling failure (Inn)

Figure3. Compression parallel to grain test

3. Compressive strength perpendicular to grain test

This test is a measure of the bearing strength values of member subjected to applying force across the grain, as shown in Figure 4.



(a) Experimental set-up of specimen (2 in. ×2 in. × 6 in.)

(b) Failure specimens

Figure4. Compression perpendicular to grain test

4. Tensile strength perpendicular to grain test

Tensile strength perpendicular to the grain is a measure of the resistance of wood to forces acting across the grain which then to cause splits or cleavage, as shown in Figure 5.

(a) Experimental set-up of specimen (18 in. length cross section 1in. ×1in. at the end, 1in. ×3/8 in. in the middle)

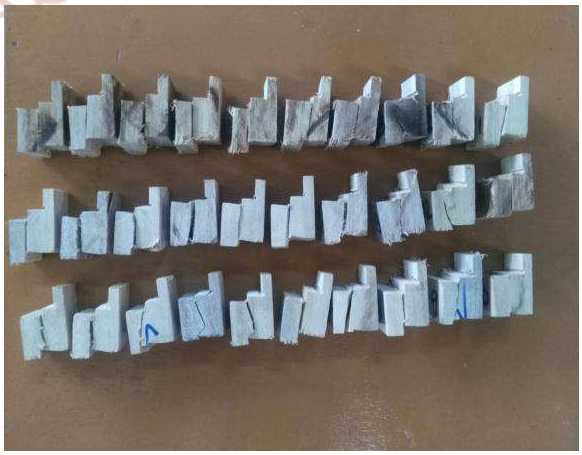
(b)Failure specimens

Figure 5. Tension Parallel to Grain Test

5. Shear parallel to grain test

This test is the measure of the total load required to shear the specimen in two. The shear strength is the ability to resist internal slipping of one part upon another along the grain or across the grain. Figure. 6 represents shear test.

(a) Experimental Set-up of specimen (2 in. ×2 in. × 2 ½ in. is notched to produce failure on 2 in. ×2 in.)



(c) Failure Specimens

Figure6. Shear parallel to grain test

III. TEST RESULTS AND DISCUSSIONS

In this study, the strength properties which are commonly used in design purposes are measured including bending, compression parallel and perpendicular to the grain, tension perpendicular to the grain, and shear parallel to the grain for four species. For each test and species 30 specimens were measured at 12%MC, according to ASTM D 143-09.

Figure 7 and 8 represent the fibre stress in bending, modulus of rupture and modulus of elasticity, respectively. The compressive stresses parallel and perpendicular to grain were as shown in Figure.9 and 10, respectively. Figure.11 and 12 represent the tension and shear strength parallel to grain, respectively.

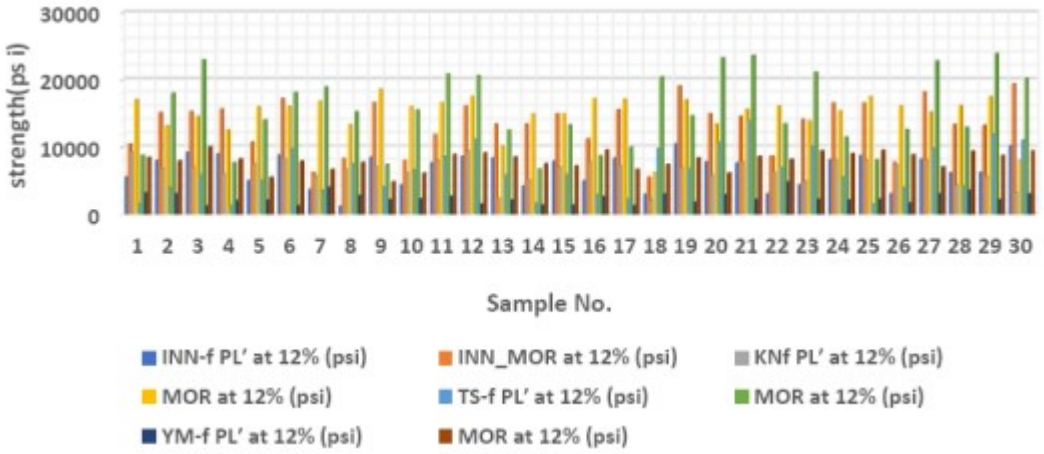


Figure 7. Comparison of PLf and MOR for Inn, Kanyin, Thit-Sein and Yemane at 12% MC

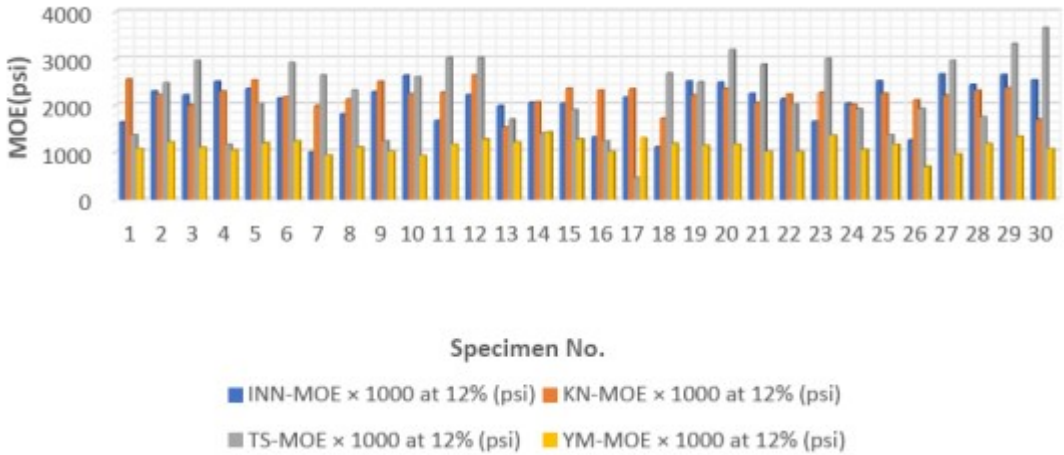


Figure 8. Comparison of MOE for Inn, Kanyin, Thit-Sein and Ymane at 12% MC

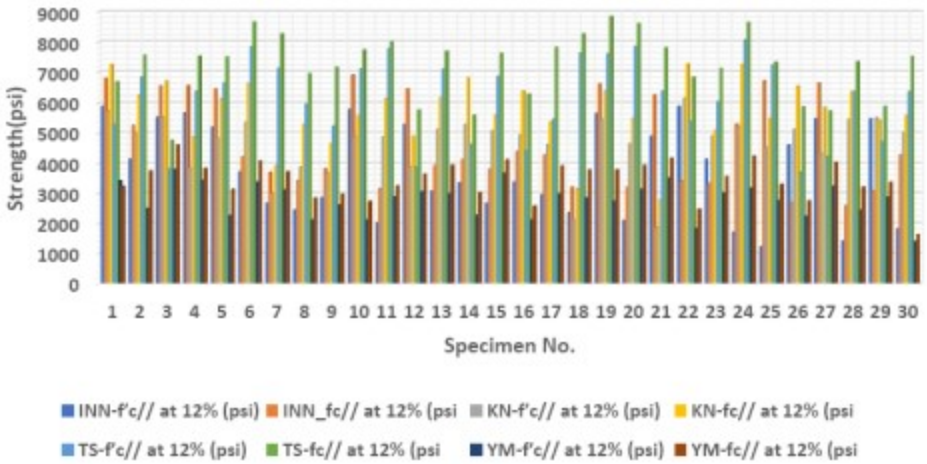


Figure 9. Comparison of f'c// and fc// for Inn, Kanyin, Thit-Sein and Yemane at 12% MC

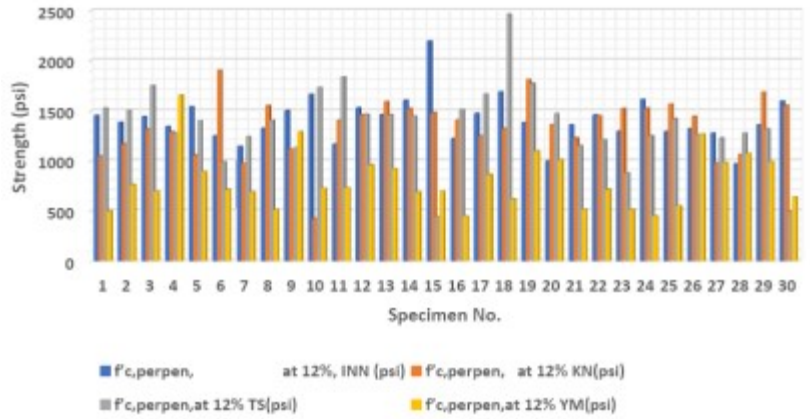


Figure 10. Comparison of ⊥ □ ,cf for Inn, Kanyin, Thit-Sein and Yemane at 12% MC

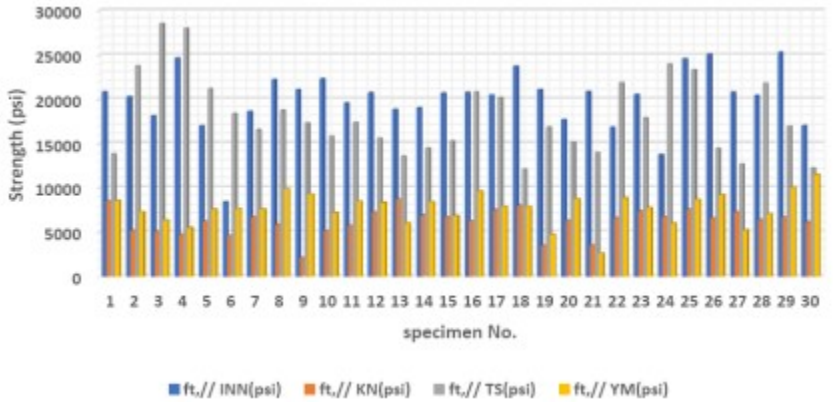


Figure 11. Comparison of Maximum Tensile Stress ft,// for Inn, Kanyin, Thit-Sein and Yemane at 12% MC

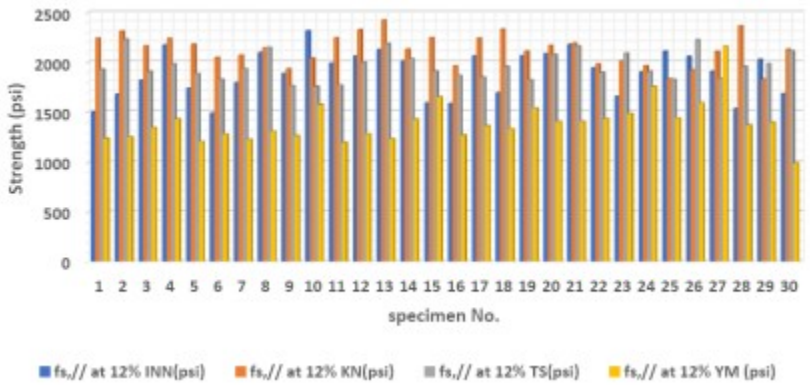


Figure 12. Comparison of Maximum Shearing Stress fs,// for Inn, Kanyin, Thit-Sein and Yemane at 12% M

From the experiments mean strength values of each property and species at 12%MC are listed in Table 2. The allowable strength of each property is obtained by multiplying the respective factor of safety given in Table 3 to the mean strength shown in Table 2. It is listed in Table 5 and as shown in Figure 13,14 and 15 respectively. The allowable density of each species is listed in Table 4.

Table 2. Strength for Four Timber Species at 12%MC

Traditional Name	(psi)	MOR (psi)	MOEx10₃ (psi)	(psi)//,cf□	(psi)//,cf	(psi)	ft,// (psi)	f,// (psi)
Inn	6696.73	13393.61	2085.51	3620.12	4710.43	1410.93	20065.11	1892.04
Kanyin	6548.81	14985.87	2199.18	4676.33	5715.85	1350.47	18201.78	2129.50
Thit-Sein	6452.98	15577.67	2251.09	6134.1	7252.4	1366.64	18090.02	1961.02
Yemane	2409.78	8043.7	1122.53	2805.6	3463.12	806.0	7712.11	1398.38

Table 3. Safety Factors for Each Mechanical Property

Strength (psi)	Strength Ratio Associated with			Adjusted Safety Factor
	Slope of Grain	Knot	Checks and Splits	
Bending f'_{PL}	0.61	0.6	-	1/6.3
Modulus of Elasticity(MOE)	0.80 for S_b <0.44			1/1.18
Compression parallel $f'_{c,//}, f_{c,//}$	0.74	0.6	-	1/4.73
Compression perpendicular $f'_{c,\perp}$	-	-	-	1/1.67
Tension parallel $f_{t,//}$	0.55× 1 for S_b (55% of S_b)			1/11.43
Shear parallel $f_{s,//}$	-	-	0.50	1/4.6

Where, Sb= bending strength ratio

Table 4. Allowable Density for Four Timber Species at 12%MC

Traditional Name	Botanical Name	Density (lb/ft3)
Inn	Dipterocarpus tuberculatus Roxb.	53-57
Kanyin	Dipterocarpus turbinatus Roxb.	52-59
Thit-Sein	Terminalia bellirica Roxb.	48-58
Yemane	Gmelina arborea Roxb.),	30-36

Table 5. Allowable Strength for Four Timber Species at 12%MC

Traditional Name	(psi)	MOR (psi)	MOEx103 (psi)	(psi)	(psi)	(psi)	ft,// (psi)	fs,// (psi)
Inn	1062.97	13393.61	1767.38	765.35	995.86	844.87	1755.48	411.31
Kanyin	1039.49	14985.87	1863.71	988.65	1208.42	808.66	1592.46	462.93
Thit-Sein	1024.28	15577.67	1907.70	1296.84	1533.28	818.35	1582.68	426.31
Yemane	382.51	8043.7	951.30	593.15	732.16	482.64	674.73	303.99

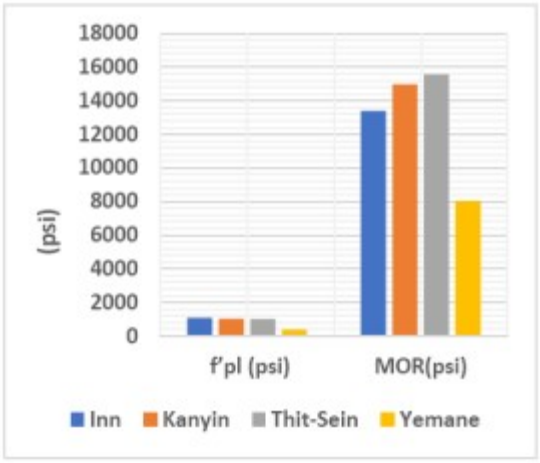


Figure 13. Comparison of Allowable (PL f □), (MOR) for Inn, Kanyin, Thit-Sein and Yemane at 12% MC

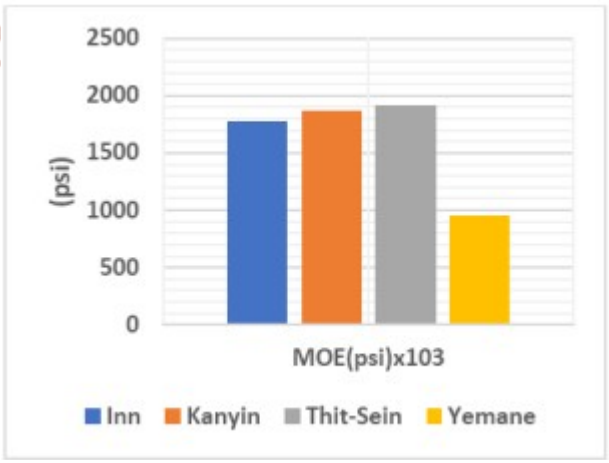


Figure 14. Comparison of Allowable (MOE) for Inn, Kanyin, Thit-Sein and Yemane at 12% MC

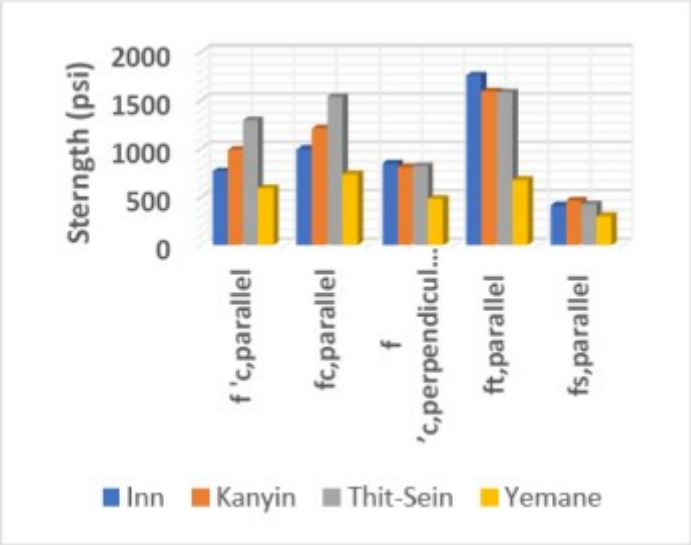


Figure15. Comparison of Allowable Values in fc//, f′c//, ∞ ′ , c f , ft,// and fs,// for Inn, Kanyin, Thit-Sein and Yemane at 12% MC

IV. CONCLUSIONS

Based on results of this study, it can be concluded that:

1. The unit weight of lesser used seasoned timber species is different from one species to another. It can be observed that as the density increases, the various strength properties also increase.
2. For the density, Kanyin has greatest and Yemane has lowest.
3. Inn has greatest value and Yemane has lowest value for bending strength, compressive strength perpendicular to grain, and tensile strength parallel to grain.
4. In compressive strength parallel to grain, Thit-Sein has greatest and Yemane has lowest.
5. In shear strength, Kanyin has the highest and Yemane has the lowest.
6. Yemane has the lowest strength for all tests and therefore it should not be used among these four lesser used seasoned species.
7. Although Thit-Sein has the high strength for almost all tests, chemical treatment should be added to this species for usage due to its nature of likely to be attacked by insets.

V. ACKNOWLEDGEMENTS

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