MORPHOLOGICAL VARIATION OF SEEDLINGS IN *SWIETENIA* RAISED FROM OPEN-POLLINATED SEEDS

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DEFINITION OF TERMS

1. Cryptocotylar (crypto, means hidden; cotyledon, a hollow vessel)—characterized by the cotyledons remaining in the testa after germination. (James A. Duke, Ann. Mo. Bot. Gar. **52**:314, 1965).
2. Cataphylls—brown or hyaline scale leaves succeeding the cotyledons, as in many cryptocotylar species (l. c.).
3. Eophylls—the first few leaves with green expanded laminae. (Tomlinsoe, J. Arnold Arb. **41**:415, 1960).
4. Metaphylls—the mature leaves as opposed to the juvenile forms. (Jackson's glossary).

INTRODUCTION

Dr. Duke (1965) described the cryptocotylar seedlings of *Swietenia mahagoni* and *S. macrophylla* based on the different phyllotaxy of the eophylls. The former has alternate eophylls, while the first two eophylls of the latter are opposite. His report is believable because the seedlings of these two species were collected from widely separated forests. Thus the possibility of cross pollination between those two forests was undoubtedly very low. But in my investigation of the seedlings from a mixed plantation in Taiwan, I have found a lot of intermediate types, in addition to the two kinds of seedlings mentioned above. Hybridization may be the important factor in this complexity.

Artificial hybridization between these two closely related species has been made successfully by the author and others (Briscoe and Nobles, 1962; Lee, 1967 and 1969). But the manner of their inheritance is not yet known. This paper attempts only to survey some variations in a mixed population in order to confirm the fact that natural hybridization is very possible in this genus.

MATERIAL AND MEHTOD

The seedlings used in this investigation were raised from the seeds of these two species collected separately in a mixed plantation on the Chung-pu Branch Station, Taiwan Forest Research Institute.

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In this mixed plantation, the typical trees of *S. mahagoni* and *S. macrophylla* are easily identified, based on their morphological characters (Lee, 1966). But there are many trees on this plantation, like *S. macrophylla*, with their large leaflets; which also have some characters similar to *S. mahagoni*, with smaller stomata and many more lenticels on the current year's twigs. It is impossible to avoid the natural cross-pollination of these trees owing to their unisexual flowers and to the overlapping of their blooming season (Lee, 1967).

The seeds of these two species were collected separately, using the leaflet size as the criterion for distinguishing the species. The seeds of doubtful intermediate trees with large leaflets were included in the bag with *S. macrophylla*.

The seeds were sown in separate seedboxes and grown under laboratory conditions. A number was given to each seedling. The phyllotaxy, the shape of the eophylls and stomata size were studied.

RESULTS

A. The phyllotaxy of eophylls

Based on the observed 41 seedlings of *S. mahagoni* and 44 seedlings of *S. macrophylla*, we found the morphylogy of the eophylls to be very divergent. Over half of the seedlings of *S. macrophylla* produced two alternate caducous scaly cataphylls. But none of the seedlings of *S. mahagoni* produced cataphylls, although some of them produced two first eophylls which were of small size and caducous. Therefore the second pair of eophylls of the seedlings with cataphylls of *S. macrophylla* corresponds to the first pair of eophylls in Dr. Duke's report. The number of seedlings with different characters are outlined in Table I.

From Table I. the variations of the seedlings can be summarized as follows:

1. In *S. mahagoni* 58.54% of the seedlings had a large alternate permanent first

Table I. Variation of eophylls on the seedlings (number of seedlings)

a. *Swietenia mahagoni*

Order of eophylls			Second pair			
			Alternate	Opposite	Total	%
First pair	Alternate	Large, permanent	24	0	24	58.54
		Large, caducous	5	3	8	19.51
		Small, caducous	6	0	6	14.63
	Opposite	Large, permanent	3	0	3	7.32
Total			38	3	41	
%			92.68	7.32		100.00

b. *Swietenia macrophylla*

Order of eophylls			Second pair			
			Alternate	Opposite	Total	%
First pair	Alternate	Cataphylls, caducous	14	13	27	61.36
		Eophylls, permanent	11	4	15	34.09
	Opposite	Eophylls, permanent	2	0	2	4.55
Total			27	17	44	
%			61.36	38.64		100.00

pair eophylls. Which may be typical for this species. The remaining seedlings had been more or less changed by hybridization or mutation.

2. Less than 30% (13 seedlings) of *S. macrophylla* produced a pair of cataphylls and the second pair (i.e. the first pair according to Dr. Duke's key) of eophylls were opposite. These seedlings were identified as typical seedlings of *S. macrophylla*. The percentage of variation is higher than in the former species.

B. Variation in size and shape of stomata

From the earlier report of the author (Lee, 1966) it is known that the stomata on the mature metaphyll leaflets of *S. mahagoni* are smaller and narrower than those of *S. macrophylla*. This is also true for the eophylls of the seedlings of these two species. The variation of stomata sizes in these two species are given in Figure 1.

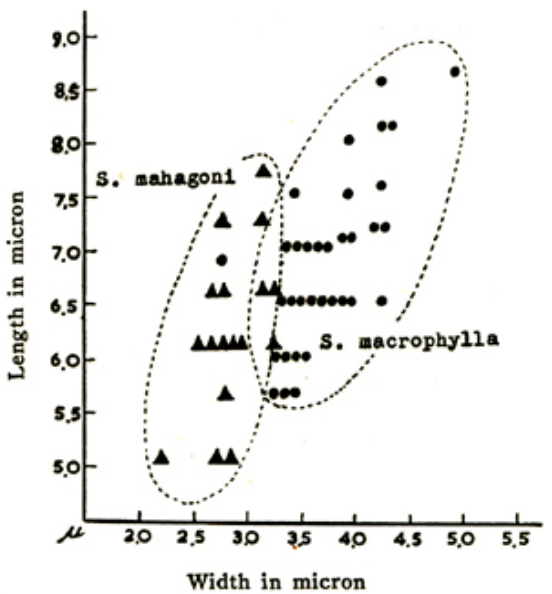

Fig. 1. Variation of stomata size, each dot represents one seedling.

It is very evident that the stomata on the eophylls of *S. mahagoni* are smaller and narrower than those of *S. macrophylla*.

The shape of the stomata is another different character and this is shown in Table II. as the ratio of the width to the length of the stomata.

Table II. Variation of stomata shape (width/length ratio)

Ratio	Number of seedlings	
	S. mahagoni	S. macrophylla
0.350–0.399	3	0
0.400–0.449	5	4
0.450–0.499	7	13
0.500–0.549	2	13
0.550–0.599	0	2
0.600–0.649	0	1
Total	17	33

C. Variation in sizes of eophylls

S. macrophylla is known as the large-leaved mahogany because its leaflets are larger than those of *S. mahagoni*, which is the true mahogany. In fact, the eophylls of *S. macrophylla* are also larger than those of *S. mahagoni*. But the size of eophylls of these two species fall into a continuous series.

In this continuous series, the range of eophyll-size of *S. macrophylla* is much greater than in those of *S. mahagoni*. The length and width of the eophylls of these two species are recorded in Figure 2.

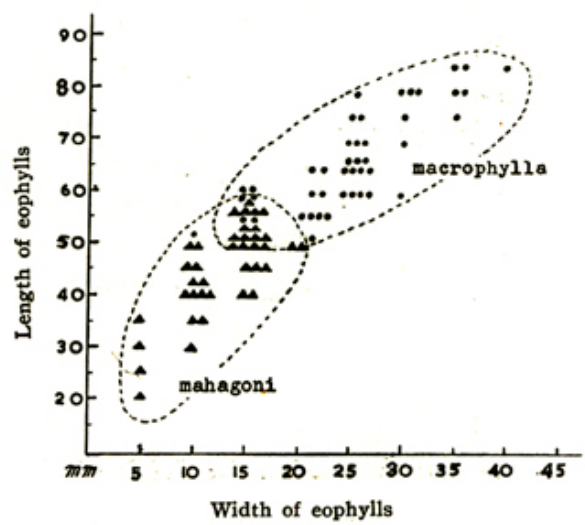

Fig. 2. Size of eophylls, each dot represents one seedling.

From the continuous distribution of the size of eophylls, the inheritance of this character may be assumed to be caused by additive genes. Natural hybridization causes the size of eophylls to become a homogeneous series.

D. Variation in the shape of the eophylls

The shape of the eophylls can be investigated by two characters, the outline of the lamina and the shape of its apex.

In the outline of the lamina, the eophylls of *S. mahagoni* is much narrower than in *S. macrophylla*. The narrowest eophylls of *S. mahagoni* are nearly lanceolate. On the other hand the widest eophylls of *S. macrophylla* are ovoid. In many seedlings the shape of the eophylls lies between these two extremes. In Table III. we can see the variation in the shape of the eophylls of these two species based on the wide/length ratios.

Table III. Variation of Shape of Eophylls (number of seedlings)

Ratio*	S. mahagoni	S. macrophylla	Shape
0.20-0.24	3	0	Lanceolate
0.25-0.29	8	4	Lanceolate
0.30-0.34	18	3	Lanceolate
0.35-0.39	11	15	Ovoidly lanceolate
0 40-0.44	0	16	Ovoidly lanceolate
0.45-0.49	0	3	Ovoidly lanceolate
0.50-0.54	0	1	Ovoid
Total	30	42	

* Width/length of laminae

The other character of the eophylls, is the shape of their apex. Typicel seedlings of *S. mahagoni* having small, narrow, alternate eophylls produce the eophylls with a gradually acuminate apex. The typical seedlings of *S. macrophylla* having the larger, wider and opposite eophylls develop the eophylls with a distinct caudate apex. Many seedlings are of intermediate forms.

This character is scored from zero (acuminate apex) to five (those having a long caudate apex). The result of the scores is shown in Table IV.

DISCUSSION

The method of pollination is a signficant factor in forming a species or in combining two separate "species" into one. From the standpoint of evolution, a new species may be formed by genetic mutation followed by its isolation from the original species. But cross pollination must be prevented between them, either by geographical barriers or other obstacles to pollination. If a new "species" can be

Table IV. Variation in the apex of eophylls (number of seedlings)

Score	S. mahagoni	S. macrophylla	Shape of apex
0	7	4	Acuminate
1	15	12	Acuminate
2	10	7	Acuminate
3	0	8	Acuminate
4	0	6	Acuminate
5	0	4	Long, caudate
Total	32	41	

freely pollinated by the original one, the mutant gene or genes will become mixed in the gene pool of the old population.

The closely related two species of *Swietenia mahagoni* and *S. macrophylla* may have become distinguished as separate species very early in Central America and the West Indies. But since the discovery of unisexual flowers in this genus (Lee, 1967), the theories of their classification need reconsideration. If the natural stands of these two species are widely separated they can be classified as two distinct species. But if not, cross pollination cannot be avoided and the progeny of these two species will show a wide range of phenotypes. The mixed or intermediate forms will be observed growing beside the typical *S. mahagoni* and *S. macrophylla.*

According to Dr. Duke (1965), the seedlings of these two species grow in very different, separate forests (*S. mahagoni* growing in dry coastal forests, while *S. macrophylla* grows in the lower cordillers and lower luquillo forests of Porto Rico). In his keys the seedlings of *S. mahagoni* were identified by their alternate eophylls and the seedlings of *S. macrophylla* by the first eophylls being opposite and the remaining eophylls being alternate. But the seedlings raised from open-pollinated seeds of both species in a mixed stand in Taiwan show some of the first pair of eophylls to be alternate and others opposite. Therefore I propose that the character of the seedlings of these two species can be mixed by natural cross-pollination.

From the above results it is shown that there is much variation in the phyllotaxy of eophylls of hybrids and only a small part of the seedlings may be identified as typical ones. The variation of these juvenile characters can be assumed to be the result of natural hybridization. Therefore, in the author's opinion, the hybrids of these two species, which are said to be disease-resistant timber trees, can be selected not only from the progeny of controlled hybridization but also in naturally cross-pollinated populations. From an economic standpoint, these natural hybrids are valuable to foresters.

CONCLUSION AND SUMMARY

1. The two closely related species of *Swietenia mahagoni* and *S. macrophylla* can be naturally cross-pollinated in mixed plantations. The possibility of natural hybridization in *S. macrophylla* is greater than in *S. mahagoni*.
2. The progeny of natural open-pollination of these two species shows a wide range of variation in the morphology of the seedlings.
3. Except for the phyllotaxy of the first pair of eophylls, the quantitative characters of the seedlings may be controlled by additive genes.
4. From an economic standpoint good pure-lines can be selected from open-pollinated progeny. But these selected lines must be planted in isolated stands in order to prevent unnecessary hybridization.

ACKNOWLEDGEMENT

The author wishes to express his sincere appreciations to Dr. Charles E. DeVol, Professor in the same Department, for his suggestions and corrections.

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