CHAPTER 5

Phenotypic Distribution of Progenies Derived from the Cross Between *Dendrobium* Cultivars and Four Fragrant Species

Orchid breeding has been done since 1840, however, genetic inheritance of orchid has been described in a few genera. Most of breeding programs have been done by the growers, thus, heritability of certain character could not be revealed. In addition, genetic inheritance study is time consuming and requires high labor cost in order to collect all the data and present in an academic way. Cash (1993) stated that only few information about characteristics inheritance of orchid were available due to the studies took along time from pollination to flowering and needed a lot of money in maintenance. However, hybridization is the most common method that grower and orchid breeder used for novelty development as Holttum (1977) reported that hybridization played a key role in viability of the orchid industry in the ASEAN countries. Additional, Vajrabhaya (1977) stated that conventional methods of plant breeding that involved selection and hybridization have had their merits, future progress and refinement of art and science of breeding depended on novel approaches. Breeding for some characters, Kalina (1992) noted that there had been fashionable and unfashionable orchids. Positive attributes were bright color, pleasant fragrance, compact growth or ease of cultivation. In additional, there were reported on an importance of fragrance. According to Groom (1995) and Nakamura *et al*. (1990), they both stated that fragrance was one the selling point. Thus, in this study, fragrance is one of the main interests in hybridization. Fragrance from Thai orchid species, *Den. parishii*, is introduced to commercial cultivar. Beside that, information on orchid inheritance, both quantitative and qualitative characteristics, has been focused on the progenies derived from the cross between *Den*. Emma White and *Den. parishii,* Chi-square and population distribution were employed for qualitative and quantitative characteristics test in this study, respectively.

Materials and Methods

Crosses of a commercial *Dendrobium*, *Den*. Emma White were made with *Den. scabrilingue*, *Den. anosmum* and *Den. peguanum,* as well as their reciprocal crosses. Number of fruit set was recorded. Fruits were harvested at twelve weeks after pollinations, their seeds were sown under aseptic conditions. The sown seeds germinated within a month, they developed into protocorms and then plantlets. They were subcultured for two times at four months intervals until the plantlets grew bigger to the size that could be transplanted out-side. The whole process took about a year. The transplanted plantlets were deflasked and kept in the nursery for three weeks before they were planted in one-inch pot using sphagnum moss as growing medium, thereafter, they were kept under a plastic roof. After the young plants developed new pseudobulbs, they were individually transplanted into a 3-inch pot using the same growing medium and kept under a shade-house at about 70% shading. Four years after deflasked, the plants produced flowers. Phenotypic characteristics such as the pseudobulb length and width, leaf length and width, inflorescence length, number of flower per inflorescence, flower width, distal of dorsal sepal and petals, color of sepals and petals, color of lip and presence of scent were recorded. The population of each character was grouped for population frequencies by their standard deviation and chi-square analysis was used to analyze the frequencies. Distribution values (skewness and kurtosis) were calculated, according to Sokal and Rohlf's method (1981).

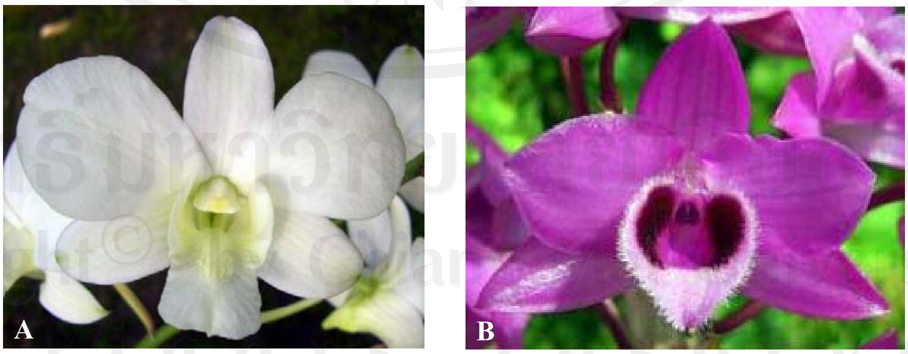

Figure 4 Parental lines of the cross.

(A) *Den.* Emma White and

(B) *Den. parishii* Rchb. f.

Results and discussion

A total of six crosses were made, only one cross, *Den*. Emma White × *Den. parishii* was obtained (Figure 4). Thus, only one set of the progenies derived from this cross was studied on their phenotypic distribution. Quantitative characteristic frequencies of the progenies and chi-square analysis of phenotypic ratio (Table 9) for each character was studied and the results were described as follows:

1. Pseudobulb length, they could be divided into four groups, 1.1-4.0, 4.1-8.49, 8.5-12.98 and 13.0-17.47 cms with the mean = 8.49 cms, and the frequencies of each group were 85, 202, 130 and 83 plants, respectively. Chi-square analysis ratio of the frequencies was 2 : 5 : 3 : 2 at probability ≈ 0.90.

2. Pseudobulb width, they could be divided into four groups, 0.3-0.69, 0.7-0.92, 0.93-1.14, and 1.15-1.36 cms with the mean = 0.92 cms, and the frequencies of each group were 98, 158, 180 and 73 plants, respectively. Chi-square analysis ratio of the frequencies was 1 : 2 : 2 : 1 at probability ≈ 0.20.

3. Leaf length, they could be divided into four groups, 2.5-5.26, 5.27-7.21, 7.22-9.19 and 9.20-11.11 cms with the mean = 7.21 cms, and the frequencies of each group were 100, 140, 182 and 78 plants, respectively. Chi-square analysis ratio of the frequencies was 3 : 5 : 6 : 2 at probability ≈ 0.15.

4. Leaf width, they could be divided into four groups, 0.6-1.33, 1.341.80, 1.81-2.27 and 2.28-2.74 cms with the mean = 1.80 cms, and the frequencies of each group were 84, 177, 159 and 80 plants, respectively. Chi-square analysis ratio of the frequencies was 1 : 2 : 2 : 1 at probability ≈ 0.70.

5. Number of leaves, they could be divided into three groups, 3-3.29, 3.30-6.89 and 6.90-10.49 leaves with the mean = 6.89 leaves, and the frequencies of each group were 48, 300 and 152 plants, respectively. Chi-square analysis ratio of the frequencies was 1 : 6 : 3 at probability ≈ 0.90.

Table 9 Quantitative characteristics frequencies of progenies derived from the cross between *Den.* Emma White × *Den. parishii,* and chi-square analysis of their phenotypic ratio.

Characters	Number of phenotypic frequencies of progenies (expected phenotypic ratio)	χ^2	P
Pseudobulb length	85 202 130 83 (2 : 5 : 3 : 2)	0.435	0.90
Pseudobulb width	98 158 180 73 (1 : 2 : 2 : 1)	5.380	0.20
Leaf length	100 140 182 78 (3 : 5 : 6 : 2)	6.10	0.15
Leaf width	84 177 159 80 (1 : 2 : 2 : 1)	1.144	0.70
Number of leaves	48 300 152 (1 : 6 : 3)	0.107	0.90
Inflorescence length	11 16 19 6 (3 : 4 : 5 : 1)	1.133	0.60
Number of flowers	9 24 17 3 (2 : 6 : 4 : 1)	0.438	0.80
Flower width	6 14 9 5 (1 : 3 : 2 : 1)	0.36	0.85
Flower longevity	10 10 12 (1 : 1 : 1)	0.25	0.80

6. Inflorescence length, they could be divided into four groups, 1-3.58, 3.59-6.54, 6.55-9.50 and 9.51-12.46 cms with the mean = 6.54 cms, and the frequencies of each group were 11, 16, 19 and 6 plants, respectively. Chi-square analysis ratio of the frequencies was 3 : 4 : 5 : 1 at probability ≈ 0.60.

7. Number of flowers, they could be divided into four groups, 1, 2, 3 and 4 flowers with the mean = 2.28 flowers, and the frequencies of each group were 9, 24, 17 and 3 plants, respectively. Chi-square analysis ratio of the frequencies was 2 : 6 : 4 : 1 at probability ≈ 0.80.

8. Flower width, they could be divided into four groups, 4.5-5.09, 5.10-5.74, 5.75-6.39 and 6.40-7.04 cms with the mean = 5.74 cms, and the frequencies of each group were 6, 14, 9 and 5 plants, respectively. Chi-square analysis ratio of the frequencies was 1 : 3 : 2 : 1 at probability ≈ 0.85.

9. Flower longevity, they could be divided into three groups, 41.00-41.66, 41.6743.59 and 43.60-45.52 days with the mean = 43.59 days, and the frequencies of each group were 10, 10, and 12 plants, respectively. Chi-square analysis ratio of the frequencies was 1 : 1 : 1 at probability ≈ 0.80.

The expected phenotypic ratios of the pseudobulb length, pseudobulb width, leaf length, leaf width, number of leaves, inflorescence length, number of flowers, flower width and flower longevity were in the range of accepted ratios, because their probabilities were more than 0.05.

The skewness value of phenotypic distributions of the pseudobulb length (Figure 5A), number of leaves and number of flowers (Figure 7A and 7B, respectively), inflorescence length (Figure 8), and flower longevity were positive (Figure 10). On the other hand, the skewness value of phenotypic distribution of the pseudobulb width (Figure 5B), leaf length and leaf width (Figure 6A and 6B, respectively), and flower width (Figure 9), were negative.

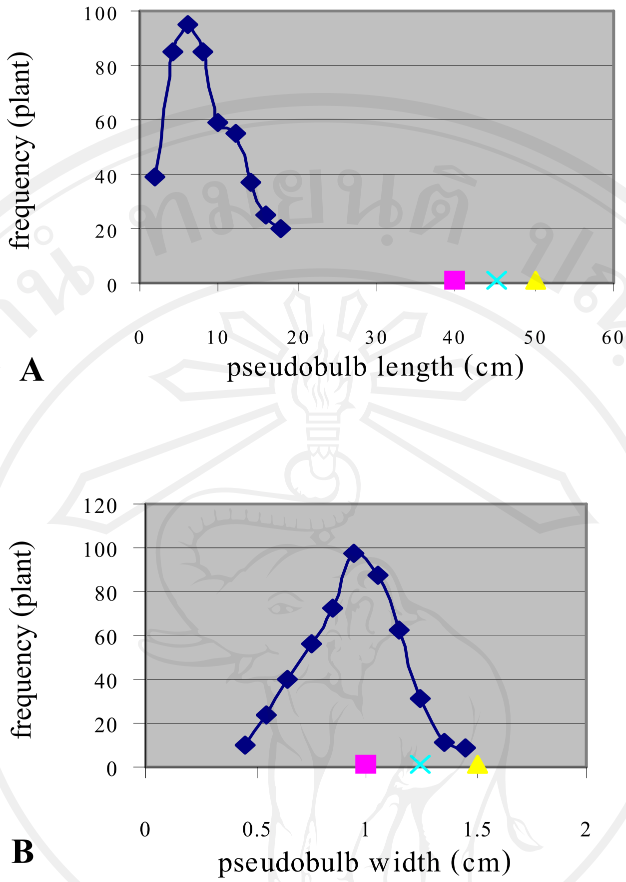

Figure 5 Distribution of progenies compared with parents and mid-parent.

(A) pseudobulb length and (B) pseudobulb width.

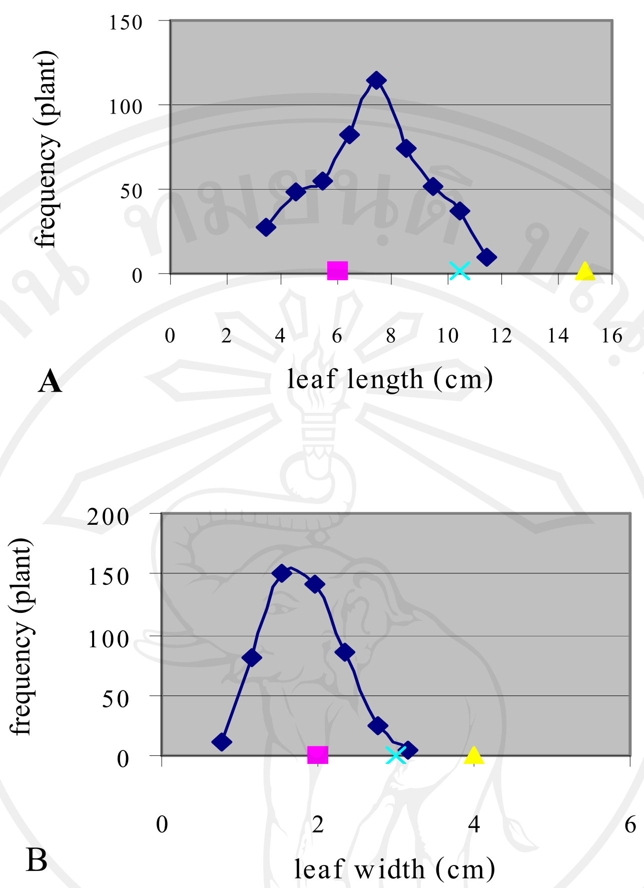

Figure 6 Distribution of progenies compared with parents and mid-parent. (A) leaf length and (B) leaf width.

progenies
female parent
male parent
mid parent

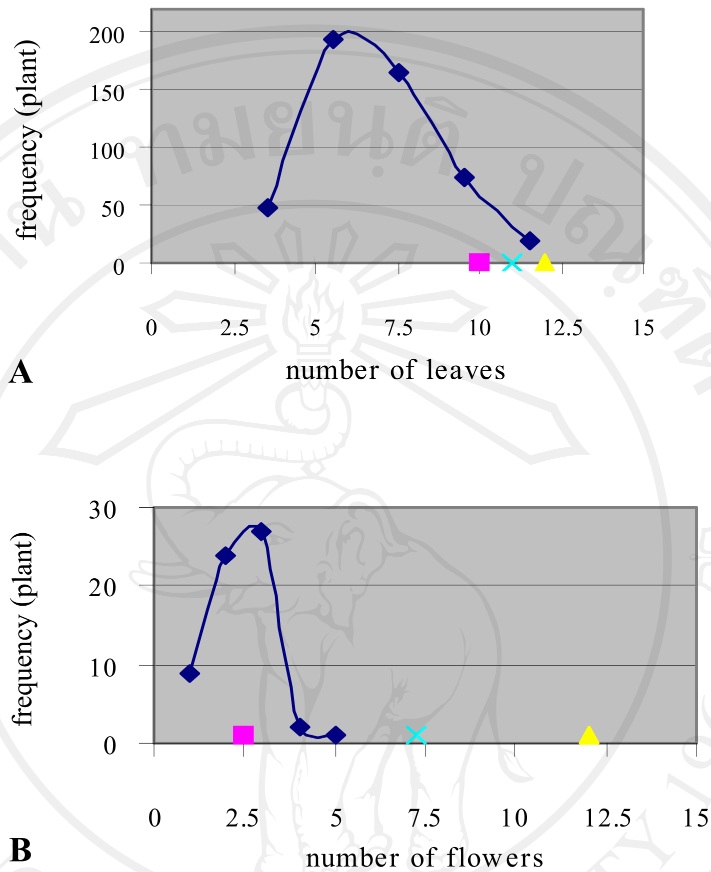

Figure 7 Distribution of progenies compared with parents and mid-parent. (A) number of leaves and (B) number of flowers.

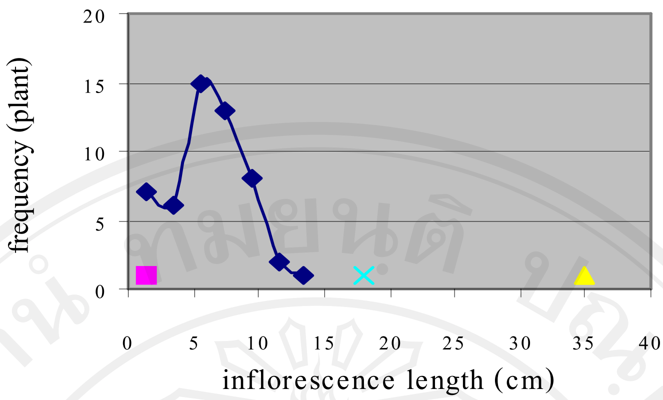

Figure 8 Distribution of progenies compared with parents and mid-parent for inflorescence length.

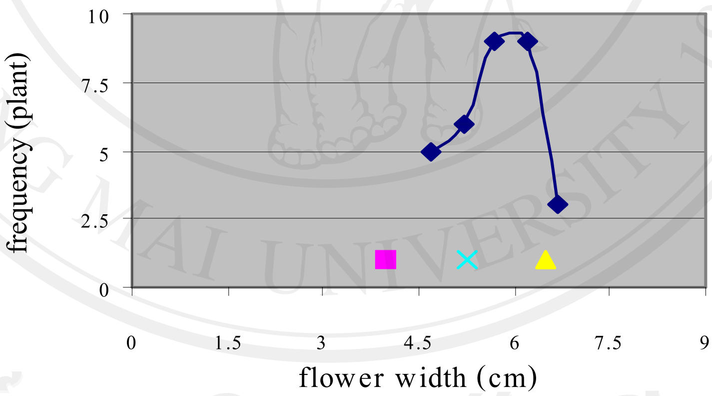

Figure 9 Distribution of progenies compared with parents and mid-parent for flower width.

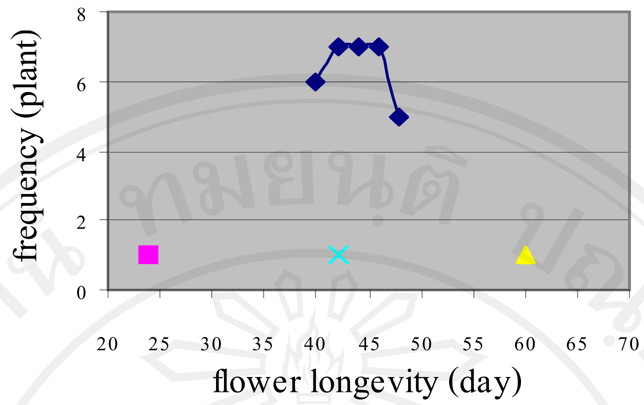

Figure 10 Distribution of progenies compared with parents and mid-parent for flower longevity.

progenies	female parent
male parent	mid parent

The kurtosis value of phenotypic distributions of the pseudobulb length, pseudobulb width, leaf length, leaf width, number of leaves, inflorescence length, number of flowers, flower width, and flower longevity on plants were positive (leptokurtosis). Pseudobulb length, pseudobulb width, leaf length, leaf width, number of leaves, inflorescence length, number of flowers, flower width, and flower longevity were quantitative characters which might have been governed by polygenes. So the phenotypic characters might be the result of the combination of polygenes actions and most of them might have been heterozygous additive gene which helped to provide the average value less than the mean of mid-parent value (negative dominance). Only two characters, flower width and flower longevity might have been heterozygous additive gene which had the average value more than the mean of mid-parent value (positive dominance). The studies on the influence of an individual gene on quantitative character were very complex because each gene influences in unequal actions and the characters were much influenced by environment. Galadee (2002) described that if dominance event had presented in Mendelian genetic, "dominance" in quantitative characters could be described as the differentiation between heterozygous mean and mid-parent value, therefore "positive dominance" has heterozygous mean more than mid-parent value and "negative dominance" has the mean less than mid-parent value.

Table 10 Qualitative characteristics frequencies of progenies derived from the cross between *Den.* Emma White × *Den. parishii,* and chi-square analysis of their phenotypic ratio.

Characters	Number of phenotypic frequencies of progenies (expected phenotypic ratio)			χ^2	P
Distal dorsal sepal	 triangle 24	(3 : 1)	 obtuse 8	0.00	1.00
Distal petals	 triangle 13	(1 : 1)	 obtuse 19	1.126	0.30
Epichile of lip	 triangle 6	(1 : 3)	 obtuse 26	0.670	0.40

There were three qualitative characteristics, distal dorsal sepal, distal petals and lip epichile, that could be detected and the number of progenies for each character was counted and chi-square analysis of phenotypic ratio was tested (Table 10). Therefore, hypothesis on number of genes that was governed this qualitative character was done. The character of distal dorsal sepal could be divided into two groups, triangle and obtuse, number of plants in each group were 28 and 8 plants, respectively and chi-square analysis ratio was 3 : 1, probability = 1. The ratio showed recessive epistasis genes action, thus, there must have been two genes that governed this character. The triangle distal dorsal sepal might be governed by homozygous alleles, *aabb*, and the obtuse distal dorsal sepal might be governed by heterozygous alleles, *AaBb*.

The character of distal petals could be divided into two groups, triangle and obtuse, number of plants in each group was 13 and 19 plants, respectively and chi-square analysis ratio was 1 : 1, probability = 0.30. The ratio showed complete dominant gene action, thus, the triangle distal petals might be governed by homozygous allele, *aa*, and the obtuse distal petals might be governed by heterozygous allele, *Aa*.

The character of lip epichile could be divided into two groups, triangle and obtuse, number of plant in each group was 6 and 26 plants, respectively and chi-square analysis ratio was 1 : 3, probability = 0.4. The ratio showed complete dominant gene action, which was similar to the genes controlling distal dorsal sepal character, the triangle of lip epichile might be governed by homozygous alleles, *aabb*, whereas the obtuse of lip epichile presented might be governed by heterozygous alleles, *AaBb*.

Sepals, petals and lip of progenies derived from the cross between *Den.* Emma White and *Den. parishii* Rchb. f. were purplish white, these phenotypic characters could be controlled by co-dominant gene action of heterozygous allele because the color of progenies was not presented in their parent. All of the progenies had purple keels and blot on central of lip, these might be due to complete dominant gene action of heterozygous allele. The result of lip epichile color was differed from the report of Poomploenphit (2006) stated that all of progenies derived from the cross between *Cattleya* Pornthip, white lip, and *Laeliocattleya* Mem. Robert Strait, reddish purple lip, showed reddish purple lip which presented complete dominance gene action and Pahirun (2006) reported that progenies derived from the cross between *Den. anosmum* var. *superbum,* white epichile, and *Den. anosmum*, purple epichile, produced white and purple epichile, 37 and 141 plants, respectively and chi-square analysis ratio was 1 : 3, probability = 0.02. The ratio showed recessive epistasis genes action.

Some of quantitative characters such as pseudobulb length, leaf length, leaf width, number of leaves and inflorescence length had their distribution in negative dominance. However, this kind of inheritance was good for breeding compact *Dendrobium* as potted orchid. On the other hand, some characters, such as flower width and flower longevity, presented additive genes action, which could help to improve bigger flower and longer flower longevity.

Conclusion

Phenotypic distribution of progenies derived from the cross between *Den.* Emma White and *Den. parishii* was studied and found that some quantitative characters such as pseudobulb length, number of leaves, inflorescence length and number of flowers showed positive skew, whereas phenotypic distribution of pseudobulb width, leaf length, leaf width and flower width were negative skew. All of the quantitative characters showed the frequency near means (leptokurtosis) and most of them had their means less than mid-parent values, except flower width and flower longevity, which had their means near mid-parent values. Number of genes controlling qualitative character such as, distal dorsal sepal and lip epichile were speculated as two genes governed each character and they were independent, whereas distal petal was governed by a single gene. Sepals, petals and epichile of lip of all progenies had purplish white color, whereas the central of lip had keels and presented purple blot color.