

The stories behind *Bauhinia* 'Blakeana' and its parents

紫荊本無種



Flowers of *Bauhinia* sp.,

1. *B. purpurea* 2. *B. variegata* 3. *B. 'Blakeana'* 4. *B. variegata* var. *candida*

Searching for Nature Stories 2015

Team 3

PLK Centenary Li Shiu Chung Memorial College

Cheung Nga Man

Lau Tsz Lok

Tsui Long Wai

Wong Shuk Yi

Wong Ka Man

Teacher: Mr. Wong Hung Tat



Abstract

Being the floral emblem of Hong Kong, *Bauhinia* 'Blakeana' or the Hong Kong Orchid Tree is the hybrid of *Bauhinia purpurea* and *Bauhinia variegata* (Lau *et al.*, 2005). The original reason for choosing *Bauhinia* 'Blakeana' as our city's floral emblem is that *Bauhinia* 'Blakeana' was first discovered in Hong Kong, and now it is commonly planted along the pavement of the streets.

The reason for us to choose this topic is highly related to the presence of *Bauhinia purpurea* and *Bauhinia variegata* trees in our school. And there is also a *Bauhinia* Garden near our school campus planting different species of *Bauhinia* trees. The visual similarity between these *Bauhinia* species especially the doubled lobed shape of their leaves grabbed our attention. In this project, we investigated the similarities and differences in morphology and physiology between *Bauhinia* 'Blakeana' and other *Bauhinia* tree species, and whether B. 'Blakeana' enjoys hybrid vigour. From our findings, we discovered that the colour of the flowers, the shape of pollens, the number of main veins in leaves, the ratio of leaf diameter to petiole length, stomata density and transpiration rate per unit area of leaf of the four species of *Bauhinia* varies. B. 'Blakeana' had flowers outsized and petals had brighter colour than their parents. Therefore, B. 'Blakeana' may enjoy hybrid vigour in attracting insects for pollination. Unluckily, B. 'Blakeana' cannot carry out successful fertilization to form seeds and is sterile.

洋紫荊作為香港的市花，其實是宮粉羊蹄甲及紅花羊蹄甲的混種 (Lau *et al.*, 2005)。香港政府選擇以洋紫荊作為香港市花，是因為這種植物乃是在香港首次被發現，也是一種常見的行道樹。而我們隊伍選擇這種植物作為我們研究的對象，是因為我們學校的後花園中種有宮粉和紅花羊蹄甲兩種植物，它們的外貌相似，由其是羊蹄形狀的樹葉令我們聯想到我們學校附近的大興洋紫荊園裡的洋紫荊及其它羊蹄甲樹。而在是次的研習中，我們嘗試找出洋紫荊及其近親 (宮粉羊蹄甲、白花宮粉羊蹄甲及紅花羊蹄甲) 的形態及生理相異及相似之處，以及洋紫荊是否具有雜種優勢。從我們的研究中發現，四種植物的花瓣的顏色、花粉的形狀、葉脈的數目、葉子直徑與葉柄長度的比例、氣孔密度和樹葉每單位面積蒸騰速度都有不同，洋紫荊具有較大與顏色較鮮艷的花朵，似乎是一種雜種優勢，以便吸引昆蟲授粉，但遺憾的是它不能夠成功受精製造種子，因此是不育的。

Content

Date and time of field work P.3

Major Physical Sites P.4

Apparatus and Equipment P.5

Microhabitat of *B. sp.* P.6

Morphology of flowers/ dissected flowers of different *Bauhinia sp.*, leaf morphology P.6-13

Experiments P. 14-19

Discussions P.18-19

Possible sources of errors and suggested further investigation P.19

References P.20

Appendix (Laminated dry specimens of dissected flowers of *Bauhinia sp.*) P.21-24

Introduction

Being the floral emblem of Hong Kong, *Bauhinia* 'Blakeana' (or the Hong Kong Orchid Tree) is the hybrid of *Bauhinia purpurea* and *Bauhinia variegata* (Lau *et al.*, 2005). It is regarded as a horticultural cultivar rather than a natural species; hence named as *Bauhinia* 'Blakeana' (Lau *et al.*, 2005). The original reason for choosing *Bauhinia* 'Blakeana' as our city's floral emblem is that *Bauhinia* 'Blakeana' was first discovered in Hong Kong, and now it is commonly planted on the pavement of the streets.

The reason for us to choose this topic is highly related to the presence of *Bauhinia purpurea* and *Bauhinia variegata* trees in our school. And there is also a *Bauhinia* Garden near our school campus planting different species of *Bauhinia* trees. The visual similarity between these *Bauhinia* species grabbed our attention. In this project, we investigated the morphological variation in *Bauhinia* 'Blakeana' and other *Bauhinia* tree species (leaves and its stomata density, flowers, pollen structure and tree shape), stem T.S. structure, flowering periods and difference in physiology (transpiration rate in leaves). We would also want to find out whether *Bauhinia* 'Blakeana' demonstrates any hybrid vigour.

Table 1: Date and time of field work

Field work	Time and Date	Venue	Objective
1 st field work	21-12-2014	Tuen Mun Tai Hing Estate- Bauhinia Garden	Collection of flower and leaf specimens of <i>Bauhinia</i> sp.
2 nd field work	1-2-2015	Tuen Mun Tai Hing Estate- Bauhinia Garden	1. Measuring the physical environment of the microhabitat of <i>Bauhinia</i> sp. 2. Measuring the height & circumference of the trunk tree of <i>Bauhinia</i> sp.
3 rd Field work	25-2-2015	Tuen Mun Tai Hing Estate-Bauhinia Garden	Collection of leafy twigs of <i>Bauhinia</i> sp. for free-hand sectioning of the stem and experiments in transpiration

Major physical (abiotic) factors of the habitat of *Bauhinia* species

Date 1-2-2015 Venue: Tuen Mun Tai Hing Estate- *Bauhinia* Garden

Figure 1 (source form google map)

Location:



Bauhinia purpurea

Bauhinia variegata

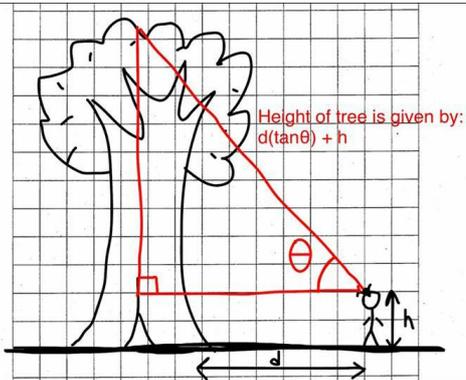


Bauhinia variegata var. candida

Bauhinia 'Blakeana'



Table 2: Apparatus and equipment

Item	Name	Quantity	Purpose of use
1	Measuring tape (30 meter)	1	1. To measure the distance between the tree and the observer. 2. Use this with the Abney level to find the height of the trees for comparison.
2.	Light Meter	1	Measure the light intensity of the microhabitat
3	Abney level	1	1. To find the angle between the observation point and the top of the tree; 2. Use this angle and the distance between the tree and the observer and trigonometry to find out the height of the trees. <u>Figure 2</u>
			
4	Compass	1	To find out the direction of the wind
5	Ruler (1 meter)	2	To measure the width and length of the leaves and flowers
6	Anemometer (wind meter)	1	To find out the wind speed around the trees
7	Nylon thread	1	To assist the compass to find the direction of the wind
8	Thermo-hygrometer	1	To measure the relative humidity and temperature of the microhabitat
9.	Microscope	1	To observe the details of the pollen grains & sections of the stem

Physical environment in the Microhabitat of *Bauhinia* sp. :

Table 3 (Date: 1 / 2 / 2015)

Name of the tree	<i>Bauhinia</i> 'Blakeana' Sample 1	<i>Bauhinia</i> 'Blakeana' Sample 2	<i>Bauhinia</i> 'Blakeana' Sample 3	<i>Bauhinia.</i> <i>purpurea</i>	<i>Bauhinia.</i> <i>variegata</i>	<i>Bauhinia.</i> <i>variegata</i> <i>var.</i> <i>candida</i>
Temperature(°C)	14.1	15.6	14.8	14.8	15.1	16.0
Wind speed (ms ⁻¹)	2.7	1.0	1.2	0.4	0.5	0.8
Wind direction	From S80° E to N40° W	From S40° E to N30° W	From S80° E to N41° W	From S50° E to N62° W	From S78° E to N50° W	From S80° E to N60° W
Relative Humidity (%)	64	64	64	62	63	57
Light intensity(lux) (below canopy)	7050	3160	7540	2830	8080	4240
Light intensity(lux) (above canopy)	16650	19640	20210	17000	15650	13820

Discussion of the physical factors recorded:

According to the data above, we can see that the physical factors measured in the microhabitats of the different *Bauhinia* sp. varied.

Morphology of flowers/ dissected flowers of different *Bauhinia* sp.

Dissection of *Bauhinia* flowers

1. Flowers of *Bauhinia* sp. were collected and dissected in the laboratory.
2. Pairs of forceps and scissors were carefully used to cut the calyx out. Petals were then peeled off. The number of sepals and petals was counted respectively.
3. The stamens and carpels were peeled off with forceps. The number of stamens and carpels was carefully counted.
4. The peeled sample was organized on a piece of paper. Some of the samples

were used to make dry specimens of the flower for future reference.

5. An anther was cut. A drop of water was added onto a slide. Pollens from the cut anther were swiped to the drop of water using a toothpick. A cover slip was placed for microscopic observation.

***Bauhinia* 'Blakeana'**

Figure 3 & 4 : Dissection of the flower of *Bauhinia* 'Blakeana'



Bauhinia purpurea

Figure 5: Dissection of the flower of *Bauhinia purpurea*



Bauhinia variegata

Figure 6 & 7: Dissection of the flower of *Bauhinia variegata*



Bauhinia variegata* var. *candida

Figure 8: Dissection of the flower of *B. variegata* var. *candida*

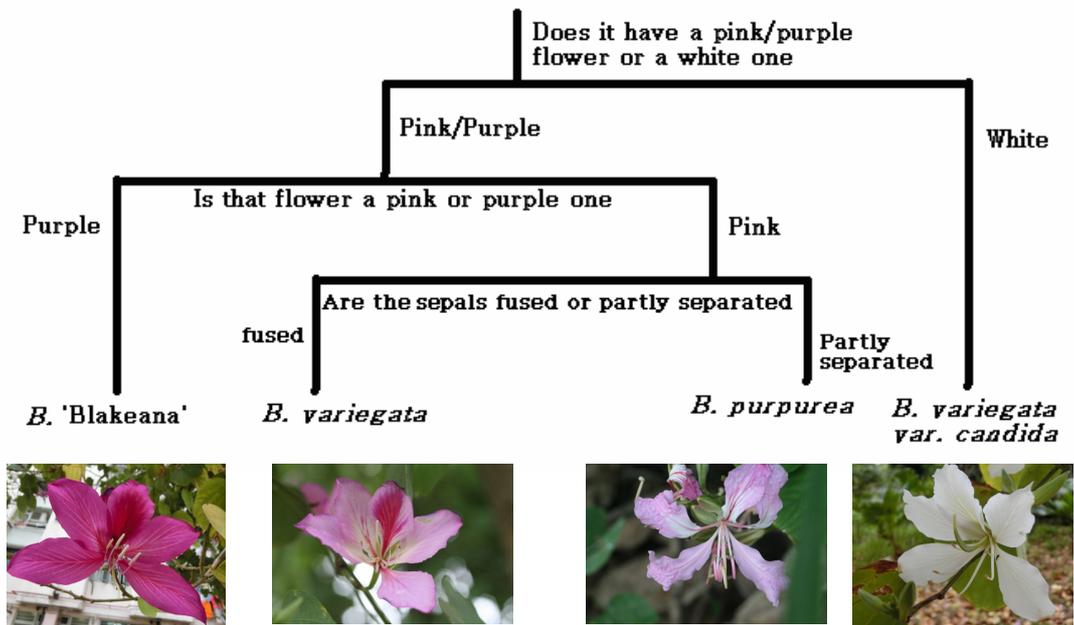




Figure 9: Photo of flowers and leaves of *B. variegata var. candida*, *B. purpurea*, *B. variegata* and *B. 'Blakeana'*, from left to right.

A homemade Dichotomous Key for the identification of the flowers of *Bauhinia sp.* was constructed below.

Figure 10: Dichotomous Key for identification of the flowers of *Bauhinia sp.*



Practical work

Observation of Pollen Grains

Bauhinia purpurea* & *Bauhinia variegata

Figure11: Pollen Grains from *B. purpurea*(400x)

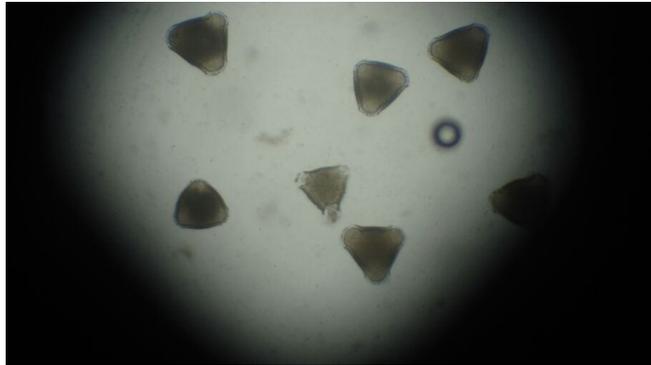
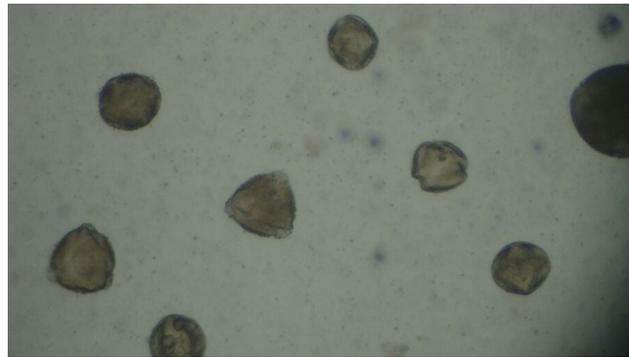


Figure12: Pollen Grains from *B. variegata*(400x)



The pollens from *B. variegata* and *B. purpurea* were very similar, with a triangular shape and a little swollen at each angle.

***Bauhinia* 'Blakeana'**

Figure 13 &14 : Pollen Grains from *Bauhinia* 'Blakeana'

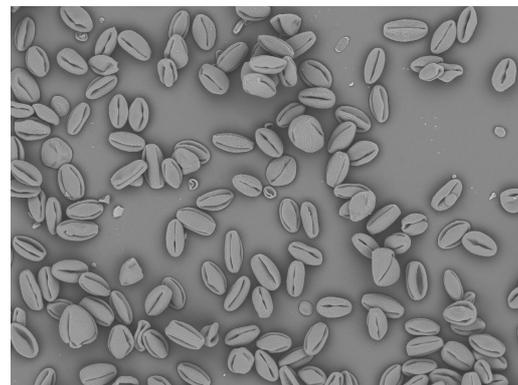


Figure 13: Low Power (100x)

Figure 14: Scanning EM (300x) taken in Ho Koon

The pollen grains of *Bauhinia* 'Blakeana' were irregular in size, with some much smaller than normal ones. These small pollens were described as "micro-pollens" which were sterile. (Lau *et al.*, 2005)

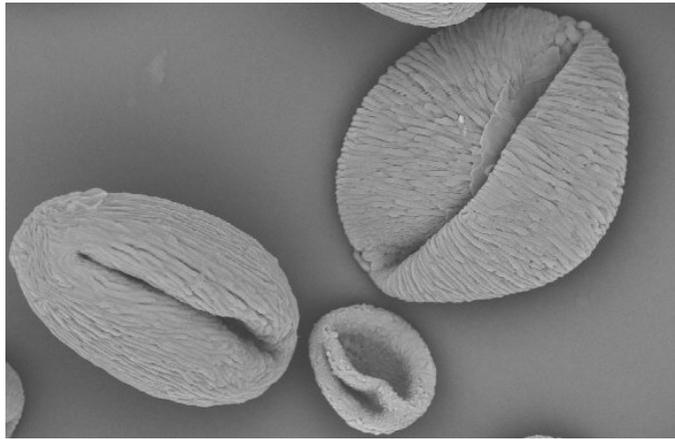


Fig. 15 Normal Pollen Grains from *Bauhinia* 'Blakeana' (on left and right),
"micropollen" (in the centre)

Scanning EM (1000x) taken in Ho Koon Nature Education Centre

Bauhinia. variegata var. candida

Figure 16: Pollens from *B. variegata var. candida*



High Power (400x)

The pollen grains of *B. variegata var. candida* were similar to that to *B. purpurea* and *B. variegata*. However, the shape is slightly different as they are more swollen and flat than that of *B. purpurea* and *B. variegata*.

Thin sections of *Bauhinia* stems.

Procedures:

1. Young stems of *Bauhinia* sp. were cut and labeled
2. A moistened sharp blade was used to cut a thin piece of cross section from the stem.
3. The piece was then stained with methylene blue or iodine solution.
4. It was rinsed with distiller water, and then put on a slide for microscopic observation. Photos were taken.

Result:

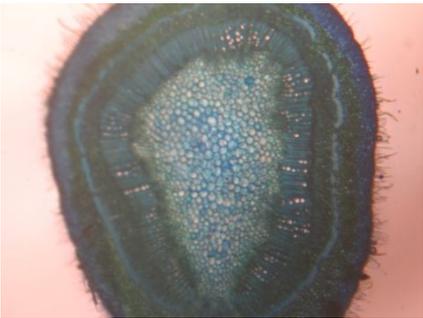
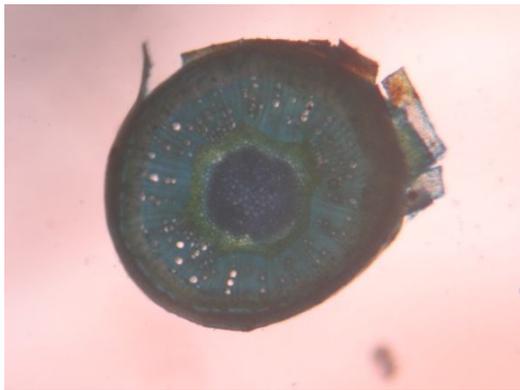
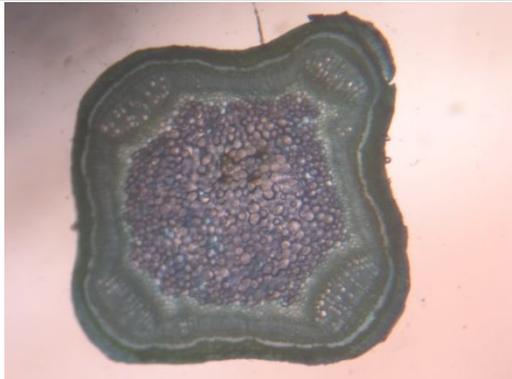
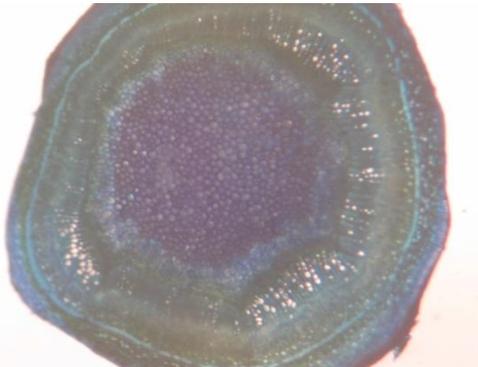
Cross section	Name of species	With/without hair	Shape
	<i>B. 'Blakeana'</i> Stem TS	v	<i>circular</i>
	<i>B. purpurea</i> Stem TS	x	<i>circular</i>
	<i>B. variegata</i> stem TS	x	<i>angular</i>
	<i>B. variegata.</i> <i>candida</i> stem TS	x	<i>circular</i>

Table 4, Figure 17-20

There was not much difference in the histology of the transverse sections of the stems of the 4 species, except in the degree of secondary thickening due to the different age of the stems. However, in *B. 'Blakeana'*, epidermal hairs were found.

Leaf morphology and Flower size

Data like leaf diameter, petiole length and number of main veins, flower breadth and width were measured and recorded.

Table 5: Leaf morphology

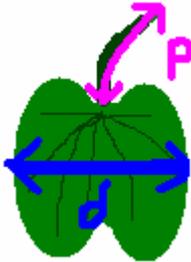
	Leaf diameter (d) (cm)	Petiole Length (p)(cm)	Leaf diameter / Petiole length (d/p)	Average no. of main veins on leaf
				
<i>B. purpurea</i>	11.28	3.84	2.94	9.00
<i>B. variegata</i>	8.55	3.92	2.18	7.42
<i>B. 'Blakeana'</i>	9.91	3.93	2.52	9.91
<i>B. variegata var. candida</i>	11.12	2.23	4.98	11.08

Table 6: Flower size

	Flower Width(cm)	Flower Breadth(cm)
<i>B. purpurea</i>	8.14	7.82
<i>B. variegata</i>	8.20	7.32
<i>B. 'Blakeana'</i>	10.18	7.32
<i>B. variegata var. candida</i>	7.17	6.27



The height and circumference of tree trunk of the tree samples of different *B. sp.* were measured.

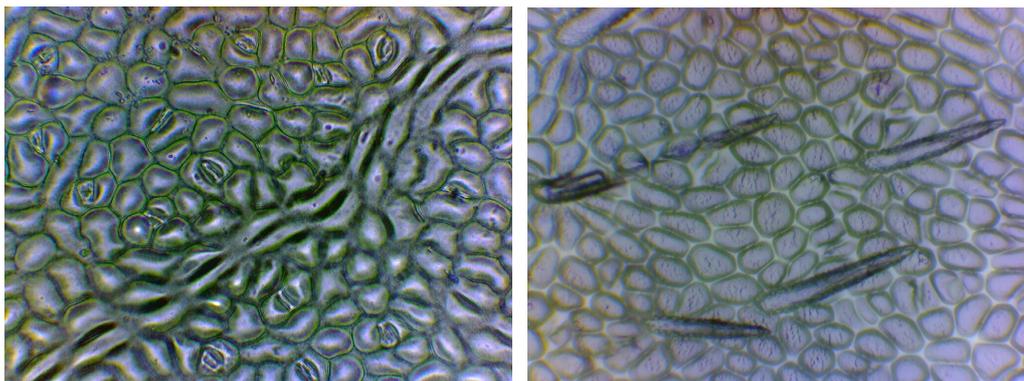
Table 7: Size of the trees

Name of tree	B. 'Blakeana'			B. <i>purpurea</i>	B. <i>variegata</i>	B. <i>variegata var. candida</i>
	Sample 1	Sample 2	Sample 3			
Height (m)	9.24	7.88	9.96	10.64	8.70	12.97
Circumference of tree trunk (cm)	56	60.3	50.5	72.5	54	192

Density of stomata in leaf epidermis

Procedure:

1. Leaf samples from 4 *Bauhinia sp.* were collected respectively.
2. A small amount of nail varnish was applied onto the upper epidermis and lower epidermis respectively. It was then left for 10 minutes to dry out.
3. The nail varnish impression was then peeled off and put on a slide for microscopic observation. The number of stomata observed from each sample at a fixed magnification was counted.



Bauhinia purpurea

Bauhinia 'Blakeana'

Fig.21: Nail varnish impression of lower epidermis of leaf, 100x

The results were listed below.

Table 8: Stomata Density

Average no. of stomata (per unit area) (x400)	Upper Epidermis	Lower Epidermis
B. purpurea	0	5.1
B. variegata	0	10.2
B. 'Blakeana'	0.1	2.2
B. variegata var. candida	0	5.4

Experiment to compare the transpiration rate of leafy twigs of different *Bauhinia* species using homemade weight potometer.

Date: 25/2 - 27/2/ 2015



Figure 22



Figure 23

Oil layer

water

Key:

A= *B. 'Blakeana'*

B= *B. variegata*

C= *B. variegata var candida*

D= *B. purpurea*

Table 9: Apparatus and equipment

Item	Quantity	Purpose
Plastic Bottles (500 mL)	4	Carrying the water, oil and leafy twigs
Electronic Balance	1	Measuring the weight of the whole set up before and after the experiment
Water	350 ml	Water reserve for the twigs to absorb and replenish the water loss by transpiration
Oil on water surface	50 ml	Prevents evaporation from the surface of the water in the plastic bottles

Procedures:

1. Samples of tree branches with leaves from *B. purpurea*, *B. variegata*, *B. 'Blakeana'* and *B. variegata var. candida*. were prepared.
2. Broken leaves were cut away. The 4 leaf twigs were cut to a most optimised size, and then inserted into the bottles of water.
3. The bottles were then labelled.
4. 350 ml water was added into each bottle respectively. A layer of oil was added on the surface of the water to prevent evaporation of water.
5. An electronic balance was used to weigh the bottles together with the specimen.
6. Their initial weights were recorded. The weight was then recorded for several

more times for 2 days. The data and results were listed in the table below.

7. The total area of the leaves in each twig was measured by putting on a piece of graph paper.

8. A graph of the cumulative weight of water loss per unit area of leaf against time of different species of *Bauhinia* was plotted

Table 10: Cumulative water loss in leaf per unit area

Time (hour)	0	5.73	16.73	21.98	27.48	31.4	37.65	Total Area of Leaves (cm ²)
Cumulative weight of water loss per unit area of leaf (10 ⁻³ g / cm ²) (<i>B. purpurea</i>)	0	2.933	5.342	8.988	9.813	10.162	10.716	630.81
Cumulative weight of water loss per unit area of leaf (10 ⁻³ g / cm ²) (<i>B. variegata</i>)	0	4.237	8.782	14.213	16.216	17.295	18.912	259.62
Cumulative weight of water loss per unit area of leaf (10 ⁻³ g / cm ²) (<i>B. 'Blakeana'</i>)	0	1.786	5.231	11.253	12.633	13.414	14.612	934.86
Cumulative weight of water loss per unit area of leaf (10 ⁻³ g / cm ²) (<i>B. variegata var. candida</i>)	0	2.853	6.804	15.539	17.163	18.128	19.489	227.82

Table 11: Average transpiration rate in leaves of *Bauhinia* sp.

Time (hour)	Average transpiration rate in leaves (weight of water loss per unit area of leaf per unit time) (10 ⁻⁴ g cm ⁻² hr ⁻¹)
<i>B. purpurea</i>	2.85
<i>B. variegata</i>	5.02
<i>B. 'Blakeana'</i>	3.88
<i>B. variegata var. candida</i>	5.18

Cumulative Weight of Water Loss per Unit Area of Leaf of Different Species of Bauhinia against Time

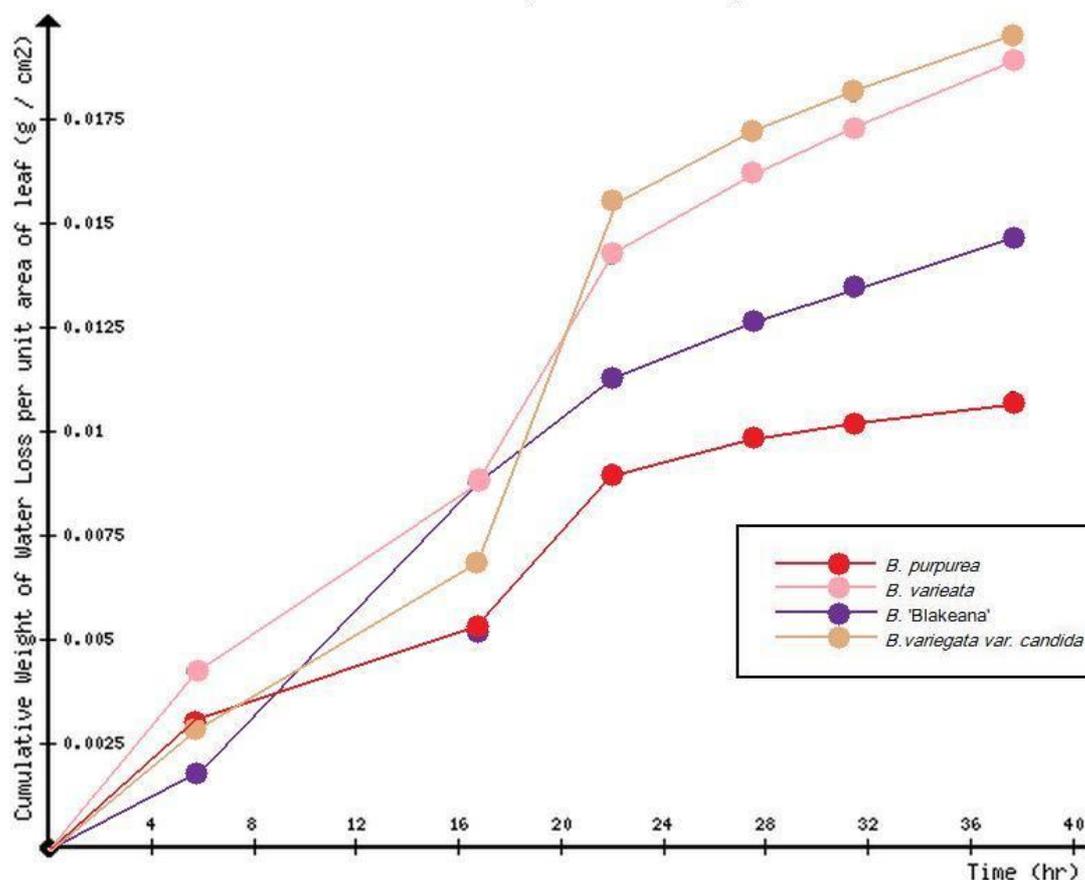


Figure 24

Table 12: Summary of the data recorded for the *Bauhinia* tree species

Species Name	<i>Bauhinia purpurea</i>	<i>Bauhinia variegata</i>	<i>Bauhinia</i> 'Blakeana'	<i>Bauhinia variegata var. candida</i>
Common Name	Purple Camel Foot	Camel's foot tree	Hong Kong Orchid Tree	White <i>Bauhinia</i>
Chinese name	紅花羊蹄甲	宮粉羊蹄甲	洋紫荊	白花羊蹄甲
Leaf Diameter / Petiole length	2.94	2.18	2.52	4.99
Average no. of main veins	9.0	7.4	9.9	11.1
Width of Flower (cm)	8.14	8.20	10.18 (largest flower size)	7.17
Breadth of Flower (cm)	7.82	7.32	7.32	6.27
Flowering Period (Jim, 2006)	Sept. to Jan	Dec. to April	Sept. to April (longest period)	Dec. to April

Petal Colour		Pink	Pink	Deep magenta (brightest colour)	White
No. of stamens		5 (with 3-4 staminodes)	5	5	5
No. of petals		5	5	5	5
No. of sepals		5(partly fused)	5 (fused)	5(fused)	5(fused)
No. of carpels		1	1	1	1
Circumference of trunk (cm)		72.5	54	55.6	192
Height of tree (m)		10.64	8.70	9.03	12.97
Tree height / circumference of tree trunk		14.7	16.1	16.4 (slimmest tree shape)	6.8
Number of stomata per unit area	Upper Epidermis	0	0	0.1	0
	Lower Epidermis	5.1	10.2	2.2 (lowest density)	5.4
Transpiration rate in leaves (weight of water loss per unit area of leaf per unit time)(10^{-4} g cm ⁻² hr ⁻¹)		2.85	5.02	3.88 (second lowest rate)	5.18

Discussion on the Results

B. 'Blakeana' had the largest flowers (in terms of width and breadth of the flower). The second and third were *B. variegata* and *B. purpurea* respectively. *B. variegata var. candida* had the smallest flowers. In addition, petals of *Bauhinia 'Blakeana'* was deep magenta in colour, it was sharper in colour than the other *Bauhinia* species. The bigger and sharper colour petals would be more attractive to insects for pollination.

The ratio between leaf diameter and petiole length of *B. variegata var. candida* was the greatest, followed by *B. purpurea*. *B. 'Blakeana'* was the third and *B. variegata* had the smallest ratio.

All the four *Bauhinia* species had different numbers of main veins. *B. purpurea* had

leaves with 9 veins, *B. variegata* with 7-8 veins and *B. 'Blakeana'* with 10 veins (rarely, 9 veins). The number of veins found in *B. 'Blakeana'* leaves was more than that in *B. purpurea* and *B. variegata*. In *B. variegata var. candida*, 11 (rarely, 12) veins were found.

The transpiration rate per unit area of leaf of *B. variegata var. candida* was the highest. *B. variegata* was the second, while *B. 'Blakeana'* is the third. *B. purpurea* had the lowest transpiration rate. Concerning the density of stomata in the leaves of different species found, all *Bauhinia* sp. had nearly no stomata in their upper epidermis. However the density of stomata in their lower epidermis varied. *B. variegata* had the highest density of stomata, followed by *B. variegata var. candida*. The third was *B. purpurea* and *B. 'Blakeana'* had the lowest.

Conclusion:

From the above it showed that *Bauhinia 'Blakeana'* had flowers outsized *Bauhinia purpurea* and *Bauhinia variegata*. *Bauhinia 'Blakeana'* also has the longest flowering period and bear flowers with the brighter petal colour than its parents, *Bauhinia purpurea* and *Bauhinia variegata*. Therefore, *Bauhinia 'Blakeana'* can be more attractive to insects for pollination. Also, unlike *Bauhinia purpurea*, it does not have any sterile staminodes. The stomata density in the leaves of *Bauhinia 'Blakeana'* was the lowest, and the transpiration rate was also the second lowest. This may help to reduce water loss by direct illumination from the sun. The above may be the hybrid vigour of *Bauhinia 'Blakeana'*. Unluckily *Bauhinia 'Blakeana'* cannot carry out successful fertilization to form seeds and is sterile. It can only be propagated vegetatively.

Possible sources of errors and suggested further investigation

1. We have only investigated 12 tree samples in total. Because of these, the information that we have recorded may not be so representative. This would also affect the reliability of our result.
2. More outings, field trips could be organized so that we can collect more samples to take data. After doing this, our final result will also be more reliable.
3. For further investigation, we would like to find out what types of insect are the pollinators of the four types of *Bauhinia* species. Are the insect pollinators specific for different species of *Bauhinia*?

Reference

1. C.Y. Jim (2006). *Bauhinia* Trees: From Obscurity to Celebrity. Cosmos Books Ltd. 432pp.
2. K M Ho; Y K Ho; K H Tam; L P Tong; H W Yung (2010). The Story of the Hong Kong Orchid Tree. New Senior Secondary Mastering Biology Book 3. Oxford University Press: 19-40
3. Lau, C. P. Y.; Ramsden, L.; Sanders, R. M. K. (2005), "Hybrid origin of "*Bauhinia blakeana*" (Leguminosae: Caesalpinioideae), inferred using morphological, reproductive, and molecular data", *American Journal of Botany* 92 (3): 525-533
4. Internet resources: *Bauhinia blakeana*.
http://en.wikipedia.org/wiki/Bauhinia_blakeana Retrieved on 26th March, 2015
5. Internet resources: Hybrid origin of *Bauhinia blakeana*
<http://www.amjbot.org/content/92/3/525> Retrieved on 26th March, 2015
6. Internet resources: Field Skills
<http://ifieldstudy.net> Retrieved on 26th March, 2015

Appendix

Laminated dry specimens of dissected flowers of *Bauhinia* sp.







Bauhinia 'Blakeana'
(Hong Kong Orchid Tree)

洋紫荊

(16-03-2015)



Bauhinia variegata var. *candida*

白花羊蹄甲

(16-03-2015)