Searching for Nature Stories

May the best knave win----------a study of the relationship between fig wasps and Ficus

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1) Abstract

Fig wasps are classified under the family Agaonidae, Pteromalidae and Hymenoptera. They are seemingly insignificant insects which have an inseparable and delicate relationship with fig trees as they both try to maintain a delicate balance for survival.

In this report, questions from various aspects were raised about this unique and intriguing relationship. Our objectives are to investigate the host specificity of fig wasps and fig trees and explore the abundance of fig trees among other trees as well as the pollination rate of female flowers in figs.

Figs were collected in 4 areas: Near the Choi Sai Wu Park, Braemar Hill; Near Cloud View Road and Wan Tin Path, Fortress Hill, an area near Leung King, Tuen Mun and on the campus of Chinese University of Hong Kong (CUHK).

The most abundant fig tree among all *Ficus* found in these areas is *Ficus hispida*, which accounted for 55.7% of all *Ficus*. It was followed by *Ficus microcarpa*, which has an abundance of 30.7%. *Ficus variegata* has an abundance of 6.8%. Both *F. hispida* and *F. variegata* have high pollination rates. The pollination rate of female flowers in *F. hispida* is 85.4% while that of *F. variegata* is 81.4%. The range of seeds in a fig is not affected by fig size. It was found that the style lengths of gall flowers of *F. hispida* and *F. variegata* are shorter than those of female flowers. It was also found that there existed a difference in the developmental stage of galls in *F. variegata*. A total of three species of fig wasps were found in *F. variegata* and *F. hispida*, the two species of fig trees under our investigation. Two of which can be identified as *Philotrypesis pilosa* and *Ceratosolen solmsi*. They were found in the figs of *F. hispida*. The remaining one, which was found from the figs of *F. variegata*, can be identified as *Apocrypta sp.* They can be divided into 2 groups: *C. solmsi* is pollinators while *P. pilosa* and *Apocrypta sp.* are non-pollinators. It was found that the number of pollinators found within the figs of *F. hispida* were much higher than the number of non- pollinators. As only one pollinator can be found in fig of *F. hispida*, it supports the host specificity of fig wasps.

2) Introduction

2.1 Introduction to the research topic

Our team was reading online materials extensively when we came upon a research about fig wasps around the world that was done recently.[1] Intrigued by the immense importance that such a tiny, seemingly peripheral insect has on the survival and reproduction of a genus of gigantic trees as *Ficus*, we decided to have fig wasps as our research direction. After much discussion, consideration and advice by our Biology teacher, Mr. Tong, we adamantly set this as our research topic to explore the host specificity and the subtle, delicate relationship between fig wasps and *Ficus* in Hong Kong.

As there were 14 species of *Ficus* in Hong Kong,[2] it would be more realistic and practical to focus our research on several species and their corresponding fig wasps only. To decide on the exact species of *Ficus* trees that our investigation would be based on, a general surveying of the area near our school in Fortress Hill was done. We walked around an area of radius 300m from our school, which is located on Cloud View Road. The abundance of *Ficus* trees among others genus and species as well as the most abundant *F.* with figs found on their stems and branches were recorded. *F. hispida* were found in the largest number with figs on their stem. They were followed by *F. microcarpa* which has no figs during our period of surveying so we opted for *F. variegata* which was third in abundance with figs found. After dissecting the figs to ensure fig wasps can indeed be found, these two native species of *Ficus* and their corresponding wasps became the subjects of our research.

2.2 Objectives

1) To investigate the host specificity of fig wasps and *F. hispida* and *F. variegata*.
2) To explore the abundance of *F. hispida* and *F. variegata* among all species of trees and within its

[1] Cruaud A. , Rønsted N. , Chantarasuwan B, *et al* (2012)An extreme case of plant-insect codiversification: figs and fig-pollinating wasps. *Systematic Biologists.* 61(6):1029–1047, Retrieved on 25 Mar 2015 from: http://geo.cbs.umn.edu/CruaudEtAl2012.pdf

[2] Corlett, R. T. (2006). Figs (Ficus, Moraceae) in Urban Hong Kong, South China1. *Biotropica*, *38*(1), 116-121.

own genus, *Ficus.*

3) To find out the pollination rate of female flowers in figs of *F. hispida* and *F. variegata.*

2.3 Research questions

1) What are the species and nature (pollinating of not) of the fig wasps parasitized in the figs of *F. hispida* and *F. variegata*?

2) What is the abundance of different species of fig trees among the genus and other species of trees?

3) What is the proportion of female fig trees to male fig trees?

4) What is the rate of pollinated female flowers in fig and its relation with number of fig wasps found in fig?

5) What is the proportion of vacant gall flowers to gall flowers with wasp found inside?

6) Is there any difference in style length between gall flowers and female flowers?

2.4 Background information of *F. variegata*, *F. hispida* and fig wasps

Ficus is a genus of nearly 900 trees with species common throughout the world. Usually found in tropic regions, their roots have now extended into semi-warm temperate zones. Hong Kong, being a subtropical and monsoonal region, hosts 14 species of *Ficus*. The *Ficus* for our investigation are *F. hispida* and *F. variegata*. Each tree of *F. variegata* and *F. hispida* is unisexual.[3] The figs of *F. variegata* grow in bundles on tree trunks and branches. The figs are round or pear-shaped, green, yellow, orange or dark red in colour, and approximately 3-4 cm in diameter.[4] The figs of *F. hispida* grow on normal leafy shoots, on leafless branch lets or branches. They are either solitary or paired. When they mature, they appear to be yellow or red in color, are rounded and measures 1.2-3 cm in diameter.[5] Each species of *Ficus* produces 3 different types of flowers that can be found to be enclosed in the figs: male, female and gall. The male and gall flowers are found in the same fig while female flowers are observed to be on their own. Each fig encloses thousands of flowers.

Fig.1 *Ficus hispida* with figs

Fig. 2 *Ficus variegata* with figs

Ficus depend solely on fig wasps for the pollination of their figs. Fig wasps belong to the family Agaonidae or Hymenoptera. Female wasps have an ovipositor, which is used for laying eggs in figs. The body length of different genus and species of fig wasps vary due to the difference in their lengths of ovipositors. There are about 900 species of fig wasps in this world responsible for the 900 species of fig trees.[6] Fig wasps need to enter figs for reproduction. Only female fig wasps enter figs to lay eggs that were fertilized before they left the figs that they were born in. In the process, the female fig wasps are left wingless and can never leave the figs again so they are left to die in it. For dioecious species, the eggs of fig wasps can develop into larvae in gall flowers only. Therefore,

[3] HK Trees. *Ficus variegata* Retrieved on 18 Mar 2015 from: http://www.hktree.com/tree/Ficus%20variegata%20var%20chlorocarpa.htm

[4] Natural Tropical Botanical Gardens. *Ficus variegata*. Retrieved on 18 March 2015 from: http://ntbg.org/plants/plant_details.php?plantid=5227

[5] Globinmed. *Ficus hispida* .Retrieved on 18 Mar 2015 from: http://www.globinmed.com/index.php?option=com_content&view=article&id=104415:ficus-hispida&catid=199&Itemid=139

[6] Encyclopædia Britannica (Jul 2013) Fig wasp. Retrieved on 18 March 2015 from: http://global.britannica.com/EBchecked/topic/206553/fig-wasp

if a female fig wasp accidentally enters a fig with female flowers, no fig wasp can survive and no larvae can develop. However, *Ficus* would prefer some fig wasps to enter its female figs for pollination. In this study, we will study the host specificity of fig wasps and *F. hispida and F. variegata*. The relationship between the abundance of fig wasps in figs and the proportion of pollinated female flowers will also be investigated.

3) Material and method

3.1 Working plan

Date	Time	Venue	Event
04-02-2015	16:00-18:00	Braemar Hill	Preliminary study
10-02-2015	16:00-18:00	Braemar Hill	Collection of figs
24-02-2015	13:00-18:00	Tuen Mun	Collection of figs
28-02-2015	10:00-12:00	Braemar Hill	Collection of figs and study of relative abundance of different species of *Ficus*
07-03-2015	10:00-16:00	The Chinese University of Hong Kong	Collection of figs and study of relative abundance of different species of *Ficus*

A preliminary field study and four other field studies were conducted for the collection of figs as well as the investigation of the relative abundance of fig trees.

3.1.1 Preliminary study

It was carried out in places around Cheung Chuk Shan College in Braemar Hill on 4/2/2015. A large amount of fig trees were recognized and marked down in Map 1. However, we found that there was no other male *F. vairegata* beside the female one found in the campus of Cheung Chuk Shan College. This led to the search for the male plant of *F. variegata*.

3.1.2 Field study 1

It was carried out along the blue route shown in Map 2 on 10/2/2015. The Sir Cecil's Ride in Braemar Hill was predicted to have a larger amount of fig trees to be found. Unexpectedly, only a few *F. hispida* with no figs and three *F. variegata* were found. But since the female figs on the *F. variegata* found near the Choi Sai Wu Park were pollinated, it showed that the wasps must came from some nearby male figs. And since no figs were found on the other two *F. variegata* found near St. Joan of Arc Secondary School, they were not regarded as male *F. variegata*. After some more investigation, according to a previous study,[7] it was found that female wasps may have the ability to disperse over distances of more than 10 kilometres. If this is true, it is not surprising that a male *F. variegata* cannot be found nearby. However, the amount of data is too small to be conclusive.

3.1.3 Field study 2

It was carried out in Tuen Mun on 24/2/2015 to investigate the relative abundance of *F. hispida* and *F. variegata* in a different area. As it was heard that a lot of *F. variegata* could be found in the region Por Lo Shan,[8] a field study was conducted there, targeting at the collection of the figs. However, a lot of *F. hispida* with figs were found instead of *F. variegata*. The *F. hispida* and their figs were randomly collected.

[7] Nason JD, Herre EA, Hamrick JL. 1996. Paternity analysis of the breeding structure of strangler fig populations: evidence for substantial long-distance wasp dispersal. *Joumal of Biogeography* (1996) 23, 501-512 Retrieved on 24 Mar 2015 from http://www.nhm.ac.uk/resources/research-curation/projects/chalcidoids/pdf_Y/NasonHeHa996.pdf

[8] *陳梓晴 高穎芝 曾浚 謝晟致青果榕與木虱之間的生物關係* Retrieved on 18 Mar 2015 from: http://ifieldstudy.net/sns/outstanding_reports/2010/files/team39_report.pdf

3.1.4 Field study 3

It was carried out by following the blue route shown in Map 1 on 28/2/2015. As it seemed that the relative abundance of fig trees varied a lot, the species and number of different fig trees and also the number of other species of trees were recorded using transect method for calculating the relative abundance of fig trees among all species of trees identified and the relative abundance of *F. hispida* and *F. variegata* among all species of fig trees identified. It was done by identifying all trees on the left and right side along the route that was accessible.

3.1.5 Field study 4

It was carried out in the Chinese University in Shatin on 7/3/2015 for more collection of figs of *F. variegata*, and the gender of fig trees in the area was identified. The purpose of this field study was to investigate the relative abundance of *F. hispida* and *F. variegata* in a different area.

3.2 Choice of *Ficus*

In our preliminary study, several *F. variegata* and *F. hispida* were found in the region and more mature figs of both species were found. Besides, these two species were dioecious. Therefore, they were chosen for investigation for convenient collection and more fair comparison.

3.3 Collection of figs

The figs of *F. variegata* were collected on the slope in Cheung Chuk Shan College (Map 1), Choi Sai Wu Park (Map1), Cloud View Road Service Reservoir (Map 1) and Chinese University (Map 2). The figs of *F. hispida* were collected in Cloud View Road Reservoir (Map 1) Tuen Mun (Map 3). The figs collected were freshly fallen on the ground or mature in the trees that were not artificially planted in parks and the figs were then put into separate plastic containers. Besides, the route (Map 1 and Map 2) and the positions of the *Ficus* (Map 1, Map 2 and Map 3) were recorded on the map.

3.4 Dissection of figs

Firstly, the maximum width of the figs was measured and the color of the figs was recorded. Then, the figs were dissected. Due to the high abundance of flowers per fig, the figs were dissected into 8 equal parts and one of them was randomly selected for examination each time. To minimize the error due to position effects, the figs were dissected longitudinally along the opening of the figs. For convenient identification, all flowers were scratched off. Number of flowers of different stages was counted under 20X magnification using a dissecting microscope. It was recorded and then multiplied by 8 to represent the total number of the whole figs. For the male figs, each gall flower is dissected to identify whether the gall flowers were parasitized or not and the parasitic species identified. Therefore, the even distribution of flowers and parasitic pattern in figs was assumed. Besides, the number of wasps presented in the figs was recorded.

3.5 Measuring of style lengths

10 styles were randomly selected from the flowers in each sex of figs. The styles were magnified under 100X microscope and the length was measured by the Vernier scale on the stage micrometer, accurate to 0.1 mm.

4) Maps and Photos

4.1 Markings of fig trees during preliminary study (04-02-2015) and field study 3 (28-02-2015) and the route of field study 3 (Map 1)

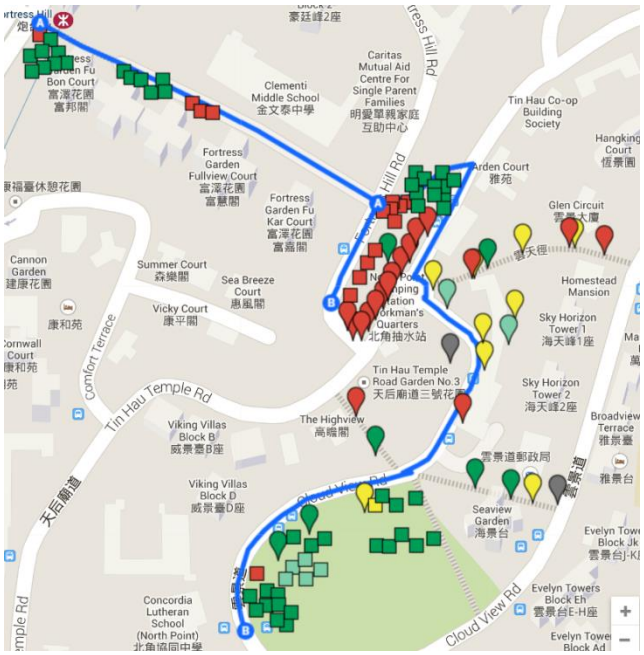
04-02-2015

- Ficus virens
- Ficus elastica
- Ficus microcarpa
- Ficus hispida
- Ficus variegata

28-02-2015

- Ficus microcarpa
- Ficus variegata
- Ficus hispida
- Ficus virens

28-02-2015: Blue route



4.2 Markings of fig trees during field study 1 (10-02-2015) and the route of the field study (Map 2)

10-02-2015

- Ficus variegata
- Ficus hispida

4.3 Fig wasps idenfication

Other than the observations found relating to the relative abundance of the two plants, a total of three species of female fig wasps were found, two in *F. hispida* and one in *F. variegata*. First, for the two female fig wasps found in *F. hispida*, one was brown with a long ovipositor, which may be used for ovipositing through the fig wall, while one was black with short ovipositor, which may be used for ovipositing inside the fig. After some research from the internet and comparing the information found with the photos taken, it was found that the former had similar appearance with a species called *Philotrypesis pilosa*[9]which is parasitic[10] while the latter had similar appearance with a species called *Ceratosolen solmsi*[11]which is pollinating.[12] Besides, according to the table 10 in result part, the population of the former wasps was only about 2% of the latter one, this supports the speculation that the former wasps were parasitic while the latter wasps were pollinating. Moreover, there was no

[9] BOLDSYSTEMS Retrieve 14 Mar 2015, from http://www.boldsystems.org/index.php/Taxbrowser_Taxonpage?taxid=162106

[10] ZHAI Shu-Wei, YANG Da-Rong, PENG Yan-Qiong (2007) SHI Zhang-Hong, BAI Li-Fen Reproductive characteristics of two non-pollinating fig wasps of *Philotrypesis* (Hymenoptera: Pteromalidae) in Ficus hispida figs[J]. ACTA ENTOMOLOGICA SINICA, 2007, 50(4): 389-394. Retrieve 27 Feb 2015, from http://www.insect.org.cn/EN/Y2007/V50/I4/389

[11] BOLDSYSTEMS Retrieve 14 Mar 2015, from http://barcodinglife.org/index.php/Taxbrowser_Taxonpage?taxid=385398

[12] ZHAI Shu-Wei, YANG Da-Rong, PENG Yan-Qiong (2007) SHI Zhang-Hong, BAI Li-Fen Reproductive characteristics of two non-pollinating fig wasps of *Philotrypesis* (Hymenoptera: Pteromalidae) in *Ficus hispida* figs[J]. *ACTA ENTOMOLOGICA SINICA*, 2007, 50(4): 389-394. Retrieve 27 Feb 2015, from http://www.insect.org.cn/EN/Y2007/V50/I4/389

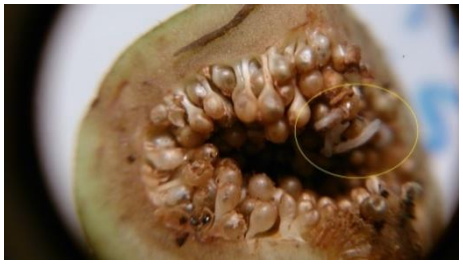
more than one kind of fig wasps with short ovipositor found in the *F. hispida*, which further supports the host specific relationship between the figs and the fig wasps. In the following report, the brown wasp with a long ovipositor would be regarded as *P. pilosa* while the black wasp with a short ovipositor would be regarded as *C. solmsi*.

As for the fig wasps in *F. variegata*, according to a previous study,[13] *Ceratosolen appendiculatus* is the pollinator of *F. variegata*. However, the female fig wasp in fig (g) had a long ovipositor while *C. appendiculatus* had short ovipositor.[14] Therefore, it was known that the fig wasps might not be a pollinator but rather a parasite as they shared the same characteristic of having long ovipositor with *P. pilosa*. Once again, after some research from the internet and comparing the information found with the photos taken, it was found that the fig wasps found in *F. variegata* had similar appearance with a species called *Apocrypta sp.* [15]which is parasitic as they both had a black body with a long ovipositor. Therefore in the following report, the female fig wasps found in *F. variegata* would be regarded as *Apocrypta sp.*

4.4 Photos taken of fig wasps and maggots found in *F. hispida*

(a) (b) (c) (d)

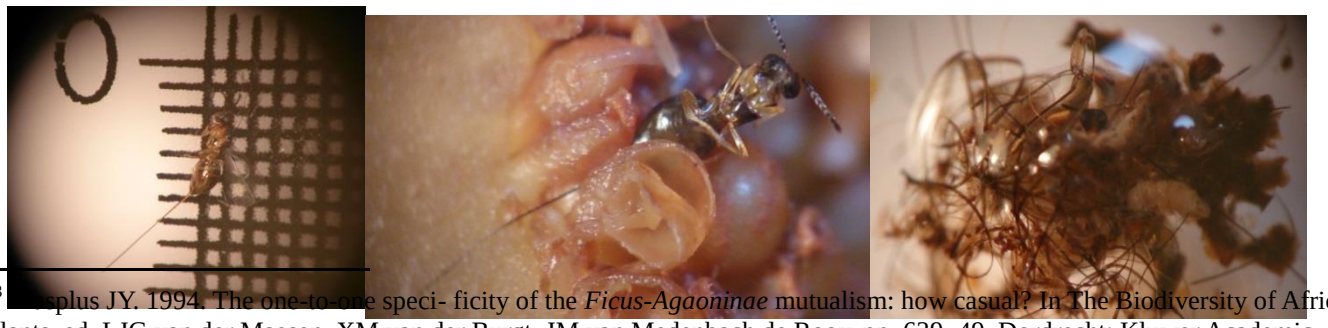
(e)



(a) It is *P. pilosa*, a brown female wasp with ovipositor longer than its body length and obvious compound eyes found in a male fig of *F. hispida*.
(b) They are *C. solmsi*, some black female wasps with short ovipositors, black stripes on their transparent wings and with a greater width found in a male fig of *F. hispida*.
(c) It is an immature *C. solmsi* in a gall flower of a male fig of *F. hispida*.
(d) It is an unidentified male brown fig wasp without wings found in a male fig of *F. hispida*.
(e) The circled white maggots were found in *F. hispida*.

4.5 Photos taken of fig wasps found in *F. variegata*

(f) (g) (h)



[13] [illegible]splus JY. 1994. The one-to-one speci- ficity of the *Ficus-Agaoninae* mutualism: how casual? In The Biodiversity of African Plants, ed. LJG van der Maesen, XM van der Burgt, JM van Medenbach de Rooy, pp. 639–49. Dordrecht: Kluwer Academic.
[14] Weiblen, G. D., Yu, D. W., and West, S. A. (2001) *Pollination and parasitism in functionally dioecious figs*, p. 653. Retrieved 18 March 2015, from http://rspb.royalsocietypublishing.org/content/royprsb/268/1467/651.full.pdf
[15] BOLDSYSTEMS Retrieved on 25 Mar 2015, from http://www.boldsystems.org/index.php/Taxbrowser_Taxonpage?taxid=157434

(i)

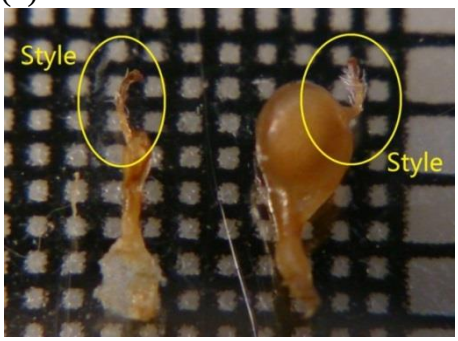
(j)

(f) It is *Apocrypta sp.*, a black female wasp with a long ovipositor longer than its body length found in a male fig of *F. variegata*.
(g) It is also *Apocrypta sp.*, as that in (f).
(h) These are the dead bodied of the unidentified female wasps screw together with their ovipositors found in a male fig of *F. variegata.*
(i) It is an unidentified male wasp without wings found in a male fig of *F. variegata.*
A video of the male wasp actively mating in fig to the following link:
https://www.youtube.com/watch?v=XyG-46249bw
(j) It shows an unidentified male wasp actively mating inside a male fig of *F. variegata.*

4.6 Photos taken of styles in both *F. hispida* and *F. variegata*

F. hispida

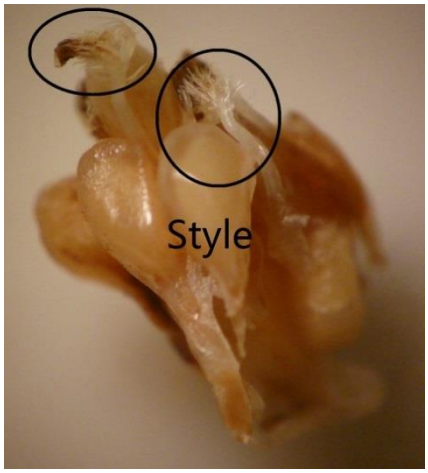
(k)



(l)

F. variegata

(m)



(n)

(o)

(k) It shows a vacant female flower (left) and a pollinated female flower (right) with their feathery styles circled found in a female fig of *F. hispida.* Each box is 0.5 mm.
(l) It shows a pollinated gall flower with its smooth style circled found in a male fig of *F. hispida.*
(m) It shows some female flowers with their feathery styles circled found in a female fig of *F. variegata.*
(n) It shows a pollinated gall flower with its smooth style circled found in a male fig of *F. variegata.*
(o) It shows some developing gall flowers (in the upper circle) and some developed gall flowers (in the lower circle) found in a male fig of *F. variegata.* It also shows the large difference in the sizes of the gall flowers in the same fig.

5) Result

5.1 Results for Relative Abundance

Route tracing on 28/02/2015 (Table 1)

Type of trees	***F. hispida***	***F. variegata***	***F. virens***	***F. elastic***	***F. microcarpa***	**Other trees**
No. identified	young: 24 mature: 25 total: 49	6	5	1	27	411
Percentage among all trees	9.8%	1.2%	1%	0.2%	5.4%	82.4%

Results of field study in The Chinese University of Hong Kong on 07/03/2015 (Table2)

Species	**No. identified**			**Percentage of**	
	Young plant	Matured plant	Total no.	Young plants	Matured plants
F. variegata	0	16	16	0%	100%
F. hispida	55	171	226	24.3%	75.7%

Plants shorter than 1 m and bear no figs were considered as young plant.

5.2 Results for *F. variegata*

Study of figs of *F. variegate* collected in Cheung Chuk Shan College on 12/2/15 (Table 3)

Fig species	**Maximum width if fig (mm)**	**Colour of fig or other features**	**Total No. of female flowers found**	**No. of vacant female flower**	**Proportion of successful pollination (%)**
F. variegata	21.05	Reddish brown	1520	416	72.6
	20.85	Reddish brown	1656	296	82.1
	23.10	Reddish brown	1176	104	91.2
	23.25	Reddish brown	1128	160	85.8
	21.80	Reddish brown	1568	304	80.6
	21.10	Reddish brown	768	88	88.5
Mean ± SD	21.86±0.977	N/A	1302±310	228±119	83.5±6.04

Study of figs of *F. variegata* （青果榕）and fig wasps collected in Choi Sai Wu Park on 25/2/15 (Table 4)

Fig species	**Maximum width if fig (mm)**	**Colour of fig or other features**	**Total No. of female flowers found**	**No. of vacant female flower**	**Proportion of successful pollination (%)**
F. variegata	24.40	green	1640	520	68.3
	20.05	green	1272	200	84.3
	23.90	green	1056	472	55.3
	23.85	Reddish brown	1440	200	86.1
Mean ± SD	23.1±1.75	N/A	1352±215	348±149	73.5±12.6

Study of figs of *F. variegata* and fig wasps collected in Cloud View Road Service Reservoir Playground on 28/2/15 (Table 5)

Plant label#	Maximum width if fig (mm)	Colour of fig or other features	Total No. of female flowers found	No. of vacant female flower	Proportion of successful pollination (%)	Total No. of gall flowers found	No. of gall flowers with uncertain status (?)	No. of male flowers found	Other remarks e.g. no. of fig wasps
P1	18.60	green	824	40	95.1				8 female dead wasps
P3a	23.80	green	704	88	87.5				0
P3b	18.25	green	808	136	83.2				0
P4	11.15	brown*	840	176	79.0				24 female dead wasps
P2	26.70	green				1120	664(?)	56	Only 1 male was found in the whole fig actively mating with the females still inside the gall flowers
	22.50	green				0	872(?)	24	
Female figs									
Mean ± S.D.	17.95±4.5	N/A	794±53.2	110±51	86.2±5.95				8±9.80female dead wasps
Male figs									
Mean ± S.D.	24.6±2.1	N/A				560±560	768±104	40±16	

The capital letter represent the region of the figs collected T, CU, P stands for Tuen Mun, Chinese University of Hong Kong and Braemar Hill. Different numbers represent different trees and the letters after the same number represent different figs from the same tree.

? These gall flowers were probably not vacant. They were just not well developed. However, for P2, according to fig (i), there is an obvious difference in size of the gall flowers.

*This fig was collect from the ground.

Study of figs of *F. variegata* and fig wasps collected in The Chinese University of Hong Kong on 07/3/15 (Table 6)

Plant label#	Maximum width if fig (mm)	Colour of fig or other features	Total No. of female flowers found	No. of vacant female flower	Proportion of successful pollination rate (%)	Total No. of gall flowers found	No. of gall flowers with uncertain status (?)	No. of vacant gall flower	No. of male flowers found	Other remarks e.g. no. of fig wasps
CU 7	25.4	Green				1312	1312		56	
CU 9	21.0	Greenish brown				1228	1228		32	
CU 14	20.25	Green with brown patches				2184	2135	48	60	
CU 15	32.0	Greenish brown				2264 (368 with wasps left already)*	1648		88	32 maggots, 1 dead male found in the part sampled
	23.45	Green with reddish brown patches				1712	1712	56		
Female										
CU 11	22.65	Green with	1104	112	89.9					

		brown patches								
Male										
Mean ± S.D.	24.4	N/A				1740±428	1670±323	48	58±18	

All figs were collected from the ground.

The capital letter represent the region of the figs collected T, CU, P stands for Tuen Mun, Chinese University of Hong Kong and Braemar Hill. Different numbers represent different trees and the letters after the same number represent different figs from the same tree.

? The gall flowers were not fully developed and were difficult to determine their status.

*This figure tends to be underestimated as the hole cannot be easily detected on most galls.

The larger sample from CU 15 was similar to P2 collected in Cloud View Road Service Reservoir Playground. The gall flowers showed two distinctly different sizes. The smaller ones were either unoccupied or they were developing much slower. (fig o)

5.3 Results for *F. hispida*

Study of figs of *F. hispida*（對葉榕）and fig wasps collected in Tuen Mun on 24/2/15 (Table 7)

No. of specimen #	**Maximum width if fig (mm)**	**Colour of fig or other features**	**Total No. of female flowers found**	**No. of vacant female flower**	**Proportion of successful pollination rate (%)**	**Total No. of gall flowers found**	**No. of vacant gall flower**	**No. of male flowers found**	**Total no. of wasps found**	
									P. pilosa	*C. solmsi*
T1a	25.00	Yellowish green	2416	1824	24.5				0	0
T1b	23.90	green	2896	320	89.0				0	0
T3a	26.10	Yellowish green	1736	160	90.8				0	1#
T3b	22.00	Yellowish green	1568	152	90.3				0	1#
T3c	23.25	Green	1544	432	72				0	0
T3d	20.85	green	1712	200	88.3				0	1#
T5	24.40	green				536	332	*	0	204
T5	27.80	green				600	336	*	32	232
T5	26.05	green				615	263	*	0	392
T5	31.50	yellow				456	328	48		
T5	34.30	Yellowish green				584	40	16	0	385
T5	31.10	Yellowish green				312	120	24	0	204
Female figs										
Mean without T1	23.05± 1.95	N/A	1640± 84.9	236± 115	85.4±7.76				0	0.75± 0.43
Total mean	23.5± 1.76	N/A	1980± 503	1980±	75.8±23.8				0	0.5±0.5
Male figs										
Mean± S.D.						517± 105	237± 115	29±16	6±12.8	283± 86.4

Note:

#The capital letter represent the region of the figs collected T, CU, P stands for Tuen Mun, Chinese University of Hong Kong and Braemar Hill. Different numbers represent different trees and the letters after the same number represent different figs from the same tree.

*The male flower could not be identified easily after preserving in alcohol.

Many maggots were observed coming out from the figs after keeping the figs for a few days.

T1's number of vacant female flowers and proportion of successful pollination will not be considered in discussion afterwards. Since specimen T1a's number of vacant female flowers is 470% greater than T1b's. T1's proportion of successful pollination is 263% less than T2's, which deviated too much from the norm

5.4 Summary

Mean of figs of sample T3 of *F. hispida*（對葉榕）and fig wasps and *F. variegata*（青果榕）and fig wasps collected (Table 8)

Fig species	Data	Maximum width if fig (mm)	Colour of fig or other features	Total No. of female flowers found	No. of vacant female flower	Proportion of successful pollination (%)	Total no. of wasps found	
							P. pilosa	*C. solmsi*
F. hispida	Mean ± S.D.	23.05±1.95	N/A	1640±84.9	236±115	85.4±7.76	0	0.75± black dead wasp in whole wasp
F. variegata	Mean ± S.D.	21.1±3.33	N/A	1170±335	229±146	81.4±9.86	0	0

Study of figs of *F. hispida*（對葉榕）collected on 4/2/15 (Table9)

No. of specimen	Maximum width of the fig (mm)	Colour of fig or other features	Total No. of female flowers found	No. of vacant female flower	Total No. of gall flowers found	No. of vacant gall flower	No. of male flowers found	#No. of wasps found			No. of maggots found
								P. pilosa	*C. solmsi*	Male	
3	36.15	pale green	0	0	1160	80	*80	16	448	320	88

Table showing the mean result of male figs of *F. hispida* (Table 10)

	Total No. of gall flowers found	No. of vacant gall flower	Vacant rate of the gall flowers (%)	No. of male flowers found	Total no. of wasps found		Proportion of *P. pilosa* to *C. solmsi*
					Species A	Species B	
Mean± S.D.	517±105	237±115	45.8±20.9	29±16	6±12.8	283±86.4	2:100

Table showing the mean result of male figs of *F. variegata* (Table 11)

	Total No. of gall flowers found	No. of gall flowers with uncertain status	No. of vacant gall flowers	No. of male flowers found
Mean± S.D.	1636±454	1450±459	48*	58±16

*Since only one of the sample's vacant gall flowers were identified, no S.D. was calculated.

5.5 Results on style length

Length of style of gall flower and female flower of *F. hispida* collected on 24/2/15(Table12)

	Sample	Length of style (mm)										
		1	2	3	4	5	6	7	8	9	10	Mean ± S.D
Female flowers	T3	1.0	0.9	1.0	1.0	0.9	1.3	1.6	1.2	1.3	1.6	1.18±0.25
Gall flower	T5	0.5	0.5	0.6	0.7	0.6	0.8	0.5	0.7	0.5	0.4	0.58±0.12

Length of style of gall flower and female flower of *F. variegata* collected on 28/2/15(Table13)

	Sample	Length of style (mm)										
		1	2	3	4	5	6	7	8	9	10	Mean ± S.D.
Female flower	P1	0.8	0.9	0.9	1.0	0.9	0.9	1.1	0.8	0.9	0.9	0.91±0.08
Gall flower	P2	0.7	0.8	0.7	0.8	0.6	0.6	0.7	0.4	0.6	0.7	0.66±0.11

6) Discussion

6.1Relative Abundance

At the beginning of the study, male *F. vairegata* had not been found for a long time near the female one at Cheung Chuk Shan College. According to a previous study,[16] it was found that female wasps may have the ability to disperse over distances of more than 10 kilometres. Therefore, the number of trees along a route within the area with a radius of 500 metres from the first female *F. variegata* discovered was counted to confirm the finding in the previous study. However, after more thorough identification, a male *F. variegata* was discovered and the research direction changed into investigating the relative abundance of *F. variegata* and *F. hispida* instead of investigating the distance between the male and female trees of *F. variegata*.

According to Table 1, fig trees only occupied a small proportion of all types of trees. According to Table 1 and 2, it was found that the relative abundance of *F. hispida* was a lot higher than that of *F. variegata*. This situation might be the result of competition between two plants and that *F. hispida* had a higher competitiveness. Moreover, according to Table 2, 24.3% of the *F. hispida* identified were young plants while the rest of them were matured plants. On the other hand, all of the *F. variegata* identified were matured plants. It was also observed that quite a large proportion of *F. hispida* were saplings with height lower then 1m while none of the *F. variegata* found were saplings and might be planted artificially. This was an interesting finding that might be caused by various factors. Some possible factors might be their adaptation to different soil, their difference in germination rate, the difference in number of seed disperser of the two fig trees. This would worth some further investigations.

6.2 Analysis of female figs

6.2.1 Proportion of successful pollination of female flowers of *F. hispida*

From Table 7, the proportion of successful pollination (%) in specimen T1a (24.5%) varies significantly from specimen T1b (89.0%). But what makes the difference? T1a and T1b are both collected from the same fig tree, at similar height? However, their colors are different and maximum width varies by 1.1mm.

In fig T3, the four figs' maximum width varies more significantly, with the greatest variation of 5.25mm, least variation of 1.15mm. And the color of T3a and T3b are also different from T3c and T3d. However, the greatest possible difference in proportion of successful pollination (%) is 18.8% only, deriving from 90.8%-72%, which is much less than the difference found in T1.

Therefore, there should be some other factors affecting the proportion of successful pollination.

The followings are trying to help further research:

According to a previous study, the number of fig wasps entering the female syconium determines the level of seed bearing.[17]

Table(14) Effect of number of wasp on proportion of successful pollination

Number of wasp	Proportion of successful pollination (%)
1	almost 51.3
2-3	Smaller than or almost 86.5
4 or more	40.2-63.8

[16] Nason JD, Herre EA, Hamrick JL. 1996. Paternity analysis of the breeding structure of strangler fig populations: evidence for substantial long-distance wasp dispersal. *Joumal of Biogeography* (1996) 23, 501-512 Retrieved on 24 Mar 2015 from http://www.nhm.ac.uk/resources/research-curation/projects/chalcidoids/pdf_Y/NasonHeHa996.pdf

[17] YANG Da-Rong, PENG Yan-Qiong, SONG Qi-shi, ZHANG Guang-Ming, WANG Rui-Wu, ZHAO Ting-Zhou, WANG Qiu-Yan,(2002)'Pollination Biology of *Ficus hispida* in the Tropocal Rainforests of Xischuangbanna, China *Acta Botanica Sinica*, 2002 44(5) 519-526Retrieved on 18 Mar 2015, from http://www.nhm.ac.uk/resources/research-curation/projects/chalcidoids/pdf_Y/YangPeSo2002.pdf

Therefore, it may account for the great difference of proportion of successful pollination.

According to our findings, there is a mean proportion of successful pollination of 85.4% without considering T1. In our studies, we just focused on the 1/8 slice of fig, but not the whole fig, so it is reasonable why we found 1 or no dead wasp, but not two. Generally, our findings agree with the results of Yang et al (2002).

Indeed, more samples of T1 should be collected. If the proportion of successful pollination in T1a or T1b does not lie within the range of 100 samples of figs' proportion of successful pollination, we may conclude that the fig outside the range is an exception. If not, further investigation is needed by monitoring growth and entry of wasps outside the figs with a video camera and comparing its proportion of successful pollination after the figs grow to a same, specified stage, e.g. same color or same maximum width.

T1's number of vacant female flowers and proportion of successful pollination will not be considered in discussion afterwards. Since specimen T1a's number of vacant female flowers is 470% greater than T1b's. T1's proportion of successful pollination is 263% less than T2's. They are highly unreliable.

So, in considering proportion of successful pollination, only specimen T3 is considered. As suggested in the study by Yang *et al* (2002), they found that *F. hispida*, which have a mean value of total flowers 2156 per fig, have a relatively high level of seed bearing (54.1%-82.5%, average 73.8%) throughout the year, with a 54.1% of seed bearing between December and February.[18] While in our findings, specimen T3 has a higher level of seed bearing (72%-90.8%, average 85.4%) just in February. Again, what makes the difference?

Indeed, the specimens are collected in 28th February. It would be embarrassing to consider putting it in 12-2 or 3-5. What's more, in February, the climate in Xishuangbanna is dry. Contrastingly, in HK, we are having humid climate in February. Then, the seed-bearing rate on different months in Hong Kong should be considered to make comparisons with the one conducted in Xishuangbanna, using the same methods as that report, to have a follow-up investigation.

What we can tell is that there is mechanisms between *F. hispida* and wasps to maintain high level of seed-bearing. At this stage, no concrete, convincing evidence is shown to support any reasons accounting for high level of seed-bearing.

However, a hypothesis can be suggested. In the study by Yang *et al* (2002), *F. hispida* under investigation are found in tropical rainforest. In our study, *F. hispida* are found to be near housing estates (specimensT1 and T3). Therefore, near *F. hispida* in our study, there are more artificial buildings than that of the fig trees in the study by Yang *et al* (2002). There may be less predators of fig wasps, such as birds and predatory insects, in our study. The survival rate of fig wasps in sampled areas of our study may be higher and thus, leading to a higher proportion of successful pollination. Moreover, male fig trees in our studies are found within a short walking distance, which female wasps are in abundance. The female figs can then achieve optimum level of seed-bearing.

The hypothesis may be tested by comparing the proportion of successful pollination from *F. hispida* found in more rural areas to the results obtained in this study, provided that the abundance of male and female trees are similar.

6.2.2 Number of female flowers and size of *F. hispida*

From Table. 7, it can be seen that specimen T1 has a mean value of total number (2656) of female flowers 62.0% greater than the mean value of total number (1640) of female flowers specimen T3.

Two different specimens of *F. hispida* have a great difference in number of total female flowers,

[18] YANG Da-Rong, PENG Yan-Qiong, SONG Qi-shi, ZHANG Guang-Ming, WANG Rui-Wu, ZHAO Ting-Zhou, WANG Qiu-Yan,(2002)'Pollination Biology of *Ficus hispida* in the Tropocal Rainforests of Xischuangbanna, China *Acta Botanica Sinica*, 2002 44(5) 519-526Retrieved on 18 Mar 2015, From http://www.nhm.ac.uk/resources/research-curation/projects/chalcidoids/pdf_Y/YangPeSo2002.pdf

and seed-bearing flowers. Therefore, comparisons concerning number of flowers cannot be made in different specimens. However, whether the proportion of successful pollination is consistent or not is still not known. Therefore, comparisons can only be made within the same fig tree at this stage.

In specimen T1, no conclusion is made due to small sampling size.

In specimen T3, there is no direct proportion for the total number of flowers and fig's size.

6.2.3 Proportion of successful pollination of female flowers of of *F. variegata*

According to a study conducted by George *et al* (1995) in Australia, the proportion of successful pollination is 69% with a standard deviation 19%.[19]

According to our findings, the proportion of successful pollination in *F. variegata* range from 55.3% to 95.1% with a mean value of 81.4% and a standard deviation of 9.86 %. There is a high level of seed-bearing proportion.

Comparatively, the total number of flowers (4320) in the foreign study is 269% greater than the mean value of total number of flowers (1170) in our investigations.

Obviously, *F. variegata* in our studies have a greater success in pollination, as *F. variegata* proportion of successful pollination (81.4%)in our findings are 12.4% greater than that of the *F. variegata* in the foreign study (69%). Moreover, standard deviation of *F. variegata* (9.86%)in our findings are 9.14% smaller than that of the standard deviation of *F. variegata* (19%) in the study in Australia.

Why the proportion of successful pollination of *F. variegata* in Australia is smaller?

The same hypothesis and possible test are suggested for *F. variegata*, just like the ones in *F. hispida*.

In addition, the total number of flowers per fig in the study in Australia is 269% greater than the mean value of total number of flowers (1170) in our investigations. Does the total number of flowers affect the pollination proportion?

Investigations can be done to compare the pollination proportion of *F. variegata* of different total number of flowers, provided that the abundance of male and female trees are similar and a large sample of figs with a significant difference in the number of female flowers can be found.

6.2.4 Number of female flowers and size of *F. variegata*

By referring to Table 3, 4 and 5, the mean value of total number of female flowers are significantly different.

The mean value of total number of female flowers of *F. variegata* collected in Cloud View Road Service is 794; while the mean value of total number of female flowers of *F. variegata* collected in CU, CCSC and Choi Sai Wu Park are 1104, 1302 and 1352 respectively.

The latters are 39.0%, 64.0% and 70.3% greater than the former one respectively.

Significant differences in total number of female flowers make comparisons within different fig trees invalid.

Therefore, comparisons are made for figs on the same tree only.

In Table 6, only a fig is collected and investigated. With no comparisons able to be made, it will be neglected.

From Table. 3, 4, 5, there is no direct correlation for the total number of flowers and fig's size.

6.2.5 By comparing *F. hispida* and *F. variegata*

The mean value of the maximum width of *F. hispida* is 23.5mm. The standard deviation is 1.76. The mean value of the maximum width of *F. variegata* is 21.2mm. The standard deviation is 3.26.The figs collected are generally of the similar size. It may due to human factors (collecting the more appealing figs). It may also not be comparable though they have similar size, as they may have a totally different growing stage. The size of *F. hispida* is more even than the size of *F. variegata*.

The mean value of the total female flowers of *F. hispida* is 1980. The standard deviation is 503; the mean value of the total female flower of *F. variegata* is 1167. The standard deviation is 324.

[19] Weiblen, Flick and Spencer (1995). Seed Set and Wasp Predation in Dioecious Ficus variegata from an Australian Wet Tropical Forest. *BIOTROPICA* 27(3): 391-394 1995. Retrieve 27 Feb 2015, from http://geo.cbs.umn.edu/WeiblenEtAl1995.pdf

The total female flower of *F. hispida* is 69.2% more than *F. variegata* per fig. The total number of female flowers of a fig of *F. hispida* fluctuates greater than that of a fig of *F. variegata*.

The proportion of successful pollination (%) of *F. hispida* has a mean value of 85.35% and standard deviation of 7.76. (T1 samples are discarded.) The proportion of successful pollination (%) of all found and measured *F. variegata* is 81.4% and its standard deviation is 9.86. The proportion of successful pollination in *F. hispida* is just 3.95% greater than *F. variegata*, which may not be significant.

F. hispida and *F. variegata* are successful in having a high proportion of seed-bearing.

Though *F. hispida* have a greater number of flowers and a slightly higher proportion of successful pollination, we cannot tell certainly which species is more successful when samplings of figs investigated is so small, and total number of figs produced on each tree is not counted. When the abundance of *F. hispida* is significantly greater than *F. variegata*, that means *F. hispida* is more successful than *F. variegata*. *F. hispida*'s pollination may not account for the success when the total number of figs is both huge and both species had a high pollination proportion. Higher abundance of *F. hispida* may due to better germination of seeds, better dispersal of seeds or faster growth rate of *F. hispida*. Further experiments should be done. For examples, by germinating the seeds of *F. hispida* and *F. variegata* with same physical environment in laboratory to compare their germination rate, by observing habits of primary consumers feeding on figs to determine whether which species' figs are attractive and collecting faces of the fig-consumers to look for number of seeds remaining and by comparing growth rate of the seedlings of *F. hispida* and *F. variegata* with same physical environment in laboratory to compare their growth rate.

For both *F. hispida* and *F. variegata*, they have different number of total number of female flowers among different fig trees in the same species. This makes comparisons among different fig trees invalid.

For both *F. hispida* and *F. variegata*, there is no direct correlation between the total number of flowers and fig's size. Also, the differences in size indicate different development stage. That means there is no direct correlation between the total number of flowers in fig and figs' development stage. In other words, within the same fig tree, with different development stages in figs, the total number of female flowers is still similar. This indicates the differences in the number of total number of female flowers among different fig trees may be significant. What determines the number of total female flowers?

6.3 Analysis on male figs

P. pilosa could not help the pollination of *F. hispida* since they oviposited on the wall of figs and preferred to grow in the ovaries in the wall layer and became parasite of pollinator by feeding on larvae of it.[20] According to our result, the proportion of pollinator *C. solmsi was* apparently higher than that of non-pollinator *P. pilosa*(2:100)(Table10) However, it is still not sure that what leaded to a higher parasitic rate of pollinator compared to the non-pollinator. Besides, it is still unknown that to what extend that the non-pollinator *P. pilosa* affects the mutualistic relationships between pollinator *C. solmsi* and *F. hispida*.

The parasitic rate of the wasp in *F. hispida* has great variation and did not show a standard pattern (45.8±20.9%) (Table 10). It implied that the successful egg laying was not regular. On the other hand, comparing the vacant ovaries in female figs and vacant galls in male figs, it was found the vacant rate in male figs was higher significantly. Female had vacant rate 14.6% while male flowers had 45.8% of vacant rate. In the previous study by Weiblen(1995), the female and male vacant rate was 30.7**%** and 37.6% respectively.[21] The vacancy in female and male flower was due to failed pollination and oviposition. Comparably, the rate of successful pollination was higher than rate of successful wasp production in both our study and previous study. Statistically, it seemed that the figs

[20] ZHAI Shu-Wei, YANG Da-Rong, PENG Yan-Qiong (2007) SHI Zhang-Hong, BAI Li-Fen Reproductive characteristics of two non-pollinating fig wasps of *Philotrypesis* (Hymenoptera: Pteromalidae) in *Ficus hispida* figs[J]. *ACTA ENTOMOLOGICA SINICA*, 2007, 50(4): 389-394. Retrieve 27 Feb 2015, from http://www.insect.org.cn/EN/Y2007/V50/I4/389

[21] Weiblen, Flick, and Spencer (1995). Seed Set and Wasp Predation in Dioecious Ficus variegata from an Australian Wet Tropical Forest. *BIOTROPICA* 27(3): 391-394 1995. Retrieve 27 Feb 2015, from http://geo.cbs.umn.edu/WeiblenEtAl1995.pdf

were more fully utilizing the pollination of wasp than the wasps utilized the gall flowers for wasp production.

For the male figs of the *F. variegata*, most of the gall flowers were still developing and it was difficult to identify the stage of development and whether it was parasitized. However, two specimens had matured gall flowers (fig f). The observation showed that that the gall flowers had different stages of development in the same fig of *F. variegata*. It was supposed that gall flowers in the same figs should have similar maturity but our result did not show. It was not sure that why the gall flowers had different developmental stage.

According to our observation, figs could be found in *F. variegata* and *F. hispida*. It is suggested that most *Ficus* species produced figs all year round but fig abundance varied seasonally. Maximum production of ripe figs by female (i.e. seed-producing) trees of most species occurred in the rainy season (May–August,), while the main fig crop of male (i.e. wasp-producing) trees peaked 1–3 months before female trees.[22] Although this time period was not the best time for them to pollinate and spread their seeds in this seasons (around January to February during our investigation), the trees still spend their resources and food to develop the figs fruit. In a view of *Ficus* species, mature figs should be developed during favorable season in order to increase higher pollination rate. It seemed that the major aim of developing fruits during this season was not only successful pollination and dispersal, but also seems that the *Ficus* tried to maintain the generation of wasps all the seasons in whole year to ensure the pollinator would not be extinct. However, due to lack data of male figs, further investigation could be done by investigation more male figs continuously throughout the years to further justify this statement

6.4 Maggots

A number of maggots were unexpectedly found only in mature male figs, meanwhile they cannot be found in unripe male figs or female figs in both *F. hispida* and *F. variegata* (we only took a few pictures of maggots in *F. hispda)*.

We are not sure about the relationship between maggot and fig wasps and the relationship between maggot and figs. The maggots and fig wasps could be in predator-prey relationship or competition. On the other hand, the reason why maggots can only been found in mature male figs has not yet been deciphered.

A video of the maggots can be found at the following link.

https://www.youtube.com/watch?v=IjPWPNv7BwY

6.5 Length of style

Unfortunately, no study about the style length of *F. hispida* had been found. In our study, style length of female flowers was greater than gall flowers by 0.6mm (Table12). Besides, a study carried out by Hill (1967), as cited in Weiblen, Flick, and Spencer(1995) observed a bimodal distribution of style lengths in mature figs of *F. variegata* The mean difference between style lengths in figs from female trees is 1.7mm (Weiblen). [23]In order to verify whether it is true or not, the length of styles of 10 figs from both *F. hispida* and *F. variegata* have been measured. The result shows a bimodal distribution in style length. It shows that the seed-bearing flowers do possess a longer style length than the gall flower. In dioecious cases, it seems that the short-styled flowers will tend to be parasitized by fig wasp. Moreover, when comparing with the study done by Weiblen, our data show only a 0.25 mm difference in style length, which is significantly smaller than that obtained by Weiblen. Maybe it is due to difference of geographical factor.

7) Limitations

Certain fig trees may not be in season for production and maturation of figs. The presence and number of fig wasps in figs may therefore be affected as the figs may not be suitable and ready for the inhabitation

[22] Cherdsak Kuaraksa, Stephen Elliott, Martine Hossaert-Mckey(2012)The phenology of dioecious *Ficus* spp. tree species and its importance for forest restoration projects *Forest Ecology and Management* 265 (2012) 82–93 Retrived on 24 Mar 2015 fromhttp://www.thaiscience.info/Article%20for%20ThaiScience/Article/4/Ts-4%20the%20phenology%20of%20dioecious%20ficus%20spp.%20tree%20species%20and%20its%20importance%20for%20forest%20restoration%20projects.pdf

[23] Weiblen, Flick, and Spencer (1995). Seed Set and Wasp Predation in Dioecious Ficus variegata from an Australian Wet Tropical Forest. *BIOTROPICA* 27(3): 391-394 1995. Retrieve 27 Feb 2015, from http://geo.cbs.umn.edu/WeiblenEtAl1995.pdf

of fig wasps yet during the time of our research, the number of wasps counted may not be representative and reliable.

8) Possible errors

Dissecting a fig into 8 equal parts was involved in our counting process. The number of female, gall and male flowers as well as the number of fig wasps in 1 sample was counted. The data would then be multiplied by 8 times. First, the dissection of a fig into 8 parts may not be even as it was done by human and human errors may be involved. Secondly, since one-eighth of the fig was sampled only, a large variation may result as the flowers were small in size but large in number. An error may result from the human counting of a large amount of small flowers. Yet, the data obtained from the current method may still be valid as the overall proportion is still clearly observed and the flowers are in a large number so there may only be an insignificant percentage error.

9) Conclusion

Through the investigative study, the abundance of fig wasps in figs was found from the proportion of vacant and wasp-inhabited gall flowers. It was found that the fig wasps are host specific The female flowers have a high pollination rate due to the presence of specific pollinating fig wasps which were also parasitized by non-pollinating wasps. The most abundant fig tree among all *Ficus* found in these areas is *F. hispida*, which accounted for 55.7% of all *Ficu*s. It was followed by *F. microcarpa*, which has an abundance of 30.7%. *F. variegata* has an abundance of 6.8%. Both *F. hispida* and *F. variegata* have high pollination rates. The pollination rate of female flowers in *F. hispida* is 85.4% while that of *F. variegata* is 81.4%. The range of seeds in a fig is not affected by fig size. It was found that the style lengths of gall flowers of *F. hispida* and *F. variegata* are shorter than those of female flowers. It was also found that there existed a difference in the developmental stage of galls in *F. variegata.* A total of three species of fig wasps were found in *F. variegata* and *F. hispida*, the two species of fig trees under our investigation. Two of which can be identified as *P. pilosa* and *C. solmsi*. They were found in the figs of *F. hispida*. The remaining one, which was found from the figs of *F. variegata*, can be identified as *Apocrypta sp.* They can be divided into 2 groups: *C. solmsi* is pollinators while *P. pilosa* and *Apocrypta sp.* are non-pollinators. It was found that the number of pollinators were much higher than the number of non-pollinators. As only one pollinator can be found in fig of *F. hispida*, it supports the host specificity of fig wasps.

10) Further studies and questions

Some intriguing questions were uncovered and by now still unresolved. Many more questions were yet to be uncovered but new discoveries always lead to more puzzle pieces left to be found. Biology is a puzzle that can never be fully completed but trying to put the pieces together is an amazing and worthwhile journey. Hereby listed are the questions we found in this research.

10.1 Difference in abundance of *F. hispida* and *F. variegata*: *F. hispida* was a lot more abundant than *F. variegata* although they were mostly in the same area. The reason why there was a difference was unsure.

10.2 High pollination rate of *F. variegata*: The female figs showed high pollination rate. A further study can be conducted to find out whether and why wasps can have such efficient pollination.

10.3 Stage of development of the gall flowers observed in *F. variegata*: It was supposed that flowers in the same fig may have similar maturity but our result showed even the flowers in the same fig were in different stage of development. It was still not sure that why different gall flowers within the same male fig had wide range of development stage.

10.4 Maggots and the fig or the fig wasps: large amount of maggots were found in mature male figs of *F. hispida*. The relationship between wasps and maggots was uncertain. Another question is why no maggots was found in female figs? Does it suggest that the maggots were really feeding on the wasps?

10.5 Difference in sex ratio of *F. variegata* growing in different areas: *F. variegata* around Cheung Chuk Shan College had a very small male to female ratio while those in the Chinese University had even more male than female. What caused the difference in sex ratio in different places was not sure.

10.6 Maintaining wasp generation: Although the result agreed that *Ficus* would try to maintain the wasp generation by producing figs throughout year. Due to limitation of time, our observation just lasted for about 2 months. Continuous observation is needed to further justify the statement.

11) Bibliography

1. Cruaud A, Rønsted N, Chantarasuwan B, Chou LS, Clement WL, Couloux A, Cousins B, Genson G, Harrison RD, Hanson PE, Hossaert-McKey M, Jabbour-Zahab R, Jousselin E, Kerdelhué C, Kjellberg F, Lopez-Vaamonde C, Peebles J, Peng YQ, Pereira RA, Schramm T, Ubaidillah R, van Noort S, Weiblen GD, Yang DR, Yodpinyanee A, Libeskind-Hadas R, Cook JM, Rasplus JY, Savolainen V. (30 Jul 2012)An extreme case of plant-insect codiversification: figs and fig-pollinating wasps. Retrieved on 24 Mar 2015 from: http://www.ncbi.nlm.nih.gov/pubmed/22848088

2. Richard T. Corlett (28 Nov 2005). Figs (*Ficus*, *Moraceae*) in Urban Hong Kong, South China. Retrieved from Biotropica, Vol. 38: 116–121. doi: 10.1111/j.1744-7429.2006.00109.x

3. HK Trees. *Ficus variegata* Retrieved on 18 Mar 2015 from: http://www.hktree.com/tree/Ficus%20variegata%20var%20chlorocarpa.htm

4. Natural Tropical Botanical Gardens. *Ficus variegata*. Retrieved on 18 March 2015 from: http://ntbg.org/plants/plant_details.php?plantid=5227

5. Globinmed. *Ficus hispida* .Retrieved on 18 Mar 2015 from: http://www.globinmed.com/index.php?option=com_content&view=article&id=104415:ficus-hispida&catid=199&Itemid=139

6. Encyclopædia Britannica (Jul 2013) Fig wasp. Retrieved on 18 March 2015 from: http://global.britannica.com/EBchecked/topic/206553/fig-wasp

7. Nason JD, Herre EA, Hamrick JL. 1996. Paternity analysis of the breeding structure of strangler fig populations: evidence for substantial long-distance wasp dispersal. *Joumal of Biogeography* (1996) 23, 501-512 Retrieved on 24 Mar 2015 from http://www.nhm.ac.uk/resources/research-curation/projects/chalcidoids/pdf_Y/NasonHeHa996.pdf

8.*陳梓晴 高穎芝 曾浚 謝晟致青果榕與木虱之間的生物關係* Retrieved on 18 Mar 2015 from: http://ifieldstudy.net/sns/outstanding_reports/2010/files/team39_report.pdf

9. BOLDSYSTEMS Retrieve 14 Mar 2015, from http://www.boldsystems.org/index.php/Taxbrowser_Taxonpage?taxid=162106

10. ZHAI Shu-Wei, YANG Da-Rong, PENG Yan-Qiong (2007) SHI Zhang-Hong, BAI Li-Fen Reproductive characteristics of two non-pollinating fig wasps of *Philotrypesis* (Hymenoptera: Pteromalidae) in Ficus hispida figs[J]. ACTA ENTOMOLOGICA SINICA, 2007, 50(4): 389-394. Retrieve 27 Feb 2015, from http://www.insect.org.cn/EN/Y2007/V50/I4/389

11. BOLDSYSTEMS Retrieved 14 Mar 2015, from http://barcodinglife.org/index.php/Taxbrowser_Taxonpage?taxid=385398

12. ZHAI Shu-Wei, YANG Da-Rong, PENG Yan-Qiong (2007) SHI Zhang-Hong, BAI Li-Fen Reproductive characteristics of two non-pollinating fig wasps of *Philotrypesis* (Hymenoptera: Pteromalidae) in *Ficus hispida* figs[J]. *ACTA ENTOMOLOGICA SINICA*, 2007, 50(4): 389-394. Retrieve 27 Feb 2015, from http://www.insect.org.cn/EN/Y2007/V50/I4/389

13. Rasplus JY. 1994. The one-to-one speci- ficity of the *Ficus-Agaoninae* mutualism: how casual? In The Biodiversity of African Plants, ed. LJG van der Maesen, XM van der Burgt, JM van Medenbach de Rooy, pp. 639–49. Dordrecht: Kluwer Academic.

14. Weiblen, G. D., Yu, D. W., and West, S. A. (2001) *Pollination and parasitism in functionally dioecious figs*, p. 653. Retrieved 18 March 2015, from http://rspb.royalsocietypublishing.org/content/royprsb/268/1467/651.full.pdf

15. BOLDSYSTEMS Retrieved on 23 Mar 2015, from http://www.boldsystems.org/index.php/Taxbrowser_Taxonpage?taxid=162106

16. Nason JD, Herre EA, Hamrick JL. 1996. Paternity analysis of the breeding structure of strangler fig populations: evidence for substantial long-distance wasp dispersal. *Joumal of Biogeography* (1996) 23, 501-512 Retrieved on 24 Mar 2015 from http://www.nhm.ac.uk/resources/research-curation/projects/chalcidoids/pdf_Y/NasonHeHa996.pdf

17. YANG Da-Rong, PENG Yan-Qiong, SONG Qi-shi, ZHANG Guang-Ming, WANG Rui-Wu, ZHAO Ting-Zhou, WANG Qiu-Yan,(2002)'Pollination Biology of *Ficus hispida* in the Tropocal Rainforests of Xischuangbanna, China *Acta Botanica Sinica*, 2002 44(5) 519-526Retrieved on 18 Mar 2015, From http://www.nhm.ac.uk/resources/research-curation/projects/chalcidoids/pdf_Y/YangPeSo2002.pdf

18. YANG Da-Rong, PENG Yan-Qiong, SONG Qi-shi, ZHANG Guang-Ming, WANG Rui-Wu, ZHAO Ting-Zhou, WANG Qiu-Yan,(2002)'Pollination Biology of *Ficus hispida* in the Tropocal Rainforests of Xischuangbanna, China *Acta Botanica Sinica*, 2002 44(5) 519-526Retrieved on 18 Mar 2015, From http://www.nhm.ac.uk/resources/research-curation/projects/chalcidoids/pdf_Y/YangPeSo2002.pdf19. Weiblen, Flick, and Spencer (1995). Seed Set and Wasp Predation in Dioecious Ficus variegata from an Australian Wet Tropical Forest. *BIOTROPICA* 27(3): 391-394 1995. Retrieve 27 Feb 2015, from http://geo.cbs.umn.edu/WeiblenEtAl1995.pdf

20. ZHAI Shu-Wei, YANG Da-Rong, PENG Yan-Qiong (2007) SHI Zhang-Hong, BAI Li-Fen Reproductive characteristics of two non-pollinating fig wasps of *Philotrypesis* (Hymenoptera: Pteromalidae) in *Ficus hispida* figs[J]. *ACTA ENTOMOLOGICA SINICA*, 2007, 50(4): 389-394. Retrieve 27 Feb 2015, from http://www.insect.org.cn/EN/Y2007/V50/I4/389

21. Weiblen, Flick, and Spencer (1995). Seed Set and Wasp Predation in Dioecious Ficus variegata from an Australian Wet Tropical Forest. *BIOTROPICA* 27(3): 391-394 1995. Retrieve 27 Feb 2015, from http://geo.cbs.umn.edu/WeiblenEtAl1995.pdf

22. Cherdsak Kuaraksa, Stephen Elliott, Martine Hossaert-Mckey(2012)The phenology of dioecious *Ficus* spp. tree species and its importance for forest restoration projects *Forest Ecology and Management* 265 (2012) 82–93 Retrived on 24 Mar 2015 fromhttp://www.thaiscience.info/Article%20for%20ThaiScience/Article/4/Ts-4%20the%20phenology%20of%20dioecious%20ficus%20spp.%20tree%20species%20and%20its%20importance%20for%20forest%20restoration%20projects.pdf

23. Weiblen, Flick, and Spencer (1995). Seed Set and Wasp Predation in Dioecious Ficus variegata from an Australian Wet Tropical Forest. *BIOTROPICA* 27(3): 391-394 1995. Retrieve 27 Feb 2015, from http://geo.cbs.umn.edu/WeiblenEtAl1995.pdf