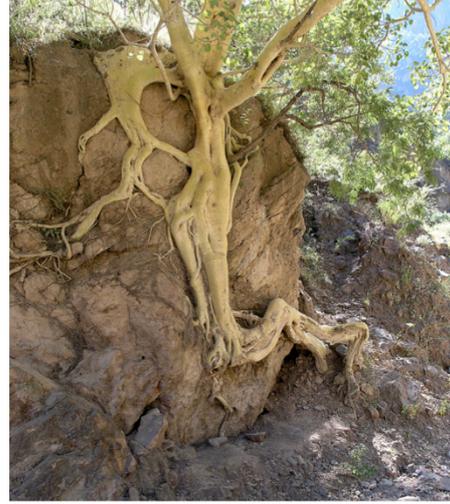


The wonderful world of figs

Genus *Ficus*

18 January 2016



Left: Rock Fig *Ficus platypoda* (Mark Marathon, Wikipedia, CC BY-SA 3.0), Right: Lava Fig *Ficus petiolaris* (Lon & Queta, Flickr, CC BY-NC-SA 2.0)

- Rock Fig *Ficus platypoda* is from northern Australia
- Lava Fig *Ficus petiolaris* is from Mexico

- I will send you notes that accompany these slides, so you don't need to take any detailed notes.
- The notes have additional details (beginning with a red dot) that you may be interested in, or may wish to skip.
- ●
- Quotes ???
- (The blue dot shows me whether all the notes have been included in the Notes pdf.)
- ●

Agenda

Figs

- Fig flowers
- Monoecious fig life cycles
- Dioecious fig life cycles
- Variations on fig reproduction
- (Figs are Keystone species)
- (Fig Diversity)
- Practical exercise
- Figs in GBG



‘Diversity is the way of life’

Agenda

- **Please interrupt** and ask if you don’t understand. I recognise that it is **not easy to remember** what each of the botanical words means!
- ●
- Quote: ‘Diversity is the way of life’ from ‘Polar Bodies – more a lack of understanding than a lack of respect’ Samuel Schmerler and Gary Wessel, (Mol Reprod Dev. 2011 Jan; 78(1): 3–8. Published online 2010 Dec 30. doi: 10.1002/mrd.21266)
- Photo: Honey bee with pollen baskets laden.
- ●

Introduction

- | | |
|---|--|
| <ul style="list-style-type: none"> • Based on talk by Dale Dixon • <i>Ficus</i> genus is very well known • They are very diverse • They all have a syconium – no others do. | <ul style="list-style-type: none"> • 841 species accepted • 312 unassessed • 48 species in Aust (inc. 4 naturalised) • 32 in Qld, 21 WA, 10 NSW, 1 Vic • 12 plants in GBG (inc. 2 introduced) |
|---|--|

- This presentation is based on a talk given at the Botanic Garden Guides conference in Sydney, September 2015.
- Dr. Dale Dixon has discovered and described 5 new species of fig, and, with his collaborating entomologist discovered 5 new species of pollinating wasps.
- These new fig species were discovered after Vol 3 of Flora of Australia was published.
- Figs are one of the best known and widespread of all plant genera. In fact, Figs are considered by some authors to be the most diverse genus of woody plants when looking at habit, growth forms and life forms (Kalko et al 1996).
- For any sexual behaviour you can conceive of, there is probably an organism that does it.' Prof. Rob Brooks, Evolutionary Biologist, University of NSW.
- 'It is Difficult to Generalise About Fig Biology Because Of All The Exceptions', Prof Wayne Armstrong, Palomar College, who offers a wholly online course. He has a website called 'Wayne's Word, An on-line Textbook of Natural History, Botany & Biology: Incl. Ecology, Adaptations & Economic Uses of Plants', <http://waynesword.palomar.edu/index.htm>
- Because of their diversity there were **proposals to split *Ficus*** into several genera.
- This was resisted because they all have syconia (figs).
- So the genus is divided into 5 levels between genus and species.
- ● Species in GBG: *F. brachypoda*, *F. coronata*, *F. macrophylla*, *F. microcarpa*, *F. rubiginosa*, *F. virens*, *F. watkinsiana*, *F. elastica* *, *F. pumila* *
- Species common in gardens & houses: *F. elastica* *, *F. pumila* *, *F. carica* *, *F. benjamina*
- * species introduced to Australia
- Close to half of Australian (and world) fig species are dioecious, the remainder are monoecious.
- Subgenus **Urostigma**, all in Australia are **monoecious**: *F. virens*, *F. benjamina*, *F. microcarpa*, *F. watkinsiana*, *F. macrophylla*, *F. rubiginosa*, *F. brachypoda*, *F. elastica* *
- Subgenus **Ficus**, all in Australia are **dioecious**: *F. pumila* *, *F. coronata*, *F. carica* * (not in GBG)

What do the flowers
of a fig look like?



Image: Common Fig *Ficus carica*, Ehret, 1771, Public domain

The flowers of a fig

- Q: Describe the flower of a fig. A: It is a fruit-like structure, as shown in the picture.
- The flowers of a fig are unique. They are inside out!
- The flowers are inside the structure we think of as the fruit.
- It is called a **syconium**.
- 

The flowers inside a fig



Ficus carica
Common Fig

Left photo: Common Fig *Ficus carica*, Zenz 2004 Wikimedia, Public Dom Right image: Common Fig *Ficus carica*, Thomé 1885 Wikimedia, Public domain

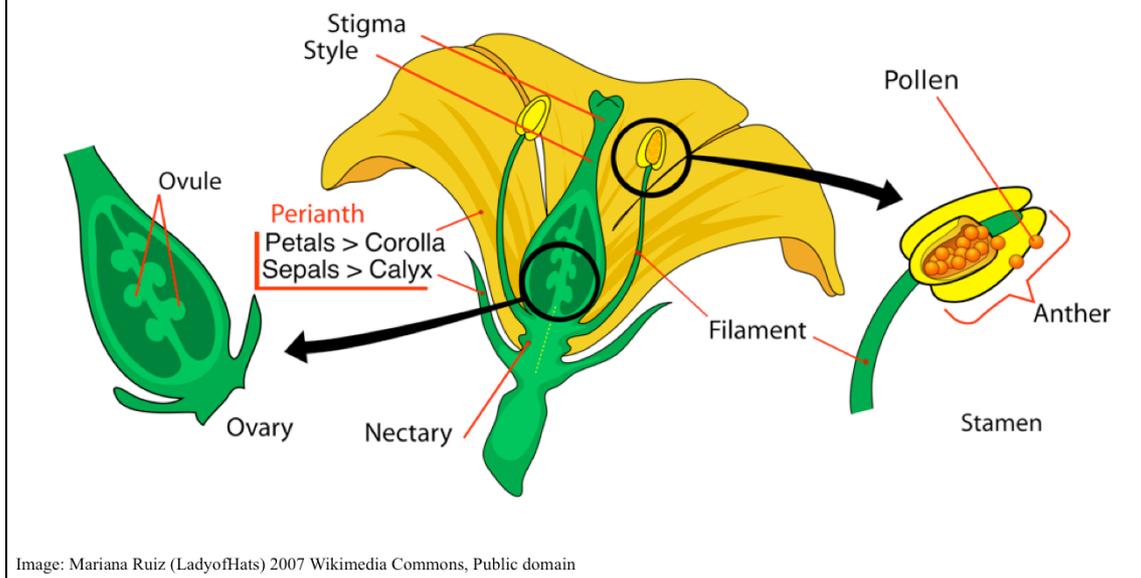
The flowers inside a fig

- *Ficus carica* Common Fig
- The juicy container that we think of as fruit is called a **syconium** (plural syconia).
- It contains many small flowers, referred to as **florets**.
- Q: Can you name the parts of these flowers?
- Q: Where are these parts: male floret, female floret, anthers, stamens, tepals, stigma, style, ovary?

- Q: How can flowers that are contained inside a syconium be pollinated?
- A: By some small that can get inside the fig. It is a pollinating wasp.
- In fact each species of fig has its own species of pollinating wasp.

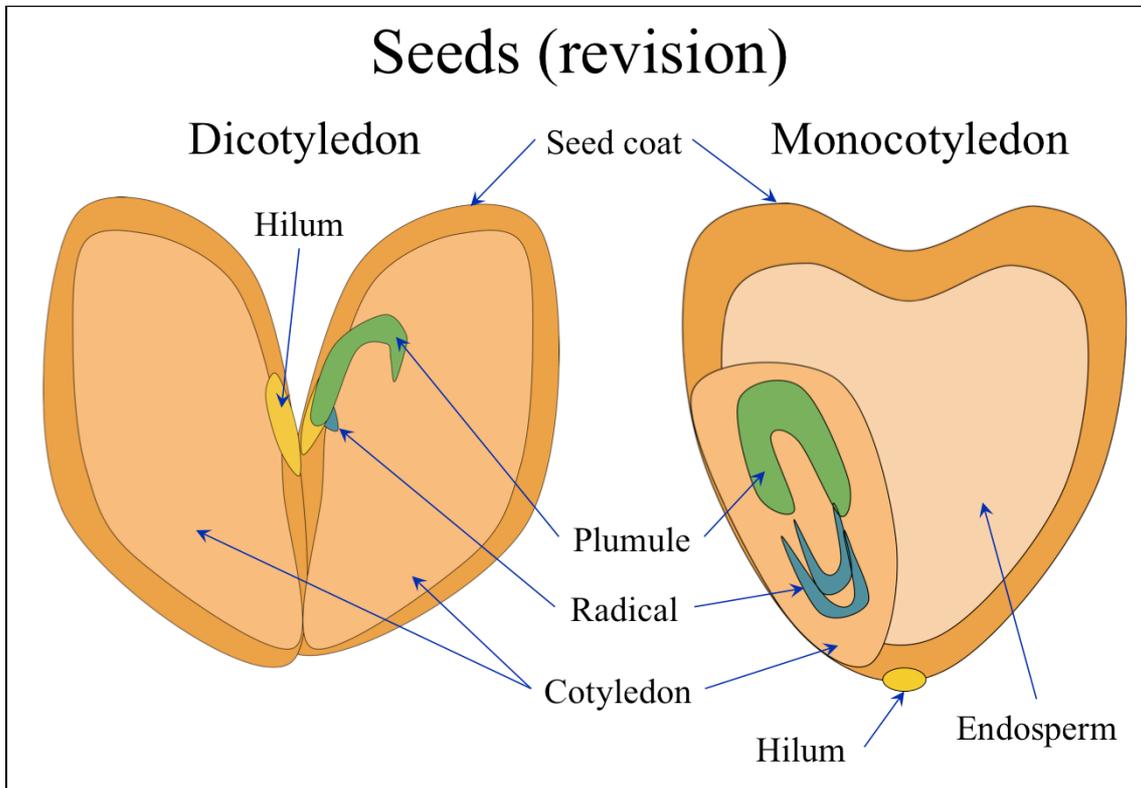
- As with most areas of biology there are variations. I will mention some of the variations, but there are more that I won't mention, to reduce confusion.
- 

Parts of a flower (revision)



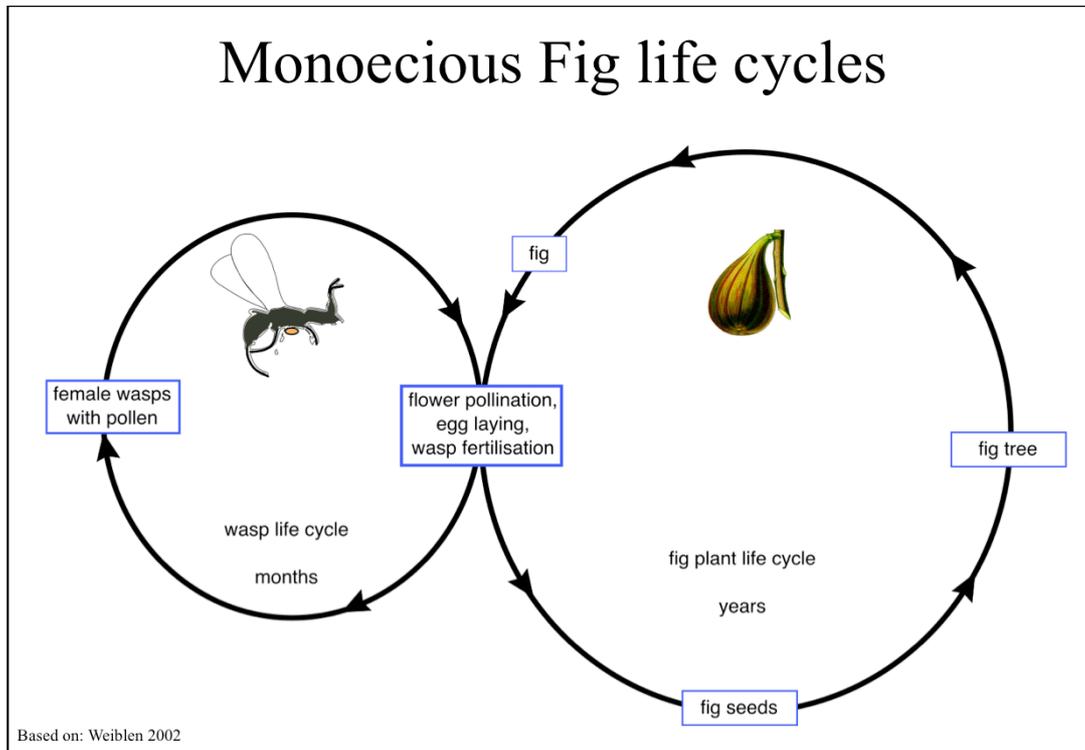
Parts of a flower

- The picture is a generalised flower containing both male and female parts. (Not all flowers do.)
- For attracting animals:
 - The **Perianth** is the outer part of a flower, consisting of: Calyx (composed of Sepals) and Corolla (composed of Petals).
 - **Nectaries** (for sugar) and even **Pollen** (for protein)
- A **Stamen** is the male fertilising organ of a flower, consisting of a pollen-containing Anther and a Filament.
- The **Stigma** has a sticky surface to give pollen grains a firm grip.
- The **Style** connects the **Stigma** to the ovaries, allowing fertilisation, as we shall see.
- The **Ovary** protects the **Ovules** (eggs). After fertilisation the ovules become the seeds.
- ●
- The **Microsporangium** in the anther produces pollen to fertilise the female parts of another (usually) flower.
- A **Carpel** is a set of the female reproductive parts of the flower, consisting of: Stigma, Style and Ovary. The term refers to one set. If there are different numbers of each item fused together, then the number of carpels is the largest of the numbers of each of the 3 types of structures.
- A **Pistil** is the female reproductive part of the flower, consisting of: Stigma, Style and Ovary. The term is ambiguous. It can refer to one carpel or a number of fused carpels.
- Image: Wikipedia CC
- ●



Main parts of Dicotyledon and Monocotyledon Seeds

- After fertilisation, the **ovary nourishes the growth of the embryo** until it becomes a mature seed.
- The **Endosperm** is the food supply for the seed. This food supports the development of the seed (especially the cotyledons) and the growth of the root and first leaves. In some seeds (often dicotyledons) the Endosperm is depleted by the time the seed is mature. In others (often monocotyledons) the mature seed has a large Endosperm, that can speed germination and growth in the first weeks after germination.
- The **Cotyledons** also store food. This food, and that in the Endosperm (if present), support the initial growth of the germinating plant until photosynthesis is strong enough to take over. There are **two cotyledons in dicot seeds, one in monocots and two or more in Gymnosperms**.
- Only in plants with Epigeal germination (later slide), where the seed is pulled above the ground, are the **cotyledons green and photosynthetic**.
- The **Radicle** is the root of the seed. It is the first part to emerge from the seed.
- The **Plumule** is the shoot of the seed where the leaves will first appear.
- We **love to eat monocot Endosperm**. We call it white flour, oatmeal, cornflour, or white rice.
- The **Seed coat** protects the seed from excessive drying out, from fungus attack, from injury and from brief showers of rain insufficient for sustained growth.
- The **Hilum** is the point where the seed was attached to its seed vessel. It is equivalent to the **navel in an animal**.
- If you look closely near the Hilum, you may see the **Micropyl**, the small hole that the pollen grain grew through to fertilise the egg. It is often visible on beans on the opposite side of the hilum from little knobs.
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Monoecious Fig Reproduction

- About half fig species are monoecious and the other half dioecious.
- Let's start with monoecious.

Definitions

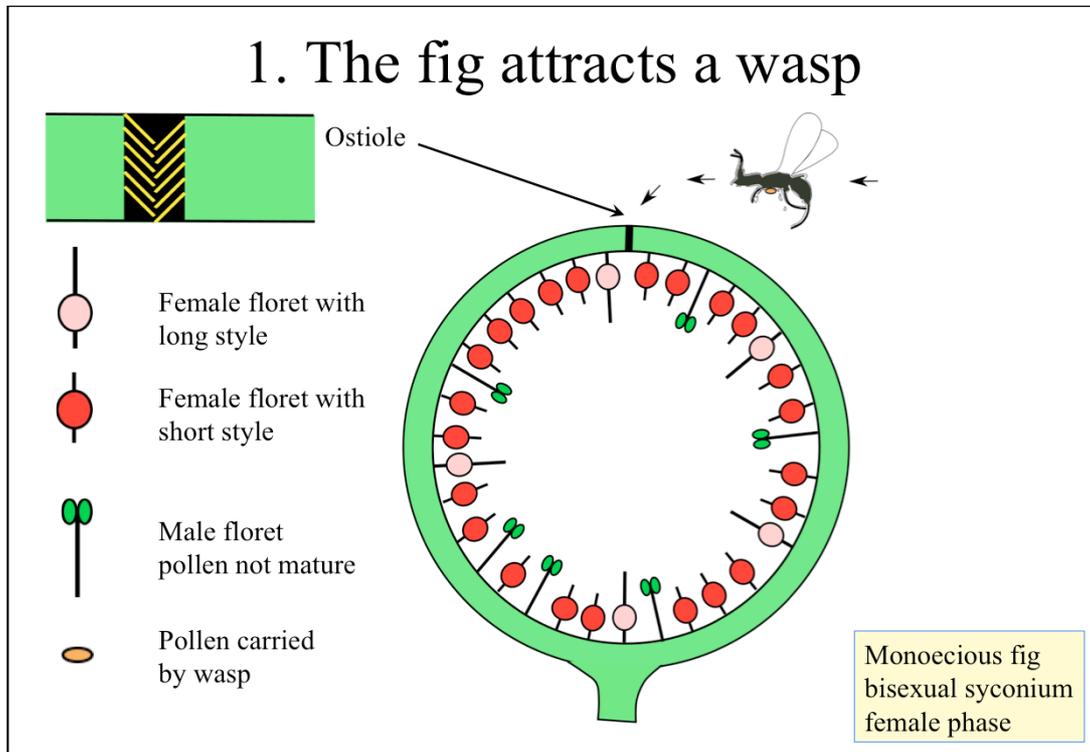
- **Monoecious:** with male and female flowers (or cones) on the same plant.
- **Floret:** A small flower or an individual flower within a dense cluster. The flowers inside the fig are referred to as flowers or florets.
- **Syconium** (plural syconia): (In the family Moraceae) the compound fruit, for example the hollow centred fruit of *Ficus*.
- **Endosperm:** the nutritive tissue (food) surrounding the embryo of a seed. The seed draws on the endosperm to develop the embryo inside the ovary of the flower or during germination of the seed. (the 'packed lunch' provided by the parent plant to help the seed in its early days of life) eg. the flour inside a grain of wheat.

Monoecious fig life cycles

- The life cycles of the fig and the pollinating wasp intersect inside the syconium of the fig.
- The wasp takes pollen from one fig plant to another.
- The endoplasm (packed lunch) of some of the fig seed is eaten by the growing young wasps.
- The timing of the activities of the wasp and fig are closely linked, despite the very great disparity in the length of their lives.
- The fig has several crops per year - 4 in some species.
- The wasps spend most of their life in the syconium.
- Only female wasps generally emerge, and then only for a very few days.

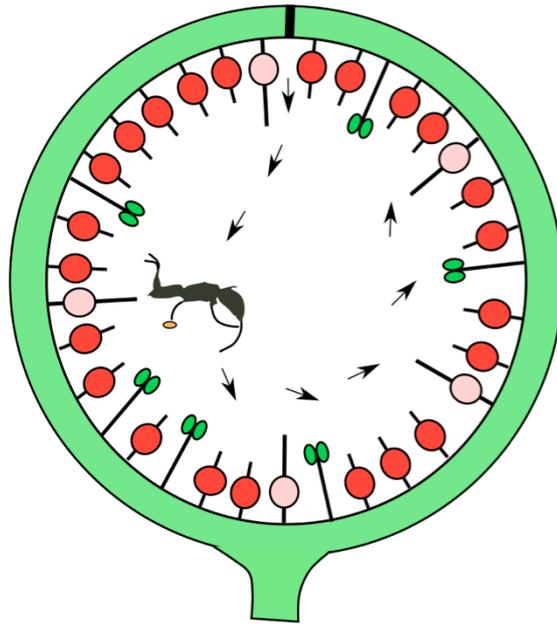
- ● Diagram based on Weiblen 2002

- ●



- The fig syconium has developed enough to begin its female phase where its female florets are receptive for pollen.
- The syconium has 3 types of florets: male (green), short-style female (red) and long-style female (pink).
- As in many plants, the male florets do not produce pollen at this time.
- The syconium emits a fig species-specific volatile oil (scent) to attract wasps.
- If there is a female wasp of the partner species flying within range she is attracted to the fig.
- As she has recently emerged from another fig, she carries pollen from that fig in her pollen pocket or in other crevices on her body.
- These containers keep the pollen from drying out, it is thought.
- The wasp enters the fig via the ostiole, the small hole at the opposite end of the fig from its stem.
- The legend on the left shows the ostiole is lined with inward facing stiff fibres that prevent the wasp leaving and also remove its wings.
- 

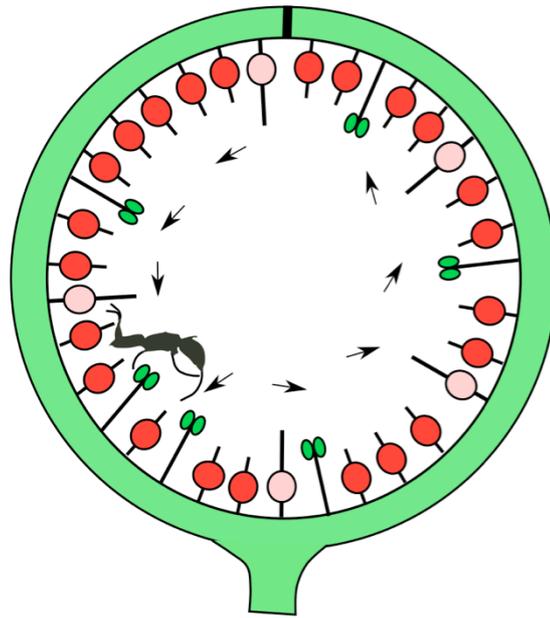
2. Pollination



Monoecious fig
bisexual syconium
female phase

- After entering the fig via the ostiole, the now wingless female wasp distributes pollen onto all the female florets.
- Pollinated florets can then develop to become seeds.
- 

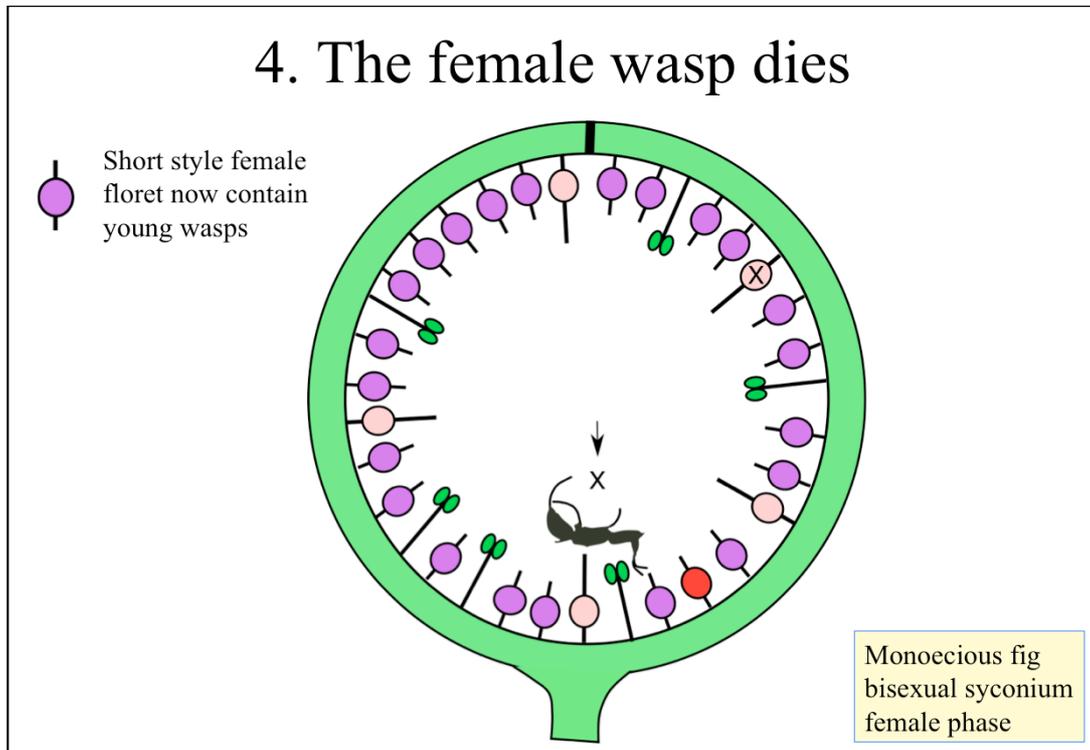
3. The wasp lays her eggs



Monoecious fig
bisexual syconium
female phase

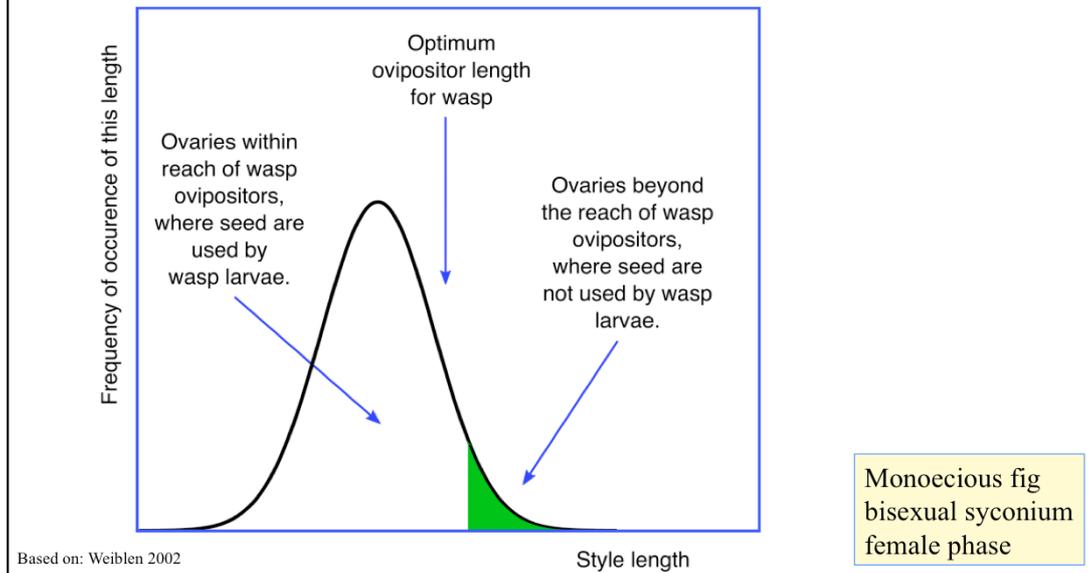
- The wasp lays her eggs in the ovary of female florets by inserting her ovipositor down the style.
- The ovipositor of a wasp is the long thin projection from its rear. In some species the ovipositor can also carry venom, so the wasp can sting.
- Because of the length of her ovipositor she can only lay eggs in florets with style shorter than her ovipositor.
- The evolutionary competition between maximising wasp off-spring and fig off-spring (seed), the survival of both species and diminishing returns, results in nearly 90% of female florets carrying wasp young in many figs.
- This leaves seed in the 10% of florets with styles longer than the wasp ovipositor.
- The eggs are laid within the seed coat so the growing young wasps can eat the endosperm (the seed's packed lunch).
- As a result the seed don't produce viable embryos.
- 

4. The female wasp dies



- The female wasp dies after a short life (a few days) as an adult.
- The short style female florets with wasp eggs (shown in purple) continue to develop.
- They are supported by the fig as it continues the development of each pollinated ovary, whether there is a seed present or not.
- Unpollinated floret ovaries may wither.
- This development phase may last several months.
- 

5. Ovipositor length determines egg laying

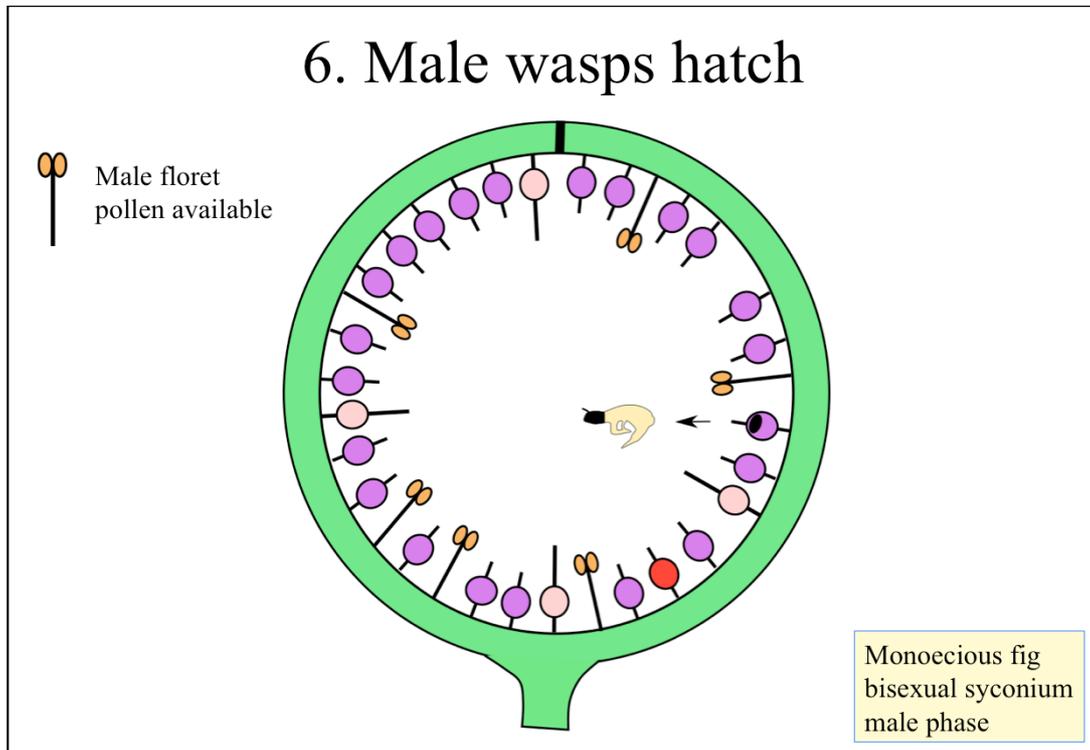


This detail can be skipped

- There are in fact not distinct short and long-style female florets.
- The optimal length of the wasp ovipositor is shown here.
- The wasp cannot lay eggs in florets that are longer than the ovipositor can reach.
- It is not in the wasp's interest to have a longer ovipositor because it requires more energy to grow and increases the risk of damage - diminishing returns.
- Thus not all florets are taken by wasp eggs, and so the fig can also reproduce.
- Diagram based on Weiblen 2002.

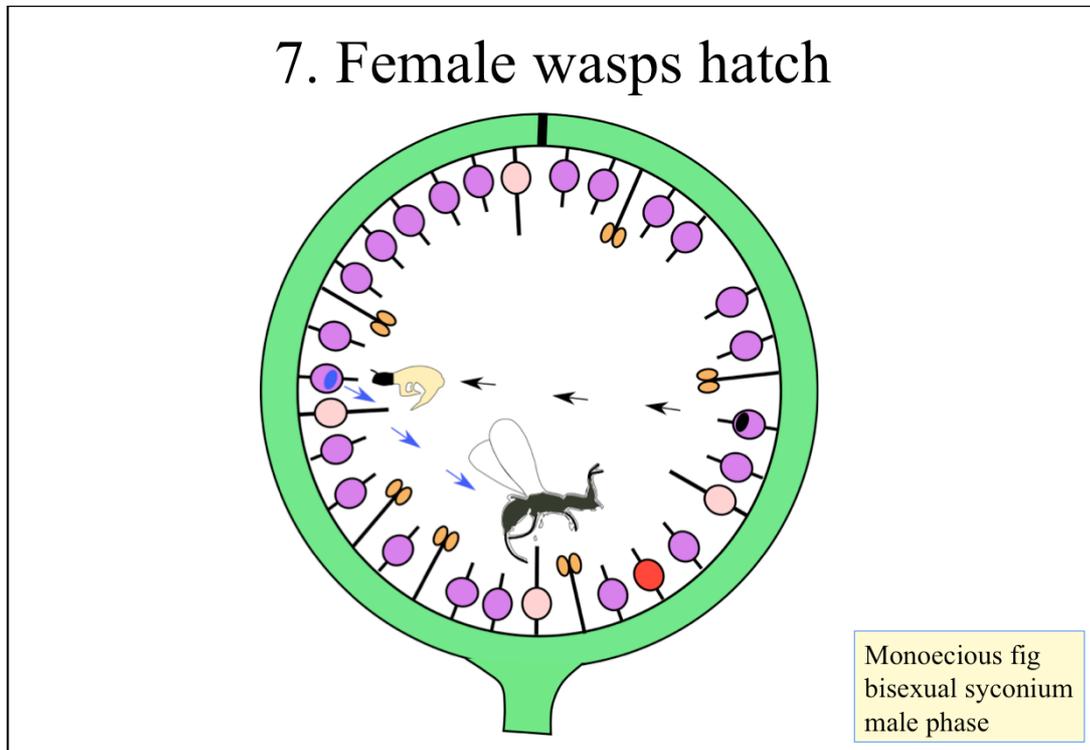


6. Male wasps hatch



- Three to 20 weeks after the female florets have been pollinated, the male florets mature and produce pollen, ie. The syconium begins its male phase.
- At the same time the young wasps are ready to hatch.
- The only young wasps that can escape from the fig ovaries are the males.
- Males have mouth parts that allow them to chew their way out. Females have no mouth parts.
- As the males of most species spend all their life inside the fig, they don't need body pigment. Only their head is pigmented.
- ●

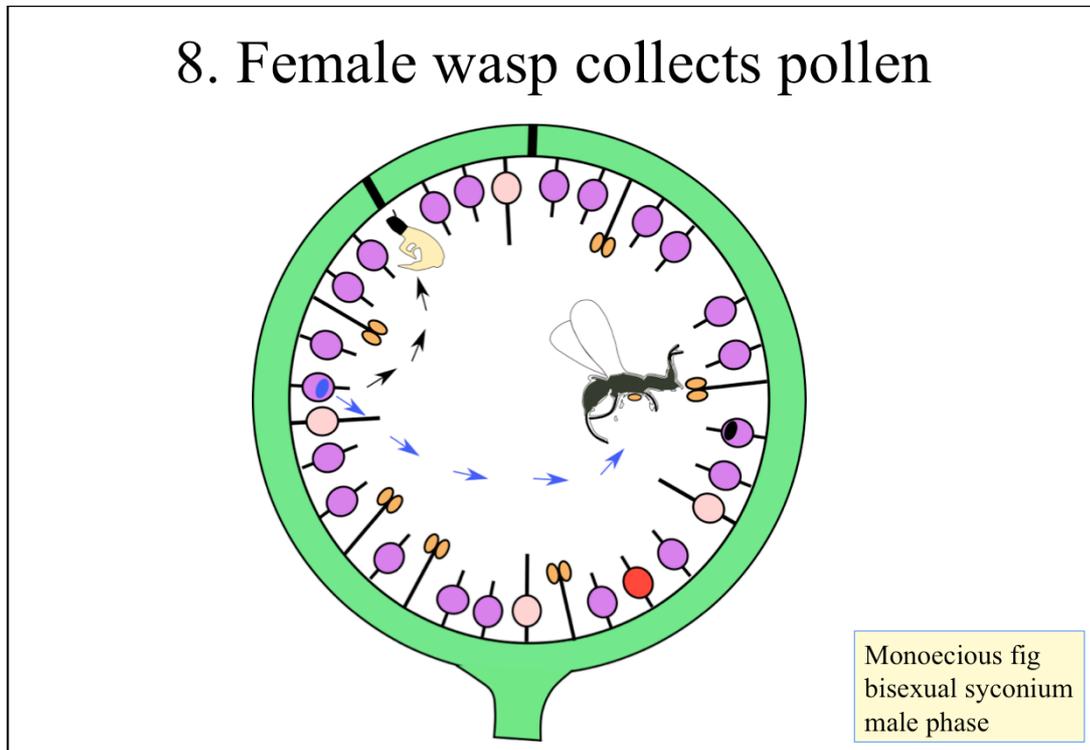
7. Female wasps hatch



Monoecious fig
bisexual syconium
male phase

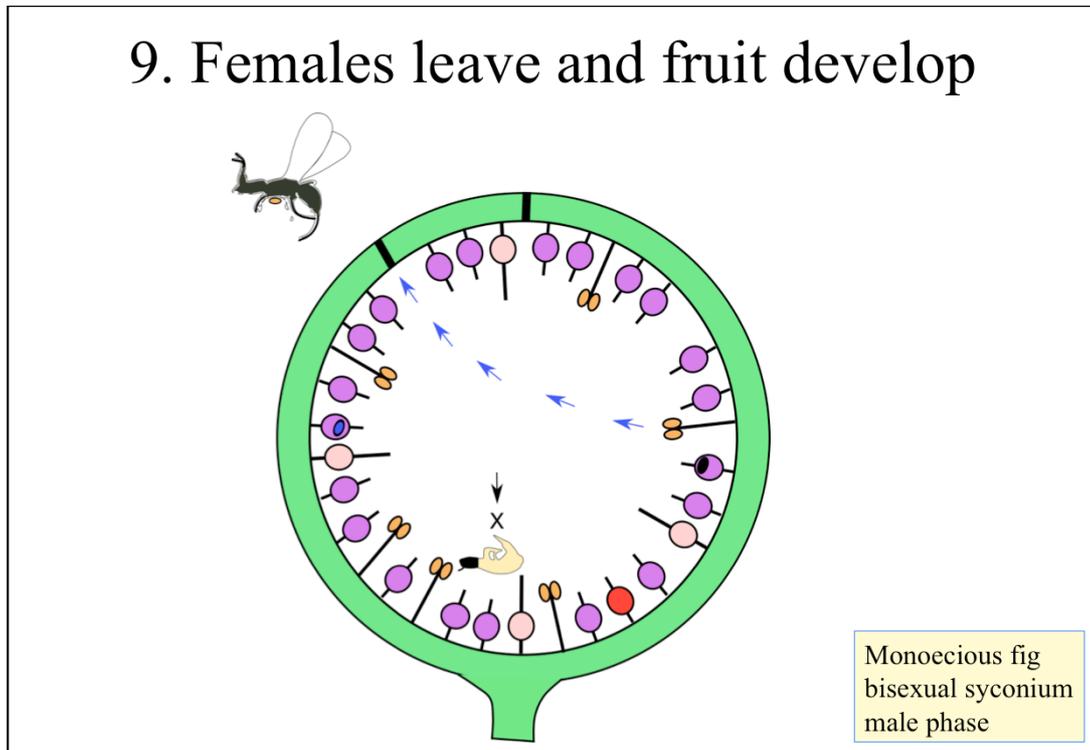
- The male wasp then searches for females of his species.
- (In some cases there may be another species of pollinating wasp.)
- (In many cases there may be several species of parasitic wasps.)
- He can smell them through the ovary wall.
- He chews a hole in the fig ovary wall and mates with the newly hatched female wasp, from outside the ovary.
- The female wasp leaves the ovary via the hole the male has cut for it.
- The males proceed to fertilise and release females.
- Males may be able to determine siblings and avoid mating with them.
- 

8. Female wasp collects pollen

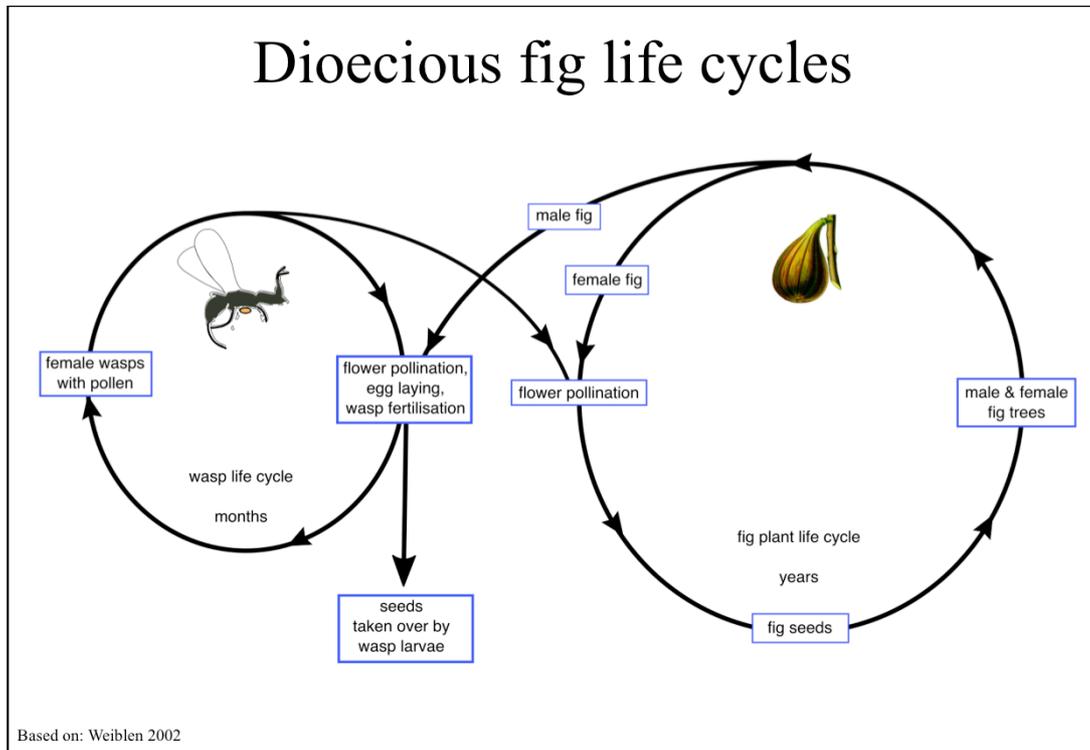


- After mating with the females, the male wasp chews a hole in the wall of the syconium (fig) to allow females to fly out.
- Meanwhile the newly hatched female wasps collect pollen from the male florets and puts it into their pollen pouches. In species without pollen pouches, the pollen may be accumulated passively or actively in specific crevices of the wasp's body.
- ●

9. Females leave and fruit develop

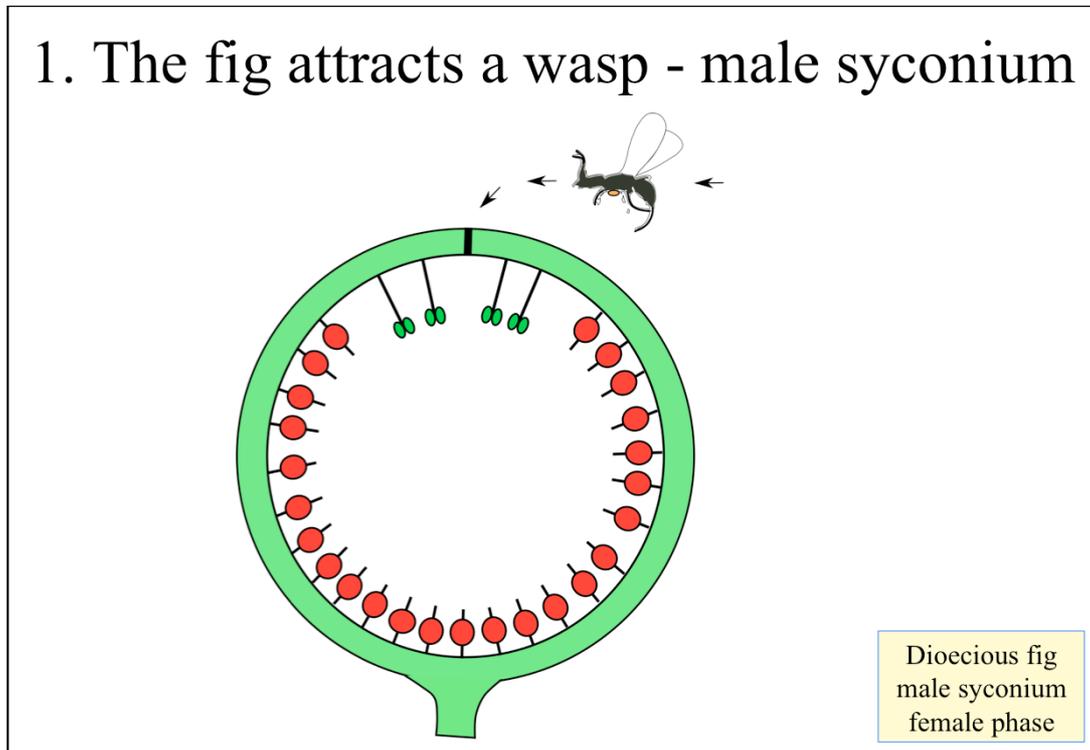


- The male wasps then die inside the fig, never having left it.
- The female wasps leave the fig via the hole chewed by the male, carrying her load of pollen.
- The female has but a few days to find a plant of its fig species that is in the female phase ready to be pollinated.
- If it is successful, the cycle of mutualism can begin again with this new generation of wasps.
- The fig seeds continue to develop.
- The syconium changes colour and may develop a sweet taste.
- When the seeds are mature, the fruit attracts animals to eat them, so dispersing the seed.
- If not taken from the tree, the fruit may fall to the ground making it accessible to another group of animals.
- The syconium contains a laxative chemical that makes it pass quickly through the animal, so the seeds are not damaged in transit.
- 



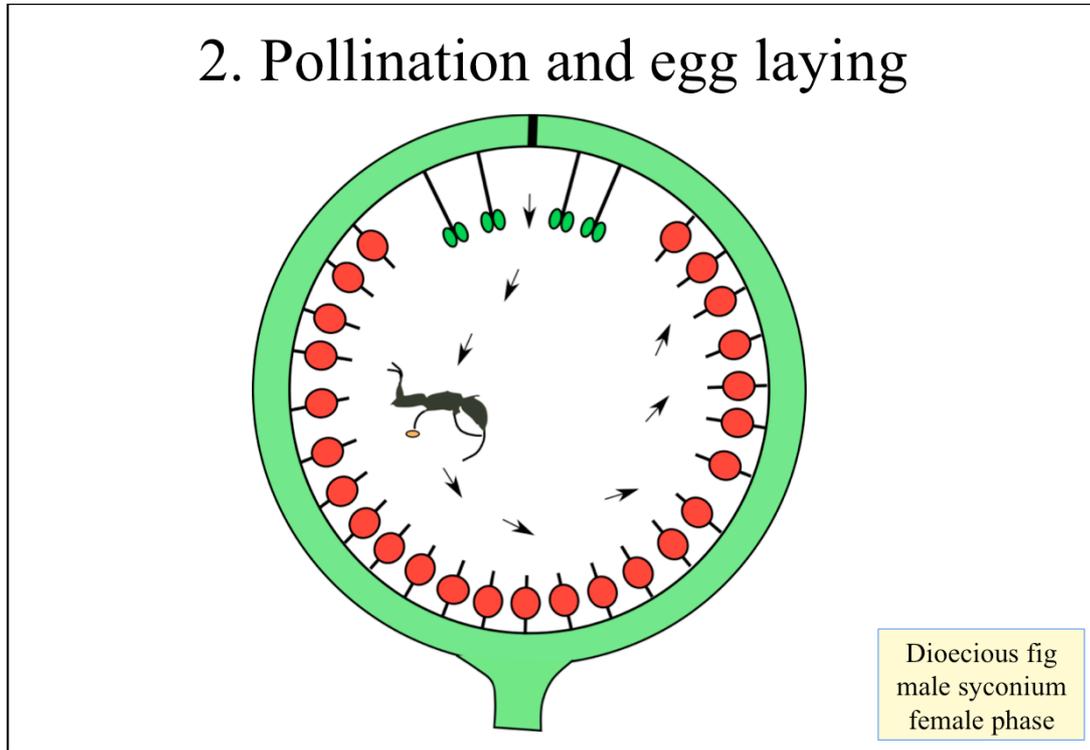
- The life cycles of fig and wasp are broadly the same in dioecious figs as in monoecious figs.
- However it is spread spread between male and female syconia.
- The female syconium produces fig seed, while the male fig produces young wasps and pollen for them to carry to a female syconium.
- Tracing through the life-cycles let's begin with the male syconium (the left cycle).
- ●
- Diagram based on Weiblen 2002
- ●

1. The fig attracts a wasp - male syconium



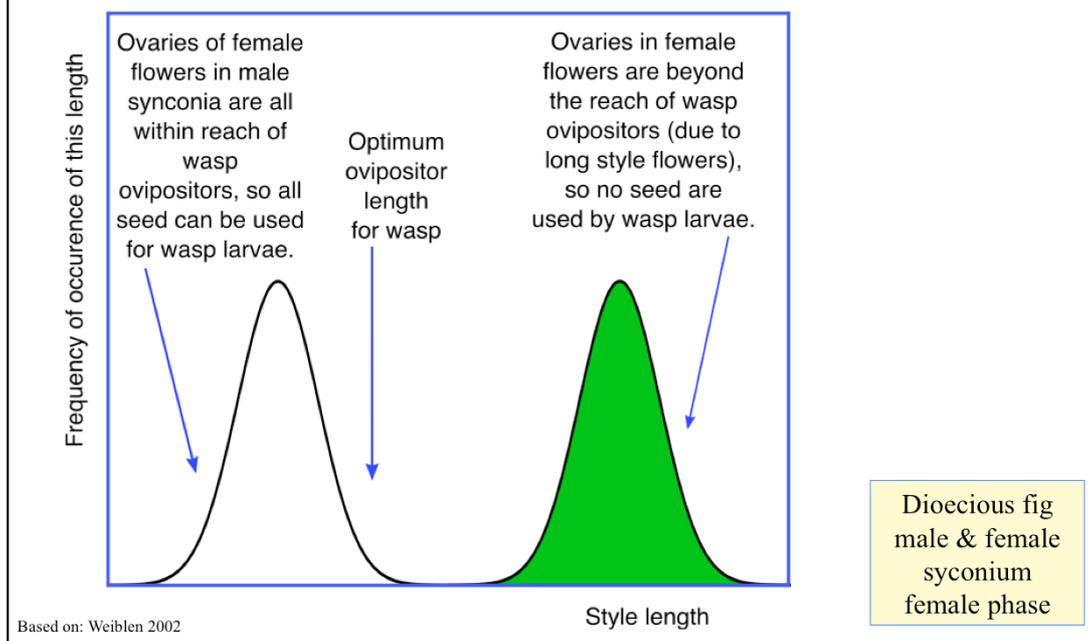
- The male syconium has male florets and short-style female florets.
- It is strictly called gynodioecious because the female plant has syconia with only female florets and the male plant has both male and female florets within its syconia.
- The female florets are ready to be pollinated and the male florets are not producing pollen, so this male syconium is in its female phase.
- The female wasp, carrying pollen, enters the syconium in the same manner as in monoecious species:
- The female wasp is attracted by the scent, carrying pollen from another fig in its pollen pocket (or pouch) or in other crevices on its body.
- These containers keep the pollen from drying out, it is thought.
- The wasp enters the fig via the ostiole.
- The inset shows the ostiole is lined with inward facing stiff bristles (ostiole bracts) that prevent the wasp leaving, remove its wings and clean it of parasites and fungal spores.
- The pollen pocket or crevices also protect the pollen from being brushed away by the bristles on in the ostiole.
- After the females wasps have entered, the ostiole may fill with an antiseptic liquid to prevent fungal infection.
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2. Pollination and egg laying



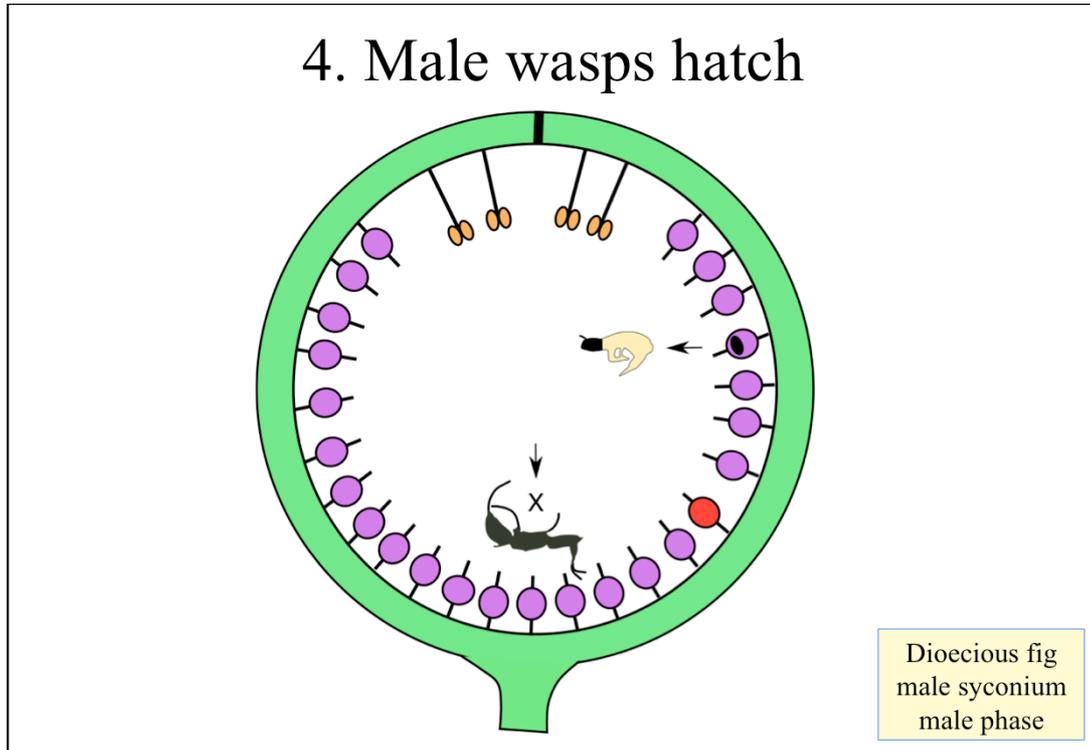
- After entering the male fig via the ostiole, the now wingless female wasp distributes pollen onto all the female florets.
- Pollinated florets develop towards seeds.
- But the seed embryos cannot develop to maturity because the endosperm of the pollinated florets supports the growth of the young wasps and deprives the seed of their ability to develop properly.
- The wasp lays her eggs within the seed coat of the ovum in the ovary of female florets by inserting her ovipositor down the style.
- Because all the female florets have short styles, she can lay eggs in every female floret.
- This male fig therefore may produce no seed despite having many female florets.
- Because the florets have been pollinated, they are not aborted, so supporting the young wasps.
- The syconium is also not aborted, so fruit develops. This fruit is called a caprifig (latin: *caper* meaning goat, *ficus* meaning fig, referring to the male of the Common fig *Ficus carica* being inedible to humans).
- Soon after laying her eggs, the female wasp dies.
- 

3. Ovipositor length determines egg laying



- ●
- As with monoecious figs, the ovipositor length determines which florets the wasp can use for its eggs.
- The wasp lays her eggs in the ovary of female florets of the male syconia by inserting her ovipositor down the style.
- Because of the length of her ovipositor she can lay eggs in all these short-style florets.
- In the female florets of the female syconia, she cannot reach any of the ovaries, so the fig can produce its full complement of seed,
- This is the advantage of the gyno-dioecious approach used by about half the fig species.
- Diagram based on Weiblen 2002
- ●

4. Male wasps hatch

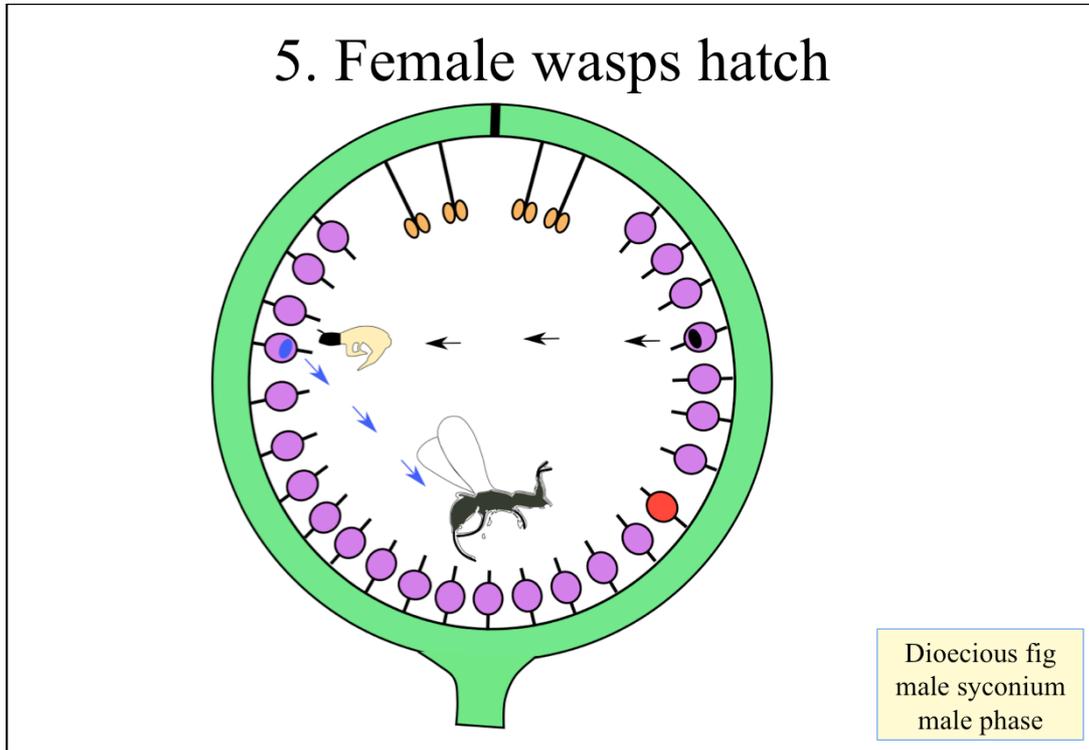


- Fig male florets produce pollen as the syconium's male phase begins and the male wasps hatch.
- The male florets are now shown orange, representing the available pollen.

- **This is the same as in monoecious figs:**

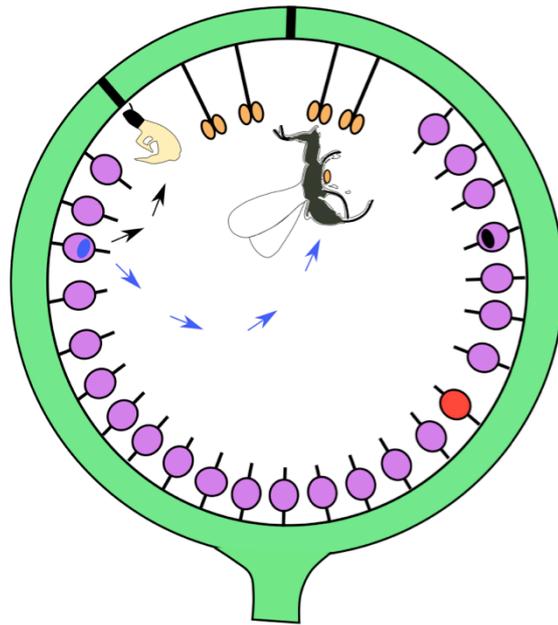
- ●
- The female florets with wasp eggs (now shown in purple) continue to develop.
- They are supported by the fig as it continues the development of each pollinated ovary, whether there is a seed present or not.
- Unpollinated floret ovaries may wither.
- This development phase may last several months.
- When the fig reaches its male phase, the pollen anthers mature and the young wasps are ready to hatch.
- The only young wasps that can escape from the fig ovary are the males.
- Males have mouth parts that allow them to chew their way out. Females have no mouth parts.
- As the males of most species spend all their life inside the fig, they don't need wings or body pigment. Only their heads may be pigmented.
- ●

5. Female wasps hatch



- After hatching, the male wasp then searches for females of his species.
- **This step is the same as for monoecious figs**, including the presence of parasitic wasps:
- ●
- The male wasp can smell females of his species through the ovary wall.
- He chews a hole in the fig ovary wall and mates with the newly hatched female wasp, from outside the ovary.
- The female wasp leaves the ovary via the hole the male has cut for it.
- The males proceed to fertilise and release females.
- Males may be able to determine siblings and avoid mating with them.
- ●

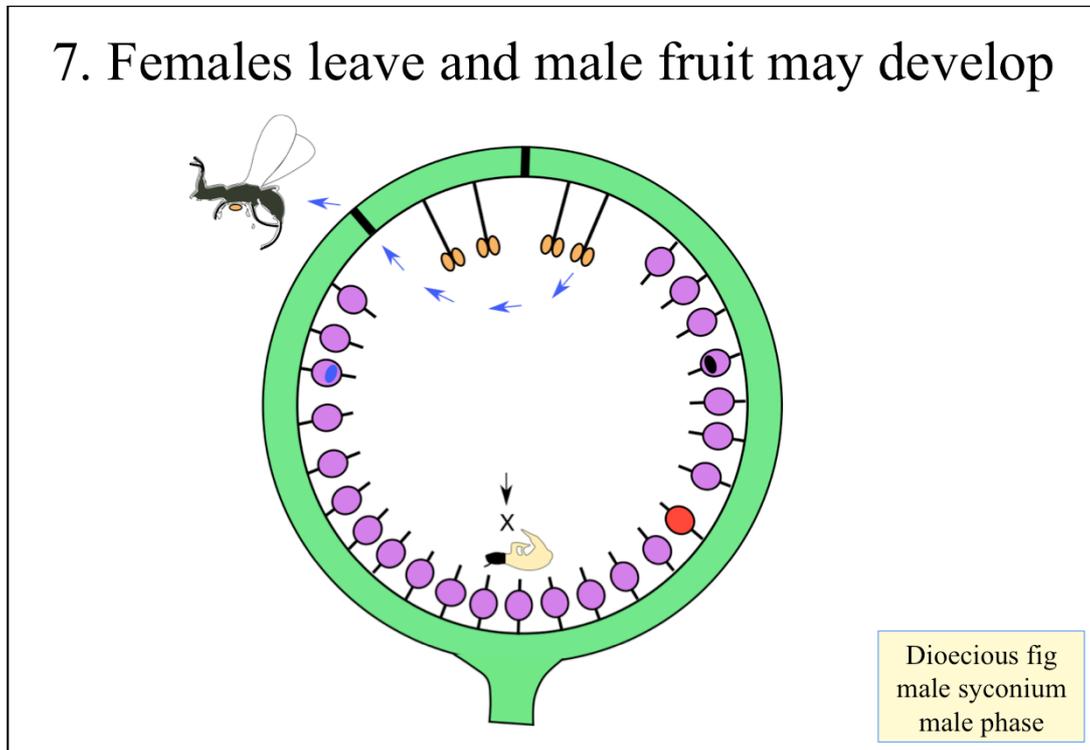
6. Female wasp collects pollen



Dioecious fig
male syconium
male phase

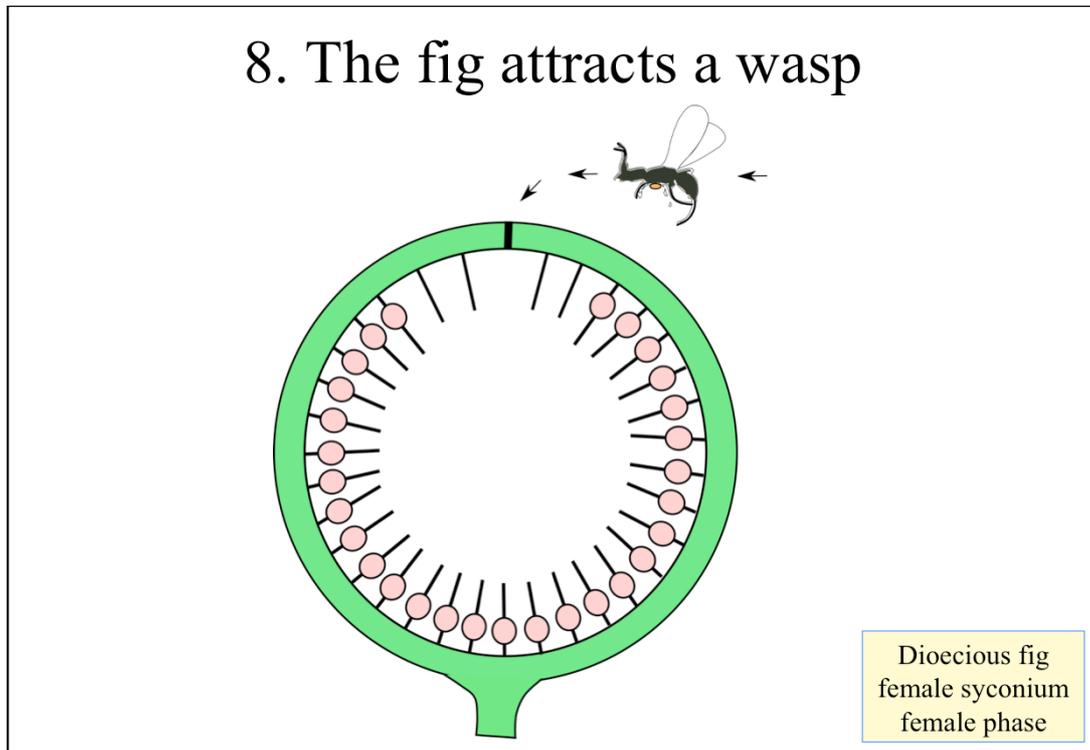
- The male wasp chews a hole in the wall of the syconium to allow females to fly out.
- Meanwhile the newly hatched female wasp collects pollen from the male florets, as for monoecious figs.
- ●

7. Females leave and male fruit may develop



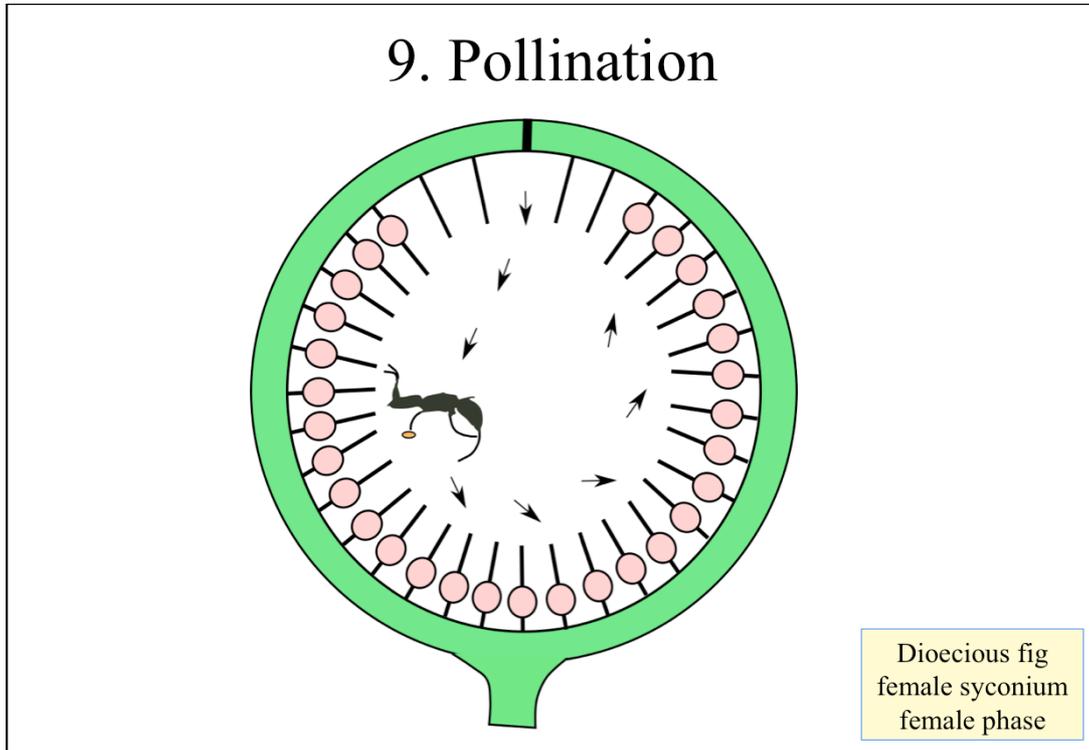
- After mating, the male wasps die inside the fig.
- Carrying pollen, the female wasps leave the fig via the hole chewed by the male.
- The female has but a few days to find a tree of its fig species that is in the female phase ready to be pollinated.
- As the female florets on the male syconium were pollinated it may continue to develop into fruit (caprifig).
- As this fig species is dioecious, the flying female wasp may find either a male or female syconium in its female phase.
- As we have just traced what happens in the male syconium, we now follow the steps in the female syconium.
- This does not imply an alternation between male and female. Some female wasps will find male and others female syconia.
- 

8. The fig attracts a wasp



- The female syconium only has long-style female florets.
- During the development of the syconium, the male florets are aborted, shown here by stalks without any coloured anthers.
- As the fig has entered its female phase, the female florets are ready to be pollinated.
- As with the male syconium, the female wasp is attracted by the scent, carrying pollen from another fig in its pollen pocket (or pouch) or in other crevices on its body.
- These containers keep the pollen from drying out, it is thought.
- The wasp enters the fig via the ostiole.
- ●

9. Pollination



- From the fig's perspective we have reached the important step.
- After entering the fig, the now wingless female wasp distributes pollen onto all the flowers.
- Pollinated flowers develop seeds.
- The syconium changes colour and may develop a sweet taste.
- When the seeds are mature, the fruit attracts animals to eat them, so dispersing the seed.
- If not taken from the tree, the fruit may fall to the ground making it accessible to another group of animals.

- As the styles of all the flowers are longer than the ovipositor of the female wasp, she cannot lay any eggs in this syconium.
- She dies in the syconium a few days later, without any off-spring.
- 

Variations on fig reproduction



- Female wasps leave via ostiole.
- Female wasps without pollen pouches.
- Female wasps passively collect and distribute pollen.
- Male wasps leave the syconium to be taken by ants to protect females.
- Parasitic wasps lay eggs from outside or inside syconium.
- Parasitic wasps lay in fig ovaries, in pollinating wasps and in other parasitic wasps.
- Some figs have more than 1 species of pollinating wasp.

Photo: Female Idarnes parasitic wasp, Sergio Jansen Gonzalez, flickr.com CC BY-NC 2.0

Photo: Female Idarnes parasitic wasp Sergio Jansen Gonzalez, flickr.com CC BY-NC 2.0

Note the long ovipositor to lay eggs from outside the syconium.



Variation: Parthenocarpic fig



Ficus carica
Common Fig

Left photo: Common Fig *Ficus carica*, Zenz 2004 Wikimedia, Public Dom Right image: Common Fig *Ficus carica*, Thomé 1885 Wikimedia, Public domain

The Parthenocarpic Fig

- *Ficus carica* the Common Fig is dioecious.
- The syconium on the left is in fact female so it doesn't produce any young pollinating wasps.
- About 11,000 years ago, someone discovered a mutant plant of *Ficus carica* that produced female figs without being pollinated by a wasp.
- People recognised that this meant that they didn't need to grow any male trees and without young wasps there would be no wasps inside the fruit.
- The seeds in these figs are viable.
- This reproduction is called parthenocarpic. It is analogous to parthenogenic in animals - so called virgin birth.

- Not all varieties of figs on sale are from parthenocarpic trees (eg. Calimyrna variety)
- When figs were first cultivated in California their trees produced no fruit, because they had not planted any male trees.
- (As they were a particular cultivar they were probably all grafted from twigs of female trees.)
- Then someone learned that their variety of fig requires pollination, so a few male trees were grown.
- The female figs then began producing mature fruit.
- 

Key Points



- Flowers inside-out
- One fig species, one wasp species
- Only females leave the fig
- Wasps pollinate figs
- Figs feed young wasps
- Finely-tuned mutualism
- Each species responds to cues from the other
- The relationship has existed for more than 50 Million years
- Figs are a keystone species
- ~50% fig species dioecious, ~50% monoecious

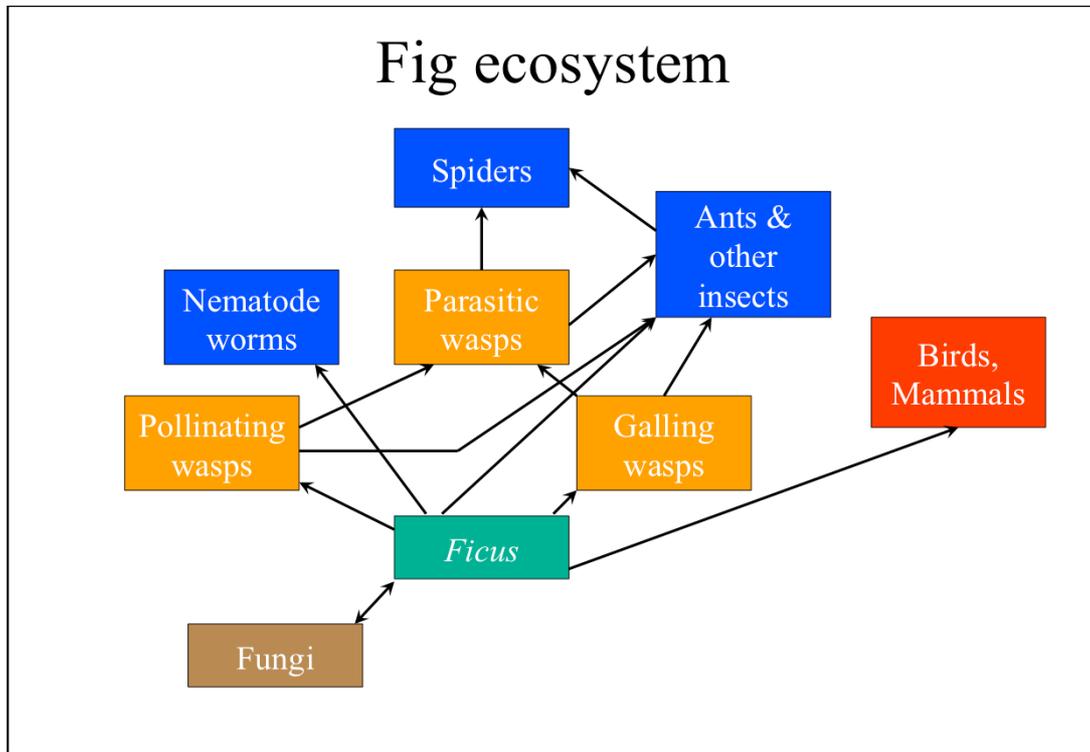
Key points to take away

- A fig is an inside-out cluster (inflorescence) of small flowers (florets).
- Each of the 800 or more fig species has its own individual species of wasp for pollination.
- Female wasps spend only two or three days of their life of 3 to 9 months outside a fig.
- They fly from the fig they were born in to another fig plant of the same species.
- Male wasps spend their whole life inside the fig they were born in.
- The wasps pollinate the figs and the figs provide food for the young wasps to develop.
- Without the wasps figs would die out and without the figs the wasps would die out.
- Evolution has crafted a finely tuned and delicate mutualism between the figs and the pollinating wasps.
- So it is important that each species is finely tuned to respond to the signals coming from the other about its current stage of its life cycle and to meet the needs of the other party in the relationship.
- This mutualism has been so successful that it has continued for more than 50 million years.
- Many animals depend on figs. The extinction of a fig affects many species.
- Figs have a wide diversity of characteristics between species.
- About half the fig species are dioecious, having separate male and female plants
- 

Figs are Keystone species



- Q: What do these Australian birds have in common?
- Top: Double-eyed Fig Parrot *Cyclopsitta diophthalma* (male) (Photo: ShotoPhoto en.wikipedia.org CC BY-SA 2.0)
- Bottom left: Green Figbird *Sphecotheres vieilloti vieilloti* (Photo: Aviceda wikipedia.org CC BY-SA 3.0)
- Bottom centre: Yellow Figbird *Sphecotheres vieilloti flaviventris* (Photo: Jim Bendon commons.wikimedia.org CC BY-SA 2.0)
- Bottom right: Pale Yellow Figbird *Sphecotheres vieilloti ashbyi* (Photo: Brian Gratwicke Flickr CC BY 2.0)
- A: They all have fig in their names because they are heavily reliant on figs for food.
- Like the keystone at the top of an arch, which will collapse if the keystone is removed, a keystone species is one where its removal (loss) results in the collapse of an ecosystem.
- Figs are keystone species in rainforest, because they continuously provide fruit. This is so their wasps can continue living. ●
- There are 5 groups of birds in Australia that have a group of plants in their name, signifying their dependence on that plant group one way or another.
- Q: What are they?
- A: Fig birds *Sphecotheres vieilloti*
- A: Double-eyed fig parrot *Cyclopsitta diophthalma*
- A: Mistletoe bird *Dicaeum hirundinaceum*
- A: Grass wrens that eat grass seed.
- A: Reed warblers that live and nest in reeds.
- There are also 5 species of fruit dove that eat figs (and other fruit).
- The birds that eat the figs help disperse the seed.
- The fig is not passive in this. It provide the figs with a laxative that ensure that seeds pass quickly through the gut without damage.



- Many species depend on figs for food.
- So energy from the sun, captured by figs, supports all these species.
- Fungi provide nutrients to the fig, from the soil.
- Species use fruit, seed and leaves of the fig.
- Pollinating and Galling wasps enter the fig.
- Nematodes occasionally enter the fig, riding on pollinating wasps.
- Ants eat wasps and fig pieces, including seed.
- ●

Fig Diversity



- Fig plant forms
- Height 450 mm to 60 m
- Leaves:
 - sandpaper, smooth, hairy
 - evergreen, deciduous
- Sex:
 - monoecious, dioecious, parthenocarpic
- Rainforest to desert
- Tropical to warm temperate

- Australia has among the smallest, the highest and those with greatest area:
 - *Ficus lilliputiana* is a small shrub sometimes only 300 mm high.
 - *Ficus macrophylla* can reach 60 m.
 - A subspecies of *Ficus macrophylla* can have a canopy area of 2 ha.
- Parthenocarpy (literally meaning virgin fruit) is the production of fruit without fertilisation of ovules.
- *F. lilliputiana* grows near the NT/WA border inland from the coast. It was named that by its discoverer, Dr. Dale Dixon, referring to the little people of the island of Lilliput in Jonathon Swift's novel 'Gulliver's travels'. Dr. Dixon understands that the location was inspired by the visit of William Dampier to what he called Shark Bay in northern WA, close to the area where this fig grows.
- See later slide for some details about growing this fig.
- 

Fig diversity - forms



Top photo: India, Biswarup Ganguly 2011 Wikipedia CC BY 3.0

- Fig plant forms:
 - Banyan
 - Strangler
 - Free-standing tree
 - Shrub
 - Root climber
 - Epiphyte (in trees)
 - Lithophyte (on rocks)
 - Rheophyte (in rivers)

Bottom photo: LHI NSW, Pete The Poet, flickr.com 2013 CC BY-NC 2.0

- Top photo: The Great Banyan *Ficus benghalensis* at the Acharya Jagadish Chandra Bose Indian Botanic Garden, Howrah, outside Kolkata, India.
- Its signboard says the tree is in the Guinness Book of World Records for the widest canopy at 1.5 hectares and with about 2880 prop-roots.
- Bottom photo: *Ficus macrophylla* forma *columnaris*, Lord Howe Island NSW. Flora of Australia, Vol 3, says they reach an area of 2ha.
- Note the trunks and leaves of *Howea fosteriana* Kentia Palm.
- 

Fig diversity



- Syconia can grow from:
 - Leaf twigs
 - Trunk
 - Branches
- Synconia can develop in leaf litter or just below the soil surface.

Some species of figs in the Australian rainforests have evolved the unusual habits of 'ramiflory' and 'cauliflory', the fruiting on the branches and the main trunk respectively.

This photo is of *Ficus coronata* Sandpaper Fig that grows in Eastern Victoria and elsewhere in Australia. This dioecious fig is Victoria's only native fig.

Ficus cordata is a dioecious species that produces (female, I believe) syconia on stems at the bottom of the trunk. These may droop and develop in the leaf litter or soil. This allows easy germination of seed. As the syconia are female there is no need for wasps to escape.



Fig syconium



- Inside a syconium of *Ficus macrophylla* Morton Bay Fig.
- There is not much free space for wasps to move around in.
- The ostiole is at the bottom left.
- ●

Fig florets



- Florets of *Ficus macrophylla* Morton Bay Fig. Female on left, male on the right.



Wasp exit holes



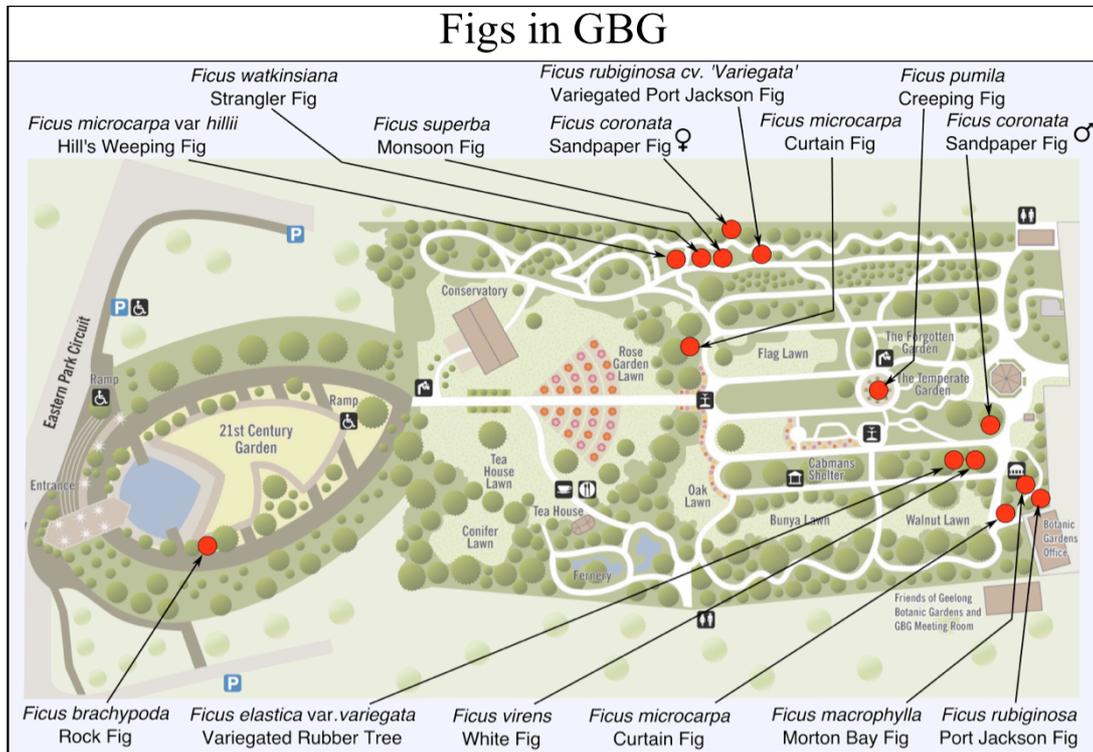
- Syconium of *Ficus macrophylla* Morton Bay Fig. Newly hatched female pollinating wasps, carrying pollen, leave through these holes chewed by the male wasps.



Female pollinating wasp



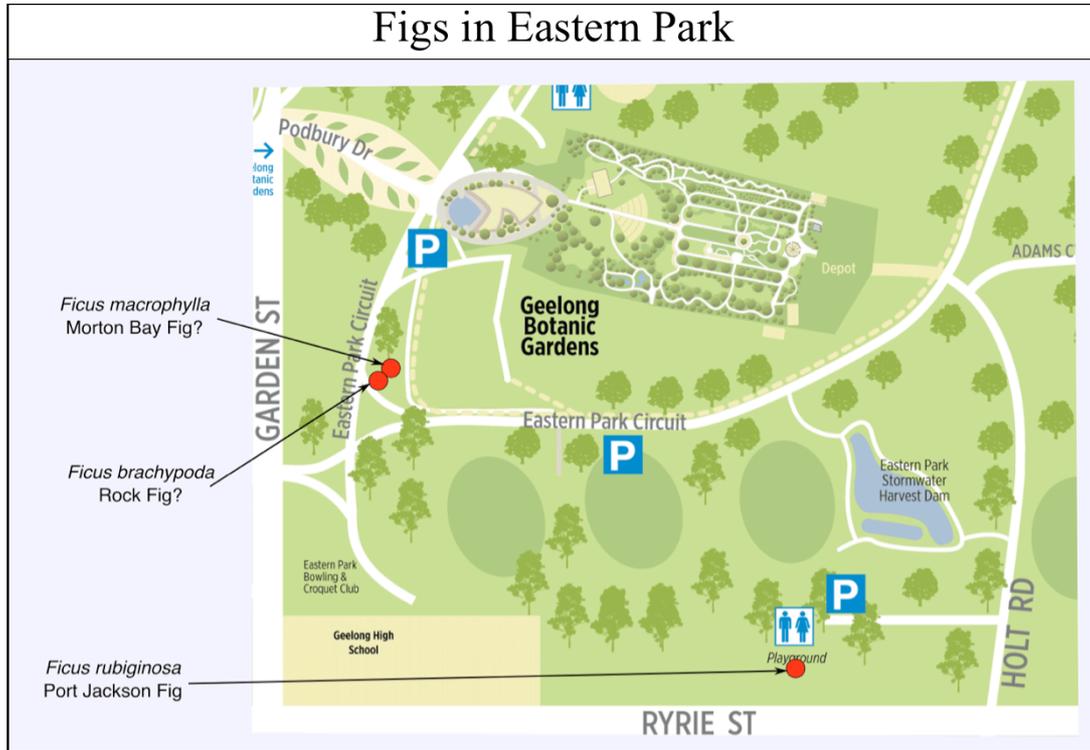
- Female pollinating wasp found in syconium of *Ficus macrophylla* Morton Bay Fig.
- She has no mouth parts and is pigmented.
- The metal object on the left is the point of a sewing pin.
- 



- All species in the GBG are monoecious except two. Q: Which two? A: *F. coronata*, *F. pumila*.
- *F. macrophylla* amongst the world's tallest figs (to 60 m). Also subsp. *columaris* of Lord Howe Island is amongst the largest banyans (up to 2 ha). C19 garden is almost exactly 2 ha.
- *F. macrophylla* was introduced into NZ in C19 without its pollinating wasp *Pleistodontes froggatti*. The trees grow well and are propagated by cuttings. However, in the 1990s the pollinating wasp appeared and the trees starting producing viable seed and young plants. It is thought that a (female) wasp was carried by wind in the 2 or 3 days before it died. Wind patterns suit this kind of dispersal about 30 days per year. (One wasp was carried quickly enough in only one of 3,000 possible days.)
- *F. rubiginosa* can sometimes be hard to separate from *F. macrophylla* as both have brown colouring on the backs of their leaves. *F. rubiginosa* has short fine hairs on the back of its leaves, which can be seen by holding the leaf edge-on and looking for the sheen of the hairs. The back of *F. rubiginosa* leaves feel soft and furry, unlike *F. macrophylla*.
- *F. coronata* is Victoria's only native species. It grows in far east Gippsland. It gets its name from the small coronet (crown) around the ostiole.
- The GBG has both a male and female plant. Q: Can you tell the difference? A: No, not until you look inside the syconium. The plant needs to go to great length to ensure the female wasp cannot detect the difference between the syconia of the two sexes, otherwise it would favour the male plants and the figs might die out.
- The flower layout inside the two sexes of fig are markedly different.
- *F. microcarpa* is called the curtain fig because aerial roots grow down from branches close together, forming a curtain. See subsequent photo. The curtain often forms when the host tree breaks at its base and falls onto another tree, at an angle. The fig then grows roots down from all along the dead host trunk.
- *F. virens* also grows as a curtain fig. See subsequent slide for image of one on the Atherton Tablelands.
- ** Note ** These notes continue onto the next slide. (Insufficient room here.)



Figs in Eastern Park



Notes about figs within the gardens, continued from the previous slide.

- *F. pumila* is an introduced fig. It is the second dioecious fig in the GBG.
- It is a root climber. Unlike many monoecious figs its fruit are not spherical, but pear-shaped. Its juvenile leaves differ from the adult ones.
- Its pollinating wasp does not occur in Australia, so it is not now considered to be naturalised, as it once was. (Flora of Australia online). It is not clear whether there are any male *F. pumila* in Australia.
- *F. brachypoda*: Recently it was found that there was sufficient diversity in *F. platypoda* to split it 4 ways. This is one of these plants with the new species name.
- *F. wakensiana* growth pattern is as a hemiepiphyte. Its seed is deposited in the cleft of a tree branch and germinate there. The young plant is therefore an epiphyte (growing on another plant without taking any of its water or nutrients). Its roots begin growing down the trunk of its host tree. Eventually it kills its host.
- *F. superba* var. *henneana* is an endemic Australian variety of fig. The small fruit is considered edible for humans, but it is not particularly palatable.





***Ficus microcarpa* Curtain fig**

(Photo: Forest & Kim Starr commons.wikimedia.org CC BY 3.0)



***Ficus virens* Curtain fig**

(Photo: Paste, en.wikipedia.org CC BY-SA 3.0)



Ficus watkinsiana Strangler fig growing on *Syzygium hemilampra* at Iluka, NSW
(Photo: Peter Woodard, en.wikipedia.org Public Domain)

F. lilliputiana

Information from Dr. Dale Dixon

Understanding the name?

- Genus: *Ficus* - The figs.
- Species: *Ficus lilliputiana*. One of 45 fig species native to Australia. One of about 750 species world wide.
- Author: D.J.Dixon – the person who first described the species - that would be me!
- Common name: I suggested Lilliput's Fig would be an apt common name.

Derivation of the name

The name 'lilliputiana' refers to the small growth habit of this species. All other species in the same group of figs are large erect shrubs or giant trees. This species is small enough to inhabit the land of Lilliput from Swift's Gulliver's Travels. To the Lilliputians, a race of people no taller than six inches tall, this fig would have truly been a magnificent banyan.

General information

A very small shrub that grows naturally on rocks in the strongly seasonal monsoonal climate of north western Australia. It can reach a height of 45 cm and spread to 100 cm but is often much smaller. It is naturally found on sandstone outcrops around Kununurra (Western Australia) and Keep River National Park (Northern Territory). The pollinator wasp is *Pleistodontes proximus* Wiebes.

Horticultural information is practically non-existent. I have grown the species in Townsville (Queensland) and Darwin (Northern Territory). It responds to extra watering during the dry season. I grow my plants in terracotta pots in good well drained potting mix. Plants were fertilised regularly with a general slow release fertiliser. What is not known is how it will respond to cool wet winters further south. We are trialling it @RBGSydney.

Meet the Australian relatives of *Ficus lilliputiana*

Ficus brachypoda, *F. platypoda*, *F. cerasicarpa*, *F. atricha*, *F. subpuberula*, *F. obliqua*, *F. rubiginosa*, *F. destruens*, *F. crassipes*, *F. pleurocarpa*, *F. triradiata*, *F. macrophylla*, *F. watkinsiana*.

Flora of Lilliput

Neoregelia lilliputiana (Bromeliad), *Gentianella lilliputiana* (Gentian), *Dryadella lilliputiana* (Orchid), *Veronica lilliputiana* (Plantaginaceae), *Syagrus lilliputiana* (Palm). You may know others – let me know.

- In the article above, Dr Dixon reports that RBG Sydney is trialling seedlings of *F. lilliputiana* for horticulture:
https://twitter.com/dale_dixon/status/539266159716360192/photo/1
- This fig seems to be easy to grow from seed, but not cuttings. It is easily killed by too much water:
<http://www.thefigsofaustralia.com/ficus-lilliputiana-your-new-favourite-fig/>

Glossary

- Bisexual
- Dioecious
- Embryo
- Endosperm
- Epiphyte
- Floret
- Gynodioecious
- Inflorescence
- Hemiepiphyte
- Monoecious
- Mutualism
- Ostiole
- Ovary
- Ovipositor
- Ovule
- Ovum
- Parasitic wasp
- Parthenocarpy
- Phase
- Pollen
- Pollen pouch, pocket, basket
- Seed coat
- Stigma
- Style
- Syconium (plural syconia)



Note

As this glossary is too large for a single sheet of notes it is also provided separately.

Bisexual

Strictly a flower with both male and female reproductive parts. In this presentation I have used the term 'bisexual' to apply to a syconium with both male and female florets.

Dioecious

With male and female florets (or cones) on separate plants

Embryo

The very young plant residing in the seed. On germination, the embryo sprouts roots and leaves.

Endosperm

The nutritive tissue (food) surrounding the embryo of a seed. The seed draws on the endosperm to develop the embryo inside the ovary of the flower or during germination of the seed. (the 'packed lunch' provided by the parent plant to help the seed in its early days of life) eg. the flour inside a grain of wheat.

Epiphyte

A plant that grows on another plant without drawing water or food from that plant (unlike a parasite).

Floret

A small flower or an individual flower within a dense cluster.