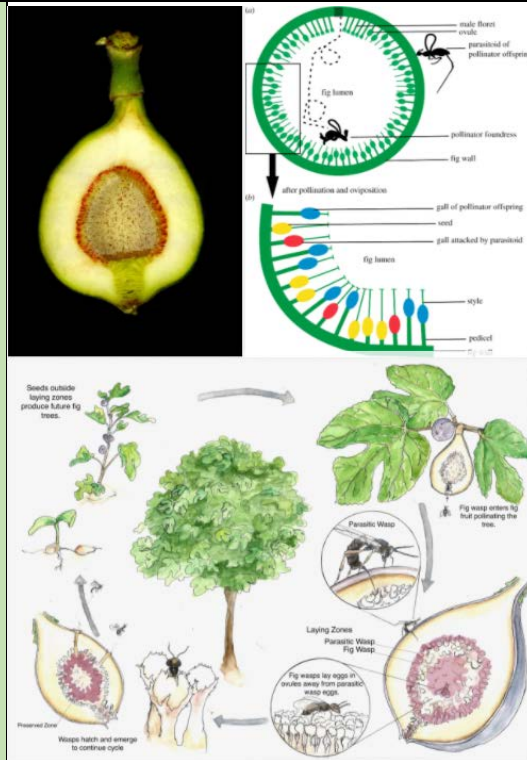


生物策略表

類別	生物策略 (Strategy)
生物策略 STRATEGY	寄生蟲幫助平衡互利共生關係 (Parasite helps balance a mutualistic relationship)
生物系統 LIVING SYSTEM	榕果小蜂 Agaonidae (Fig Wasp)
功能類別 FUNCTIONS	#不同物種之間合作/競爭 #授粉 #保護免受動物傷害 #Cooperate/compete between different species #Pollinate #Protect from animals
作用機制標題	寄生蜂透過限制榕樹及榕果小蜂的共生關係，來增加榕樹的生育 (Parasitic wasps increase fig tree production by placing limits on the mutualism between figs and fig wasps.)

生物系統/作用機制
示意圖



作用機制摘要說明 (SUMMARY OF FUNCTIONING MECHANISMS)

互利共生 (mutualism) 是物種之間的合作以有利於雙方的存活。一個物種提供某些東西給另一物種作為交換，再從另一物種中得到某些好處。例如榕樹 (fig tree) 與榕果小蜂 (fig wasps) 之間關係的例子，已經演化超過六千萬年了。

在任何互利共生關係中，都需要有一些手段來維持平衡。若非如此，可能會造成參與者佔其他參與者的便宜。在澳洲有種榕樹是由一種特定的蜂所授粉，被稱為榕果小蜂。

樹上的榕果是充滿細小種子的香甜果實。榕果中的花朵非常嬌小，附著在內壁上（請看照片及繪圖）。如同任何開花植物，榕果如果沒有授粉就無法產生出種子。小巧的榕果小蜂在進入榕果時會幫助植物授粉。當牠們將卵產進花朵的胚珠 (ovules) 時也會到處散

播花粉。卵最後會成長為小蜂成蟲，並離開到其它樹進行授粉。然而，榕果小蜂並未在所有胚珠裡產卵，讓部分能生長成為當你吃無花果時會咬到的種子。

是什麼阻止了榕果小蜂在所有胚珠中產卵呢？在這個三方互利共生關係中的另一位參與者是寄生蜂 (parasitic wasp)。牠會利用細長的產卵管 (egg-laying tube) 由榕果外穿刺，並產卵在已經帶有小蜂卵的胚珠中 (繪圖中紅色橢圓圈所示)。然後寄生蜂幼蟲會吃掉榕果小蜂的幼蟲。但產卵管並不够長，無法到達所有胚珠，只能達到最接近表面的胚珠。結果，為了躲避寄生蜂，榕果小蜂傾向把大部分的卵產在榕果最深處的「無天敵區域」 (enemy-free zone) (繪圖中藍色橢圓圈所示)。這使得外圍的胚珠 (黃色橢圓圈) 能夠發育成種子，並產生下一代的樹。

我們能從榕樹、榕果小蜂及寄生蜂之間的互利共生關係中學習到什麼呢？有時候，我們需要重新思考一些我們可能自動想成是「壞」的東西，例如寄生行為。寄生蜂是這段關係中的重要成員。透過限制榕果小蜂產卵，寄生蜂使榕樹能產生種子來長成下一世代的榕樹。這也會使榕果小蜂受益，讓牠們有另一世代的榕樹可以授粉並產卵育幼。

Mutualism is cooperation between species that helps each of them survive. One species provides something for the other and in exchange, receives something good in return. One example is the relationship between fig trees and fig wasps that has evolved for longer than 60 million years.

In any mutual relationship, there needs to be some way to maintain balance. Otherwise, one partner might take advantage of the other. In Australia, there is a species of fig tree that is pollinated by a specific wasp, known as a fig wasp.

The figs of the tree are sweet fruit full of small seeds. The flowers are tiny and found inside the fig, attached to the inside wall (see photo and illustration). As with any flowering plant, a fig can't produce seeds without being pollinated. The tiny fig wasp pollinates the plant as it enters the fig. It spreads pollen around as it lays its eggs inside the flowers' ovules. The eggs eventually grow into adult wasps and leave to pollinate other trees. However, the fig wasp doesn't lay its eggs in all of the ovules, leaving some to grow into the seeds that crunch when you eat the fig.

What keeps the fig wasp from laying eggs in all of the ovules? Another partner in this three-way mutualism is a parasitic wasp. It uses its long egg-laying tube to pierce the outside of the fig and lay its own eggs into the ovules with the fig wasps' eggs (the red ovals in illustration). The parasitic wasps' young then eat the young of the fig wasp. However, the egg-laying tube isn't long enough to reach all of the ovules, just the ones closest to the surface. As a result, to escape the parasite, the fig wasp tends to lay most of its eggs in the "enemy-free zone" deepest inside the fig (the blue ovals in the illustration). This leaves the outer ones

(yellow ovals) free to develop into seeds and create the next generation of trees.

What can we learn from the mutualistic relationship between the fig tree, wasp and parasite? Sometimes, we need to rethink something we might automatically think of as “bad”, like parasitism. The parasitic wasp is an important member of this relationship. By limiting where the fig wasp lays its eggs, the parasite allows the fig tree to produce seeds to make the next generation of fig trees. This in turn benefits the fig wasp, as it has another generation of trees to pollinate and lay eggs for its young.

文獻引用 (REFERENCES)

許多生物多樣性最終還是需要依賴不同物種之間的合作，這種互動稱為互利共生。參與者能從另一位獲得資源而得益，卻也衍生出一個問題：是什麼阻止參與者以非永續 (unsustainable) 方式來利用其他參與者呢？榕樹由榕果小蜂幫忙授粉，牠們只能透過破壞單朵的榕果小花才能成功發育，而沒被破壞的小花才能長成種子。榕果小蜂傾向出現在接近果實中央的長柄花朵 (long flowers)，而種子則在接近外壁處發育。因此榕果小蜂雌蜂偏好以長柄花朵培育後代，並留下短柄花朵 (short flowers) 發育成種子。為了理解榕果小蜂為何能永續地利用榕樹，我們需要解釋為何牠們會演化出這種偏好。榕果-傳粉者互利共生關係會被小型寄生蜂所利用，牠們從果實外部攻擊傳粉者。在三種澳洲榕樹物種中，我們發現在較外層花朵中傳粉者的子代相對地較在內層花朵中更容易被寄生。我們的數據因此顯示果實中心的長柄花朵提供了無天敵空間給傳粉者的後代。我們推測榕樹提供多變長度的花朵可能有助於互利共生關係的穩定性，且第三方透過間接方式涉入：寄生蜂，在以往牠們常被認為對互利共生者雙方都有害。(Dunn et al. 2008: 0491)

“Much biodiversity ultimately relies on cooperation between different species, interactions called mutualisms. Benefits to one partner are gained by obtaining resources from the other, presenting a problem: what prevents one partner from exploiting the other at an unsustainable level? Fig trees are pollinated by tiny wasps that only develop successfully themselves by each destroying a single female fig flower that would otherwise become a seed. Wasps tend to occur in long flowers near the fruit’s centre, with seeds developing near the outer wall. Female wasps therefore favour long flowers for their offspring, and leave short flowers to develop into seeds. To understand why wasps exploit fig trees sustainably, we need to explain why this preference has evolved. The fig-pollinator mutualism is exploited by small parasitic wasps that attack pollinators from outside the fruit. In three Australasian fig species, we found that pollinator offspring in the outer layer of flowers were more likely to be parasitized than those in the inner layer. Our data thus indicate that long flowers provide enemy-free space for pollinator offspring at the fruit’s centre. We suggest that the provision of variable length flowers by fig trees may contribute to mutualism stability by indirectly involving a third party: parasitic wasps, previously regarded as detrimental to both mutualists.” (Dunn et al. 2008: 0491)

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延伸閱讀

生物系統延伸資訊連結 (LEARN MORE ABOUT THE LIVING SYSTEM/S)

<https://en.wikipedia.org/wiki/agaonidae>

<https://www.onezoom.org/life/@agaonidae>

<https://eol.org/pages/736>

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