# 生物策略表

| 類別 | 生物策略 (Strategy) |
|---|---|
| 生物策略<br>STRATEGY | 花粉從花朵中彈射出<br>(Pollen catapults from flower) |
| 生物系統<br>LIVING SYSTEM | 加拿大草茱萸 *Cornus canadensis*<br>(Bunchberry dogwood) |
| 功能類別<br>FUNCTIONS | #排出固體 #改變速度 #在氣體中移動 #授粉<br>#Expel solids #Modify speed #Move in/through gases #Pollinate |
| 作用機制標題 | 加拿大草茱萸花朵的花粉透過釋放貯存的彈力能來散播<br>(Pollen from bunchberry flowers are dispersed by release of stored elastic energy.) |
| 生物系統/作用機制<br>示意圖 |  |

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

「花瓣限制著花蕾中彎曲的四枚雄蕊並貯存彈力能來發射花粉。每枚雄蕊都由一根花絲及裝有花粉的花藥囊 (anther sac) 組成，花藥與雄蕊頂端連接處有彎曲的轉軸 (hinge)。花藥囊在花朵開放前就會開裂，並準備好在花朵觸發打開時立刻推出花粉。」
([http://www.williams.edu/go/explodingflower/plant.html](http://www.williams.edu/go/explodingflower/plant.html))

「這些驚人的花朵能夠在 0.4 微秒內綻放，這比子彈通過來福槍筒的時間還要短。根據所知，這是地球上綻放最快的花朵。花粉被加速到 24,000 m/s²，是重力加速度的 2400 倍，等同於太空人升空時感受到的 800 倍。花粉以高於 4 m/s 的初始速率離開植株，並令人印象深刻的推進到上方 2.5 公分的空氣中，超過花朵高度的十倍。」

「爆炸性開花現象 (explosive flowering) 能以兩方面促進蟲媒授粉。第一在於爆炸性開花可減少被昆蟲吃掉的花粉量，因為爆發使花粉散佈到昆蟲的身體上，而且高速的花粉深入附著到昆蟲的剛毛中，使其難以收集及吞食。第二是爆炸性開花可侷限在足夠重量的傳粉昆蟲才能觸發花朵。如體型足以觸發花朵的大型蠅類、熊蜂及甲蟲，因它們能在花序之間迅速移動；而通常只停留在同一花序中的螞蟻及小型蠅類，則無法觸動花朵。」

"The petals restrain the four stamens that are bent in the bud and store elastic energy used to launch pollen. Each stamen consists of a filament with a pollen-containing anther sac attached

with a hinge to the filament tip. The anther sacs dehisce or split open before the flower blooms and are ready to propel pollen as soon as the flower is triggered open."
(http://www.williams.edu/go/explodingflower/plant.html)

"These amazing flowers can bloom in under 0.4 ms--a time shorter than it takes for a bullet to travel the length of a rifle barrel. To our knowledge this is the fastest flower on earth. Pollen is accelerated at 24,000 m/s², which is 2400 times the acceleration of gravity and 800 times that experienced by astronauts during liftoff. Pollen leaves the plant with an initial velocity of more than 4 m/s and is propelled an impressive 2.5 cm into the air, over ten times the height of the flower."

"Explosive flowering enhances insect pollination in two ways. First explosive flowering reduces the amount of pollen eaten by the insects because the pollen spray from the explosion disperses the pollen on insects' bodies and the high speed of the pollen imbeds it deep in the insects' hairs where it is less likely to be gathered and eaten. Second, explosive flowering limits pollinators to insects heavy enough to trigger the flower. Large flies, bumblebees and beetles are large enough to trigger flowers and move rapidly between inflorescences, whereas ants and small flies, which often stay on one inflorescence, cannot trigger the flowers."

## 文獻引用 (REFERENCES)

「我們敘述了加拿大草茱萸 (bunchberry dogwood, *Cornus canadensis*) 花朵的雄蕊如何依靠這個 [釋放貯存彈力能的] 原理，在花朵爆炸性綻放時把花粉投射到空氣中。我們的高速錄影觀察展示了花朵在少於 0.5 微秒內綻放，據我們所知，這是植物最快的記錄。」

「加拿大草茱萸密集如草毯狀，生長在北美廣闊雲杉-冷杉針葉林 (taiga) 中。隨著它的花朵瞬間開放，它們的花瓣迅速地分離向後翻，以釋放原本被花瓣包覆的彎曲雄蕊向外反彈 （圖 1）。在開首的 0.3 微秒中，雄蕊加速至 $24,000\pm6,000$ m/s$^2$ (2,400g)，達到推進花粉所需的高速 ($3.1\pm0.5$ m/s; n=7)，花粉很輕但會被空氣阻力劇烈地減速（最終速率 $0.12\pm0.03$m/s）。這些花粉粒被發射到 2.5 公分的高度（範圍為 2.2-2.7 公分；n=7），這是花朵高度的十倍以上：在這個高度，花粉粒能被風帶走。」

「加拿大草茱萸被設計成像是微型的中世紀彈射投石機(medieval trebuchets)，特化的彈射構造透過把負載物（花藥中的花粉）以轉軸或彈力帶（連接花藥及花絲頂端的細長維管束）附著在投擲臂上（花絲），使投擲距離最大化。這個花朵彈射投石機能使雄蕊以比簡易槓桿彈射器更快的速度向上推進花粉。花瓣綻開之後，原本向內彎曲的花絲向外回彈，釋放出彈力能。花絲的尖端跟隨弧形向外運動，但花藥在連接花絲尖端反方向旋轉使花粉加速向上達到最大垂直速度，等到花藥彈回水平方向加速時釋放出花粉。」(Edwards et al. 2005: 164)

"[W]e describe how the flower stamens of the bunchberry dogwood (Cornus canadensis)

rely on this principle [release of stored elastic energy] to catapult pollen into the air as the flower opens explosively. Our high-speed video observations show that the flower opens in less than 0.5 ms — to our knowledge, the fastest movement so far recorded in a plant.

"Cornus canadensis grows in dense carpets in the vast spruce-fir forests of the North American taiga. As bunchberry flowers burst open, their petals rapidly separate and flip back to release the stamens (Fig. 1). During the first 0.3 ms, the stamens accelerate at up to 24,000 + or - 6,000 m/s2 (2,400g), reaching the high speed (3.1+ or - 0.5 m/s) necessary to propel pollen, which is light and rapidly decelerated by air resistance (terminal velocity, 0.12 + or - 0.03m/s (mean = or - s.e.m.); n=7). These pollen granules are launched to an impressive height of 2.5 cm (range, 2.2–2.7 cm; n=5), which is more than ten times the height of the flower: from this height, they can be carried away by the wind."

"Bunchberry stamens are designed like miniature medieval trebuchets — specialized catapults that maximize throwing distance by having the payload (pollen in the anther) attached to the throwing arm (filament) by a hinge or flexible strap (thin vascular strand connecting the anther to the filament tip). This floral trebuchet enables stamens to propel pollen upwards faster than would a simple catapult. After the petals open, the bent filaments unfold, releasing elastic energy. The tip of the filament follows an arc, but the rotation of the anther about the filament tip allows it to accelerate pollen upwards to its maximum vertical speed, and the pollen is released only as it starts to accelerate horizontally. (Edwards et al. 2005: 164)

| 參考文獻清單與連結 (REFERENCE LIST) |
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Edwards, J., D. Whitaker, S. Klionsky, and M. J. Laskowski. (2005). A record-breaking pollen catapult. *Nature* 435: 164. (https://www.nature.com/articles/435164a)

| 延伸閱讀 |
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https://www.youtube.com/watch?v=aSn45PE0Sjo
（譚國鋆提供）

| 生物系統延伸資訊連結 (LEARN MORE ABOUT THE LIVING SYSTEM/S) |
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https://en.wikipedia.org/wiki/cornus_canadensis
https://www.onezoom.org/life/@cornus_canadensis
https://eol.org/pages/585632

| 撰寫/翻譯/編修者與日期 |
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譚國鋆翻譯 (2021/03/22)；王俊能編修 (2021/04/19)

| AskNature 原文連結 |
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https://asknature.org/strategy/pollen-catapults-from-flower/