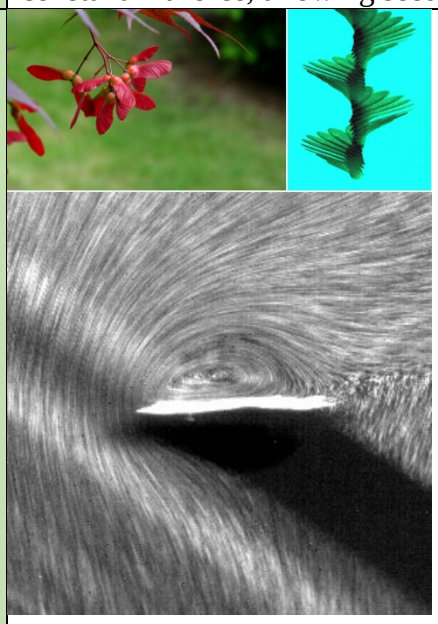
生物策略表

類別	生物策略 (Strategy)
生物策略 STRATEGY	龍捲風式旋轉增加種子散播效率 (Tornado-like spinning increases seed dispersion)
生物系統 LIVING SYSTEM	日本楓 *Acer palmatum* (Japanese Maple)
功能類別 FUNCTIONS	#散佈種子 #分配固體 #氣體中移動 #機械能轉型 #Disperse seeds #Distribute solids #Move in/through gases #Transform mechanical energy
作用機制標題	如龍捲風般旋轉的楓樹種子前緣提供持續的升力，使種子得以散播到更大的區域 (The leading edge of the tornado-like spinning maple seed provides a constant lift force, allowing seeds to disperse over a greater area.)
生物系統/作用機制示意圖	

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

種子散播對所有植物來說是重要的機制，通常借助於鳥類或是陣風。當鳥類吃下樹木的種子時，牠們會飛到遠方並藉由糞便排出種子，使新的樹木隨機散佈地長出。而當被陣風刮起帶走，種子則會掉落並最終彼此相鄰一起生長。為了增加種子散播的範圍，楓樹種子在龍捲風般的渦旋中轉動，比那些不會轉動的種子產生更多升力。種子前緣可降低種子頂部的氣壓，將種子周遭的風往上吸，從而產生額外的升力，亦或是額外的飛行時間。這導致種子延長抵達地面的時間，使得散播變得更有效率。

這項升力產生的機制類似於昆蟲與懸停中的蜂鳥，都是使用翅膀形成連續的空氣渦流來維持飛行。楓樹種子結構所產生的旋轉運動可產生升力渦流，從而延長飛行時間。還需注意的是，死亡（棕色）的種子能散播得更遠，因為它們的重心位置有別於活著（綠色）的種子。這是因為種子的重心更靠近升力中心，與能飛得較遠的紙飛機原理相近。

Scattering seeds is a prominent mechanism in all plants, often assisted by birds and gusts of wind. When birds eat the seeds of trees, they transport and defecate them, creating a randomized scatter where new trees will grow. When caught in a gust of wind, seeds fall and end up growing in close vicinity to one another. To increase the reach of where their seeds are planted, maple tree seeds twirl in a tornado-like vortex, creating more lift than their non-twirling counterparts. The leading edge of the seed lowers the air pressure over the top of the seed, sucking the wind of the seed upwards, giving it extra lift, or extra travel time. This leads to a prolonged arrival at the ground, and more efficient dispersal.

The lift mechanism is similar to those of insects and hovering hummingbirds who use their wings to develop a continuous air vortex, sustaining their flight. The spinning motion created by the maple seed structure sustains a lift vortex which prolongs the flight. It's also important to note that dead (brown-colored) seeds scatter further because they have an altered center of gravity from alive (green-colored) seeds. This is because the center of gravity in the seed is closer to the center of lift, similar to a paper airplane that is able to fly further than its opponents.

文獻引用 (REFERENCES)

「詳細的飛行表現研究揭示了自轉 (autorotating) 種子儘管尺寸小且速率緩慢，卻能夠產生出乎意料的高升力。如同自轉種子一般，昆蟲的翅膀能夠產生非常高的升力，儘管以更高的攻角 (angle of attack) 運行，也不會像傳統飛機機翼或直升機旋翼般發生失速 (stall)。」 (Lentink et al., 2009: 1440)

"Detailed performance studies revealed that autorotating seeds are able to generate unexpectedly high lift forces despite their small size and slow velocity. Like autorotating seeds, insect wings generate very high lift despite operating at angles of attack well above those that will stall conventional aircraft wings and helicopter blades" (Lentink et al., 2009: 1440)

參考文獻清單與連結 (REFERENCE LIST)

Lentink, D., W. B. Dickson, J. L. van Leeuwen, M. H. Dickinson. (2009). Leading-edge vortices elevate lift of autorotating plant seeds. *Science* 324: 1438-1440. (https://science.sciencemag.org/content/324/5933/1438?sso=1&sso_redirect_count=1&oauth-code=a87b838a-170d-4195-a39d-401b8765def5)

延伸閱讀

AskNature Team. (1 October, 2016). Monocopter. *AskNature*. Retrieved from: https://asknature.org/idea/monocopter/

AskNature Team. (2 October, 2019). PowerCone. *AskNature*. Retrieved from: https://asknature.org/idea/powercone/

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https://en.wikipedia.org/wiki/acer_palmatum https://www.onezoom.org/life/@acer_palmatum https://eol.org/pages/596824
撰寫/翻譯/編修者與日期
譚國鎏翻譯 (2021/03/22)；紀凱容編修 (2021/04/27)
AskNature 原文連結
https://asknature.org/strategy/tornado-like-spinning-increases-seed-dispersion/