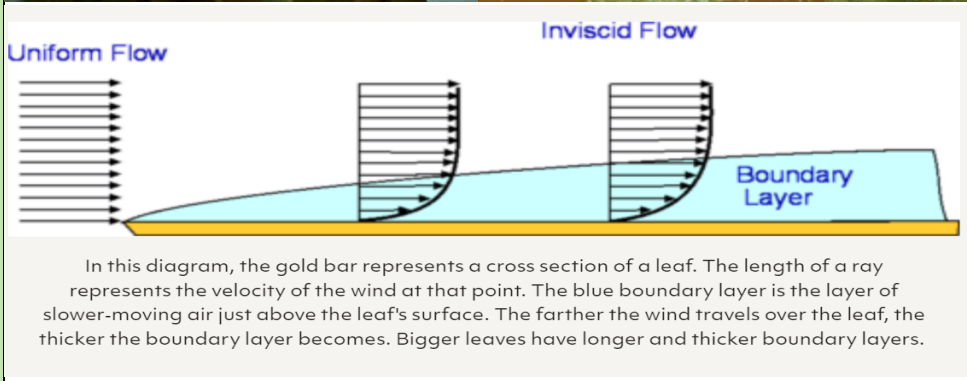
生物策略表

類別	生物策略 (Strategy)
生物策略 STRATEGY	細小葉片緩衝蟲卵受熱力危害 (Small Leaves Buffer Insect Eggs from Heat)
生物系統 LIVING SYSTEM	神聖曼陀羅 *Datura wrightii* (Sacred datura)
功能類別 FUNCTIONS	#保護免受溫度危害 #Protect from temperature
作用機制標題	細小的葉片在保持涼爽和保護蟲卵免受致命的高溫危害較有效 (Small leaves are more effective at keeping cool and protecting insect eggs from fatally high temperatures)
生物系統/作用機制示意圖	   In this diagram, the gold bar represents a cross section of a leaf. The length of a ray represents the velocity of the wind at that point. The blue boundary layer is the layer of slower-moving air just above the leaf's surface. The farther the wind travels over the leaf, the thicker the boundary layer becomes. Bigger leaves have longer and thicker boundary layers. 
作用機制摘要說明 (SUMMARY OF FUNCTIONING MECHANISMS)	
亞利桑那大學 (University of Arizona) 的一項最新研究顯示，神聖曼陀羅 (sacred datura) 較小的葉片比較大的葉片更能透過蒸散作用 (transpiration) 降溫，這使它們更好地保護蟲	

卵；而蟲卵與植物和人類不同，牠們無法調節自身的溫度。由於熱力會促進蒸散作用，因此其在一天最熱的時段中發揮最大的作用，這也是蟲卵最有可能被陽光烤焦的時段。研究發現在午後的溫度高峰下，所有大小的葉片普遍比周圍的空氣涼爽。然而，長約兩英寸的小葉片比長約四英寸的大葉片平均低 5.4℉(14.8℃)。較小的葉片較為涼爽的原因是它們蒸散得更快。為什麼？是因為所謂的邊界層 (boundary layer)。

當風吹過一片葉子時，在葉片表面正上方會有一個靜止區域 (still zone)。距離葉片表面更遠的地方，風渦旋 (wind vortex) 將空氣混合，但是在這個稱為邊界層的靜止小區內不會發生混合。沒有混合，離開氣孔 (stomata) 的水分必須先穿越邊界層才能進行擴散 (diffuse) 。當風吹過葉子時，邊界層會沿著葉子的長度變寬。由於較大的葉子具有較厚的邊界層，水分擴散時必須先穿越更長的距離，這意味著蒸發作用要比較小的葉片慢。較大葉片不能很好地冷卻的事實，並不一定會使蟲卵處於危險之中。為了測試是否有實際危害，研究人員將天蛾 (sphinx moth) 的卵曝露在模擬成亞利桑那午後的溫度下，當在 104℉(40℃) 下，所有實驗的蟲卵都保持活力，但在 107℉(41.7℃)時，只有 62.5%的卵孵化，而在 110℉(43.3℃)時，沒有卵孵化。而一些較大的曼陀羅葉片的溫度則可高達 115℉(46.1℃)。

A recent study at the University of Arizona showed that transpiration in the sacred datura plant cools smaller leaves more than larger leaves. This makes them better at protecting the eggs which, unlike plants and humans, have no way to regulate their own temperatures. Heat stimulates transpiration, so it has the largest effect during the hottest part of the day. This is also the time when insect eggs are most at risk of scorching in the sun. During peak afternoon temperatures, the study found that leaves of all sizes were generally cooler than the ambient air. However, the small leaves, with lengths of about two inches, were on average 5.4 ℉ cooler than large leaves having lengths of about four inches. The reason smaller leaves are cooler is that they transpire faster. Why? Because of something called a boundary layer.

As wind blows across a leaf, a still zone exists just above the surface. Farther from the surface, wind vortices mix the air, but inside this still pocket, known as the boundary layer, no mixing occurs. Without mixing, water leaving the stomata must diffuse across the boundary layer. As wind travels along the length of a leaf, the boundary layer widens. Because bigger leaves have thicker boundary layers, water has to diffuse for longer distances, translating to slower evaporation than their smaller counterparts. The fact that larger leaves aren’t as good at cooling themselves doesn’t necessarily put eggs lain on them in peril. To test the actual danger, the researchers exposed sphinx moth eggs to temperatures that mimicked those experienced during Arizonan afternoons. When subjected to 104 ℉, all of the tested eggs remained viable, but at 107 ℉, only 62.5% of the eggs hatched, and at 110 ℉, none did. Whereas some large datura leaves reached temperatures as high as 115℉.

文獻引用 (REFERENCES)

「美國西南部的神聖曼陀羅 (*Datura wrightii*) 葉片能在致命的高環境溫度為煙草天蛾 (*Manduca sexta*) 的卵提供緩衝。此外，葉片之間溫度曲線的細微差異能導致蟲卵的新陳代謝率 (metabolic rate) 和發育時間產生巨大變化。具體來說，白天時大葉片比小葉片更熱，使蟲卵面臨溫度逆境。」(Kristen et al. 2021)

「邊界層是包裹著葉子表面的一層薄而靜止的空氣。這層空氣並不會流動。為了產生蒸散作用，離開氣孔的水蒸氣必須擴散通過這靜止的空氣層以到達大氣，在大氣中被移動的空氣帶走。邊界層越大，蒸散速率就越慢…邊界層隨著葉片大小而增加，從而也降低了蒸散速率。例如，來自沙漠氣候的植物通常有較小的葉片，因此其較小的邊界層將有助於以較高的蒸散速率冷卻葉片。」(Tracy.)

"*Datura wrightii* leaves buffer *Manduca sexta* eggs from fatally high ambient temperatures in the southwestern USA. Moreover, small differences in temperature profiles among leaves can cause large variation in egg metabolic rate and development time. Specifically, large leaves were hotter than small leaves during the day, reaching temperatures that are stressfully high for eggs." (Kristen et al. 2021)

"The boundary layer is a thin layer of still air hugging the surface of the leaf. This layer of air is not moving. For transpiration to occur, water vapor leaving the stomata must diffuse through this motionless layer to reach the atmosphere where the water vapor will be removed by moving air. The larger the boundary layer, the slower the rates of transpiration. . . Boundary layers increase as leaf size increases, reducing rates of transpiration as well. For example, plants from desert climates often have small leaves so that their small boundary layers will help cool the leaf with higher rates of transpiration." (Tracy.)

參考文獻清單與連結 (REFERENCE LIST)

延伸閱讀: Harvard 或 APA 格式（取自 AskNature 原文；若為翻譯者補充，請註明）

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

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AskNature 原文連結

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