

生物策略表（模板）

類別	生物策略 (Strategy)
生物策略 STRATEGY	幼生期的鈎子幫助緊抓 (Larval hooks hold on tight)
生物系統 LIVING SYSTEM	透翅蝶 <i>Greta oto</i> (Glass-winged butterfly)
功能類別 FUNCTIONS	#永久性附著 #改變大小/形狀/質量/體積 #物理性組成結構 #Attach permanently #Modify size/shape/mass/volume #Physically assemble structure
作用機制標題	蝴蝶幼蟲的鈎爪和絲線在葉面下形成牢固的附著 (Hooks and silk of butterfly larvae form a strong attachment under leaves)
生物系統/作用機制示意圖	
作用機制摘要說明 (SUMMARY OF FUNCTIONING MECHANISMS)	
<p>大部分的昆蟲行完全變態，這代表牠們的身體需要從一個形態轉變為一個新的形態。牠們會被包覆在一個硬殼下進行變態，我們稱這個階段為蛹。變態的過程中，昆蟲的幼蟲會分解為一種細胞的湯狀物，再由此重新構成一個全新的形態。在這個過程中，昆蟲無法自衛，而且非常脆弱。蝴蝶和蛾類有很多把蛹藏起來的方法，包括擬態成樹葉或其它植物的部分，使牠們不容易被掠食者發現。其中有一種蝴蝶，透翅蝶 (<i>Greta oto</i>)，在化蛹的時候會將自己懸掛在葉面下達到偽裝的效果。</p> <p>透翅蝶的幼蟲會在葉面下編織一個絲墊 (silken pad)。這個絲墊中的絲會糾纏在一起，組成大量的細小圓圈。當這個絲墊旋轉後，幼蟲會在絲墊上插上一排特化的鈎子，稱</p>	

為臀棘 (cremaster)。臀棘由堅硬的幾丁質 (chitin) 所組成，使這個不易斷裂的構造變成蛹的一個永久部分，將會跟隨著牠直到變為成蟲。

高度特化的臀棘能確保穩固的懸掛在葉面下，臀棘的鉤子會以球形排列在臀棘的表面上，這使這些鉤子更容易穿過絲墊的中心而不會壓扁它，這還同時增加了鉤住的表面積。

而這些鉤子本身也高度特化。每個鉤子的末端都帶有向後的倒鉤，用以確保絲線雖然可以輕鬆地在鉤子末端滑動，但不會輕易地滑下來。每個倒鉤都分成幾個部分，形成迷你倒鉤，迷你倒鉤中間有一個凹槽。絲線會被這些凹槽鉤住，形成另一個防止滑落的保障。

透翅蝶的絲墊和臀棘創造了一種非常堅固的魔鬼氈結構，它的強度是它所需要支撐蛹重量的 50 倍以上。極有可能這額外的力量是用以保護蛹，使其免受原始棲地時常出現的強風所引起的擺動傷害。

Most insects go through complete metamorphosis, where their body pattern alters from one form to a new one. The change occurs inside a hard casing, called a pupa, and is a complete remodeling of their entire bodies. During metamorphosis, the body of the larva breaks down completely into a sort of cellular soup that then reforms into an entirely new shape. During this process, the insect is unable to defend itself and is very vulnerable. Butterflies and moths have a number of ways of hiding their pupae, including mimicking leaves and other plant parts so as to be less obvious to predators. One species, the *Greta oto*, or glass-winged butterfly adds to the protection from camouflage by suspending itself from the underside of leaves when pupating.

Greta oto caterpillars weave a silken pad that is glued to the underside of the leaf. The silk fibers in the pad are deliberately tangled as they are spun to create large numbers of tiny loops. Once the pad has been spun, the animal inserts a specialized array of hooks, called a cremaster, into the silk pad. The cremaster is made of tough chitin that will not snap and it becomes a permanent part of the case of the pupa as the insect inside metamorphoses into the adult butterfly.

The hooks of the cremaster are highly specialized for hanging securely from the silk pad. The hooks are arrayed over the surface of the cremaster in a ball shape, which makes it easier for the hooks to penetrate the center of the pad without squashing it, whilst also increasing the available hooked surface area.

The hooks themselves are also highly specialized. Each hook ends with a backward facing barb that ensures that, while the threads of the silk can slip easily over the end of the hook, it cannot so easily slide off. Each barb is split into segments, forming mini barbs with a groove in between. Silk fibers can also sit in these grooves, forming a further barrier that prevents the hooked loops from sliding off.

The silk pad and cremaster of the *Greta oto* creates a sort of super hook-and-loop fastener that is at least 50 times stronger than is necessary to support the weight of the chrysalis. It is likely the extra strength is to protect the animal from the extra stresses caused by swaying caused by the strong winds that are common in its native habitat.

文獻引用 (REFERENCES)

參考文獻清單與連結 (REFERENCE LIST)

Ingram, A. L. and A. R. Parker. (2006). Structure, mechanism and mechanical properties of pupal attachment in *Greta oto* (Lepidoptera: Nymphalidae: Ithomiinae). *Entomological Science* 9: 109-120. (<https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1479-8298.2006.00158.x>)

延伸閱讀: Harvard 或 APA 格式

(胡芳碩提供)

Urquhart, F. A. (1970). Mechanism of cremaster withdrawal and attachment in pendant rhopaloceros pupae (Lepidoptera). *The Canadian Entomologist* 102: 1579-1582. Retrieved from: <https://www.cambridge.org/core/journals/canadian-entomologist/article/mechanism-of-cremaster-withdrawal-and-attachment-in-pendant-rhopaloceros-pupae-lepidoptera/1EDEF70A8B331D17264BAEEFACFD8B3F>

Hinton, H. E. (2009). The origin and function of the pupal stage. *Physiological Entomology* 38 (4-6): 77-85. Retrieved from: https://www.researchgate.net/publication/229833205_The_origin_and_function_of_the_pupal_stage

Binetti, V. R., J. D. Schiffman, O. D. Leaffer, J. E. Spanier, and C. L. Schauer. (2009). The natural transparency and piezoelectric response of the *Greta oto* butterfly wing. *Intergrative Biology* 1: 324-329. Retrieved from: <https://pubmed.ncbi.nlm.nih.gov/20023733/>

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

https://en.wikipedia.org/wiki/Greta_oto

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