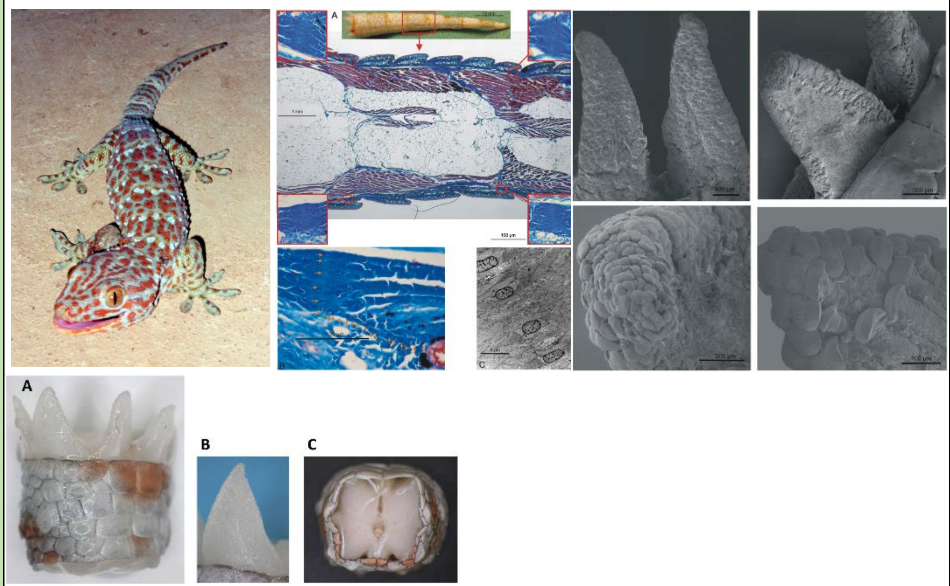
生物策略表

類別	生物策略 (Strategy)
生物策略 STRATEGY	立即斷尾 (Tail instantly breaks off)
生物系統 LIVING SYSTEM	大守宮 *Gekko gecko* (Tokay gecko)
功能類別 FUNCTIONS	#排出固體 #改變大小/形狀/質量/體積 #保護免受動物危害 #Expel solids #Modify size/shape/mass/volume #Protect from animals
作用機制標題	受到掠食者攻擊時，大守宮借助預先形成的弱點使尾巴立即斷掉 (The tail of the Tokay gecko instantly breaks off during a predator attack with the help of pre-formed lines of weakness.)
生物系統/作用機制示意圖	

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

壁虎是一種小型的蜥蜴，可以藉由一種立即斷尾的獨特機制去逃離正在攻擊他們的敵人，這種脫落部分身體的行為稱為自割。當有敵人抓住壁虎，壁虎可以藉由此行為讓敵人在抓住斷尾或使其分心時掙扎逃走。

大守宮的尾巴有幫助脫落的構造。第一，在尾巴基部有數條脆弱的線，就像是紙張上有穿洞的線或刻畫好的線可以更方便地撕開。這些脆弱的線或斷裂平面佈滿在尾巴的皮膚、肌肉、骨頭和其他組織上。像其他動物一樣，壁虎的肌肉也能在身體和尾巴之間形成許多片段。大片的結締組織會分離鄰近片段。斷裂平面分佈在結締組織和肌肉片段之間，並且連續分佈至組成尾巴骨頭的脊椎。

在沒有威脅的情況下，壁虎的尾巴會藉由附著在兩邊斷裂平面之間固定住。這種附著會藉由肌肉片段的形狀和排列去增強。每一個片段都可以被想成W形的側面連接著隔

壁的W型片段。跟簡單平坦的表面比起來，這種W型的結構擁有更多的表面積供附著。在個別的肌肉纖維末端上有微米級的結構，似乎在尾巴的附著和脫落擔當著重要的角色。研究人員假設斷裂平面上的肌肉纖維末端形狀可以改變，在自割的時候可以減少附著，讓尾巴更容易斷掉。在斷裂平面的周圍收縮肌肉也可以幫助組織的斷裂和尾巴的脫落。在這個機制中，附著達到了一個平衡，當需要時能使尾巴更容易脫落，但在不需要時可以避免意外脫落。

自割也發生在其他很多的動物上，包括其他的蜥蜴，還有兩棲類和海星。許多的這些動物失去的身體部位也都能隨著時間而再生。

Geckos are small lizards that can escape an attacking predator using an unusual strategy—by instantly losing their tails. This process of actively shedding a whole body part is called autotomy. When a predator grasps onto a gecko, releasing the tail can help the gecko wriggle free and escape while the attacker is holding onto a severed tail or distracted by it.

In the Tokay gecko (*Gekko gecko*), structures in the tail appear to help the shedding process. First, the base of the tail has built-in lines of weakness going across it, similar to perforated lines or score lines that make pieces of paper easier to tear apart. These lines of weakness, or fracture planes, cross the tail's skin, muscles, bones, and other tissues. Like many animals, the gecko's muscles form segments spanning the length of the body and tail. Sheets of connective tissue separate neighboring segments. The fracture planes run through the connective tissue between muscle segments and continue through the bony vertebrae that make up the backbone in the tail.

When not under threat, the gecko's tail is likely held in place by adhesion between the two sides of a fracture plane. This adhesion may be enhanced by the shape and arrangement of the muscle segments. Each segment can be thought of as a sideways "W" that interlocks with neighboring W-shaped segments. Compared to simple flat surfaces, the W-shaped structures have more surface area for adhesion. Micro-sized structures on the tips of individual muscle fibers also appear to play a role in tail adhesion and release. Researchers hypothesize that the shape of muscle fiber tips at the fracture plane can change to reduce adhesion during autotomy, making the tail easier to release. Contracting muscles around the fracture plane are also likely to help break tissues and release the gecko's tail. Adhesion in this system appears to be a balance between enabling easy tail release when it's needed, but preventing accidental release when it's not.

Autotomy occurs in many other animals, including other lizards, as well as amphibians and sea stars. Many of these animals can also regenerate their lost body parts over time.

文獻引用 (REFERENCES)

「壁虎尾部自割依靠著有助生物附著的表面微米結構。生物影像技術的結果證明大守宮的尾巴會預先斷裂在不同的地方，而結構的完整性則依靠這些片段之間的附著力。」(Sanggaard et al. 2012: 1)

「我們的數據顯示壁虎的尾部自割是一種生物的摩擦和附著現象。尾巴在不同的水平斷裂平面上有著『刻畫好的線』(score line)，當被掠食時，尾巴可能會沿著這些線斷裂以做出反應。這些線穿透所有組織，而組織的完整性則是藉由附著力維持。肌肉的交叉指狀排列方式可能有助於藉由產生較大的相互作用表面積以供附著。跟簡單的「末端對末端」結構比起來，這種結構增加了接觸的面積和減少意外斷尾的風險。肌肉末端的「蕈形」微結構是在自割後被發現的，這些結構藉由減少尾部片段間附著而有助於脫落。」(Sanggaardet al. 2012: 6-7)

"…[gecko] caudal autotomy relied on biological adhesion facilitated by surface microstructures. Results based on bio-imaging techniques demonstrated that the tail of *Gekko gecko* was pre-severed at distinct sites and that its structural integrity depended on the adhesion between these segments." (Sanggaard et al. 2012: 1)

"Our data suggest that caudal autotomy in lizards is a biological friction- and adhesion-based phenomenon. The tail contains "score lines" at distinct horizontal fracture planes where the tail may be released as a response to predation. These scores penetrate all the way through the tissue where the structural integrity is maintained by adhesion forces. The interdigitation arrangement of muscles is likely to facilitate adhesion by generating a larger surface area of interaction. This architecture increases the contact area and most likely decreases the risk of accidental tail loss as opposed to a simple "end-to-end" arrangement. "Mushroom-shaped" microstructures at the muscle termini are observed after autotomy. These structures are likely to facilitate tail release by reducing the adhesion between tail segments." (Sanggaard et al. 2012: 6-7)

參考文獻清單與連結 (REFERENCE LIST)

Sanggaard, K. W., C. C. Danielsen, L. Wogensen, M. S. Vinding, L. M. Rydtoft, M. B. Mortensen, H. Karring, N. C. Nielsen, T. Wang, I. B. Thøgersen, and J. J. Enghild. (2012) Unique structural features facilitate lizard tail autotomy. *PLoS ONE* 7: e51803. (https://dx.doi.org/10.1371/journal.pone.0051803)

Gilbert E. A. B., S. L. Payne, and M. K. Vickaryous. (2013) The anatomy and histology of caudal autotomy and regeneration in lizards. *Physiological and Biochemical Zoology* 86: 631-644. (https://www.journals.uchicago.edu/doi/10.1086/673889)

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生物系統延伸資訊連結 (LEARN MORE ABOUT THE LIVING SYSTEM/S)
https://en.wikipedia.org/wiki/gekko_gecko https://www.onezoom.org/life/@gekko_gecko https://eol.org/pages/794412
撰寫/翻譯/編修者與日期
陳怡瑄翻譯 (2020/04/30)；譚國鋈編修 (2020/06/08)；許秋容編修 (2020/07/04)
AskNature 原文連結
https://asknature.org/strategy/tail-instantly-breaks-off/