


生物策略格式

KJC, 2019/10/21

類別	生物策略 (Strategy)
生物策略 STRATEGY	肌肉產生熱能來溫暖蜂巢 (Muscles create heat to warm nest)
生物系統 LIVING SYSTEM	西方蜜蜂 <i>Apis mellifera</i> (Western honey bee)
功能類別 FUNCTIONS	#保護免受溫度危害 #從環境感應溫度線索 #熱能轉型 #Protect from temperature #Sense temperature cues from environment #Transform thermal energy
作用機制標題	西方蜜蜂利用飛行肌的收縮，而非翅膀運動，將熱能轉移至撫幼室來溫暖牠們的撫育蜂巢 (Flight muscles of the western honey bee warm the brood nest by contracting without wing movement and transferring heat to brood cells.)
生物系統/作用機制示意圖	

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

蜜蜂群落利用肌肉運動將撫幼蜂巢 (the brood nest) 的溫度維持在攝氏 33 至 36 度之間，來保持蜂巢的溫暖。像許多昆蟲般，蜜蜂也是冷血性的，幼蟲必須在小範圍的溫度內，才能持續的正常發育。特殊的加熱蜂 (heater bee)，則負責回應環境溫度變化或是巢穴溫度調節的工作。如果加熱蜂要試著使一個撫幼室暖和，牠可以用胸部或腹部按壓撫幼室的頂端，再將熱能傳遞給發育中的幼蟲。同樣的，蜜蜂也可以在隔壁撫幼室內爬行以傳遞熱能。近期主流的假說，提及肌肉收縮所產生的熱能可以持續達 45 分鐘。飛行肌是他們所收縮的肌肉，將翅膀與這些肌肉脫離，則翅膀的揮動就會與正常啟動飛行的肌肉分開。如此，肌肉可以在不移動翅膀的情況下收縮。從肌肉收縮所產生的熱能可以使蜜蜂體溫達攝氏 44 度，大約比一隻正常蜜蜂的體溫高 10 度。體溫轉換到撫幼室後，可在蜂巢中有效地循環，且維持整個蜂巢穩定的溫度。

Honeybee colonies keep the brood nest temperature between 33 and 36 degrees Celsius using muscle movement to warm the hive. Bees, like many insects, are cold blooded and require their brood to remain within a small temperature range to continue normal development. Responding to temperature changes in the environment, or thermoregulation of the nest, is the job of special heater bees. If a heater bee is trying to warm an individual brood cell, it can press against the top of the cell with its thorax, or midsection, to transfer heat to the developing young inside. Similarly, bees

can also crawl inside a neighboring cell to transfer heat. The current leading hypothesis says heating is accomplished using muscle contraction for periods of time up to 45 minutes. The muscles that contract are flight muscles, and decoupling the wings from these muscles separates wing movement from muscle activity that would normally initiate flight; that way, the muscles can contract without moving the wings. The heat produced from muscle contraction warms the bee's body up to 44 degrees Celsius, about 10 degrees warmer than a normal bee. Body heat transferred to the brood cells can effectively circulate around the hive and maintain a stable temperature in the hive overall.

文獻引用 (REFERENCES)

「我們發現許多撫幼蜂巢空室中看來在休息的蜜蜂，其實參與了撫幼蜂巢的溫度調節，牠們提供熱源到隔壁密封的撫幼室。目前尚未證實的撫幼室內之溫度活動是令人驚訝的，因為以往會認為這些長駐在撫幼室中的來訪者是在休息，也因為撫幼室內的熱能產生提供了一個傳遞熱能到幼蟲的方式，比起透過加熱撫幼室頂蓋更有效率。」(Kleinhenz et al. 2003: 4218)

“We find that many bees that are apparently resting inside empty cells in the brood comb are participating in the regulation of brood temperature by serving as a heat source for the neighbouring, sealed, brood cells. This hitherto unrecognised thermal activity of bees inside cells is remarkable because long-duration cell visitors were previously considered to be resting and also because heat production inside cells provides a way to transfer heat to the brood more efficiently than heating via the brood caps.” (Kleinhenz et al. 2003: 4218).

參考文獻清單與連結 (REFERENCE LIST)

Kleinhenz, M., B. Bujok, S. Fuchs, and J. Tautz. (2003). Hot bees in empty broodnest cells: heating from within. *Journal of Experimental Biology* 206: 4217-4231.

(<https://jeb.biologists.org/content/206/23/4217>)

Esch, H. and F. Goller. (1991). Neural control of fibrillar muscles in bees during shivering and flight. *Journal of Experimental Biology* 159: 419-431. (<https://jeb.biologists.org/content/159/1/419>)

延伸閱讀:

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

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

文章貢獻/編修者與日期:

謝愷和翻譯 (2019/04/03)；朱天愛編修 (2019/12/19)；吳皓編修 (2020/01/04)；譚國銜翻譯/編修 (2020/07/30)；紀凱容編修 (2020/11/26)；施習德編修 (2020/12/15)

AskNature 原文連結

<https://asknature.org/strategy/muscles-create-heat-to-warm-nest/>