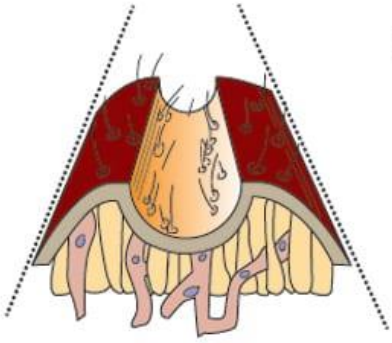
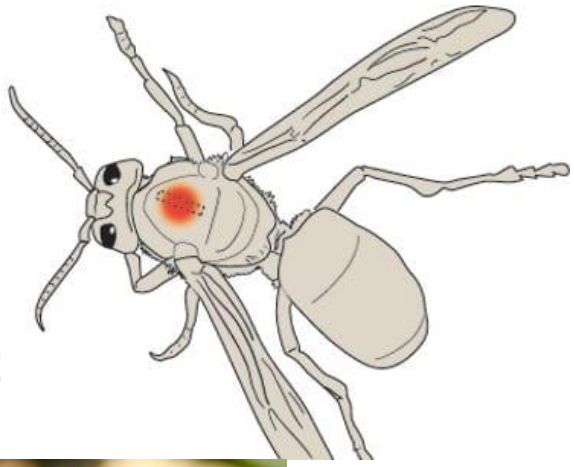
生物策略表

類別	生物策略 (Strategy)
生物策略 STRATEGY	表皮可作為散熱機制 (Cuticle Acts As Cooling Mechanism)
生物系統 LIVING SYSTEM	東方胡蜂 (Oriental horner)
功能類別 FUNCTIONS	#抵抗溫度 # Protect From Temperature
作用機制標題	黃蜂表皮上的毛、薄膜和氣管分支上作為散熱機制 (The cuticle of wasps provides a cooling mechanism by use of hairs, thin layers, and tracheal branches.)
生物系統/作用機制示意圖 (確認版權、註明出處；畫質)	  
作用機制摘要說明 (SUMMARY OF FUNCTIONING MECHANISMS)	

大黃蜂 (Hornets) 和黃蜂 (wasps) 的獨特性在於，即使缺乏汗腺，在攝氏 40 度的高溫下振翅，身體也不會過熱。臺拉維夫大學 (Tel Aviv University) 的 Jacob Ishay 及其同事等人，提出大黃蜂是利用其角質層 (cuticle) 當作電動散熱幫補，使自身不會過熱。
Jacob Ishay 的團隊相信大黃蜂的角質層是由大量的熱電偶 (thermocouples) 組成。當熱電偶接上電力時，熱電偶能將熱由材質 A 轉移至材質 B；而黃蜂的能量來源不是電力，而是由黃蜂本身的新陳代謝或是太陽能供能。
在 *Vespa orientalis* (東方胡蜂) *和 Paravespula germanica* (膜翅目 ，胡蜂亞科) 的前胸背側發現一個散熱中心。前胸散熱中心的區域比腹部末梢的溫度高 6-9℃，這種溫度分布情形適用於劇烈飛行中 (工蜂、雄蜂或女王蜂) 以及在蜂巢中照顧幼蟲的黃蜂。從外面觀察角質層，能觀察到渠道或裂縫，這個渠道由前胸腹側中央的表面一路延伸到中胸。渠道的長度大約 5-7 mm 並包含無數與周遭毛髮形狀不同的細毛。在表皮之下有大量背側中樞器官、縱肌，這些背側中樞器官、縱肌的數量和中、後胸驅動兩對翅膀的肌肉組織數量相當。有渠道的部分缺少翅膀，且與角質層相連，在這個區域，角質層的形狀像一個碗，其內連接多層上皮組織，並包含著無數蝴蝶狀的氣管分支。
除此之外，有充滿淋巴的間隙層、穿透層及凹槽，在這些之下有像蕾絲般覆蓋角質層的中空層。在真角質層 (cuticle proper) 之下，有無數巨大的粒線體和氣管，粒線體和氣管佔據角化上皮相當大的比例。這些數量龐大的粒線體非常可能是產熱中心主要製造熱的主成分。

“Hornets and wasps are unique in that, even in the absence of sweat glands, they are able to buzz around at temperatures of 40 degrees Celsius without overheating. A new theory presented by Jacob Ishay and colleagues at Tel Aviv University suggests that hornets may keep cool by using their cuticle as an electrical heat pump. The team believes that hornet cuticle is comprised of a stack of thermocouples, which transfer heat from one type of conductive material to another when voltage is applied. The voltage in this scenario would be the hornet’s own metabolism, or conversely, solar energy.” (Courtesy of the Biomimicry Guild)

“In the social wasps Vespa orientalis and Paravespula germanica (Hymenoptera, Vespinae), a thermogenic center has been found in the dorsal part of the first thoracic segment. The temperature in this region of the prothorax is higher by 6-9℃ than that at the tip of the abdomen, and this in actively flying hornets outside the nest (workers, males or queens) as well as in hornets inside the nest that attend to the brood in the combs. On viewing the region from the outside, one discerns a canal or rather a fissure in the cuticle, which commences at the center of the dorsal surface of the prothorax and extends till the mesothorax. Thus the length of this canal or fissure is ~5-7 mm and it is seen to contain numerous thin hairs whose shape varies from that of the hairs alongside the structure. Beneath the cuticle in this region there are dorsoventral as well as longitudinal muscles in abundance, much the same as the musculature in the remaining thoracic segments (i.e. the meso- and metathorax), which activate the two pairs of wings. The canal-bearing segment is of course devoid of wings, and its dorsoventral muscles are attached to the cuticle, which in this region resembles a bowl harboring several layers of epithelium that boasts numerous butterfly-shaped tracheal branches. Additionally there are layers that display lymph-filled spaces and also perforated layers and depressions, and beneath all these is a lace-like layer that also coats the cuticle’s hollows. Underneath the cuticle proper, there are numerous large mitochondria and tracheae, which occupy a considerable part of the cuticular epithelium surface. These abundant mitochondria are, most probably, the main element of heat production in the thermogenic center.” (Ishay et al. 2006:41)

文獻引用 (REFERENCES)

參考文獻清單與連結 (REFERENCE LIST) **Harvard 或 APA 格式**
J. S. Ishay.(2006). Journal of Electron Microscopy.41. (www.ncbi.nlm.nih.gov/pubmed/16621888)
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