

國立清華大學

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碩士論文

黑翅螢發光器之顯微構造

A study on the Fine Structures of the Light Organ in a
Firefly , *Luciola cerata* (Coleoptera: Lampyridae)

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摘要

螢火蟲是生物發光最為人熟知的例子，雖然科學家對於螢火蟲的研究也已經超過百年的歷史，但是仍有許多未知的領域尚待探索。螢火蟲的螢光是來自名為發光器的組織，在全世界兩千餘種的螢火蟲中，不同種類的螢火蟲發光器外型變異甚大，成蟲的發光器大多位於蟲體尾端體節的腹面，幼蟲則分布在尾端體節的側邊。

我們用台灣數量最多的螢火蟲—黑翅螢作為材料，利用顯微方法觀察，比較成蟲和幼蟲發光器的構造差異。雄性成蟲發光器位於第五、六體節腹面，緊貼著下表皮，而幼蟲的發光器則在第八體節的側邊，左右各一。從成蟲發光器的橫切面的觀察可知，構造上分為兩層，一為發光層（**photogenic layer**），二為反光層（**reflecting layer**）。發光層是螢光反應的區域，需要大量的氧氣參與反應，數量可觀的氣管分枝緊鄰著發光細胞；反光層佔有發光器50%以上的體積，裡面的細胞填滿著大小均勻，圓形的尿酸顆粒，每個顆粒包附著單層膜。幼蟲的反光層也含有大量的尿酸顆粒，但是排列較為鬆散，尺寸大小較不均勻，顆粒密度僅有成蟲的14.03%。反光層中，成蟲的尿酸顆粒直徑尺寸0.46-1.36 μm ，而幼蟲尿酸顆粒大小變異較大，直徑範圍在1.70-7.49 μm 。螢火蟲成蟲反光層含有大量的尿酸，佔體重的5.21%。尿酸是排泄氮的代謝廢物，但是成蟲階段只吸食花蜜和露水，因此尿酸來源可能是幼蟲階段時儲存下來，到了蛹期，發光器形態和位置改變，從腹節兩側變成腹節下方，尿酸顆粒也漸漸形成厚度均勻的反光層。

Abstract

Fireflies are well-known in bioluminescent organisms. They have been studied over hundred years. There are still many unknown details to figure out. Bioluminescence is localized to the particular region of the fireflies body named the lantern or light organ. The light emission of fireflies ranges from steady glows through to complex pulse and flash systems. The light organ can be identified by white color and found in the terminal abdominal segments. It varies in the external morphology as well as the internal physiology between lampyrid species. In general, lanterns of fireflies are composed of photocytes, a tracheal system and nervous supplies. A more complex form of lantern includes an additional layer on the inner surface of the photogenic tissue. This layer is called the “reflective layer” and filled with white opaque cells that are structurally different to the photocytes.

58 species of lampyrid have been found in Taiwan. A large number of *Luciola cerata* are seen in spring and they emit yellow-green light. We use *Luciola cerata* as materials because of collecting easily. Male lanterns occupy the entire last two abdominal sternites while female lanterns degenerate to the penultimate segment. Larva have tiny two-paired lanterns in their eighth abdominal segment. The male adult emits yellow-green light, λ_{\max} is 561nm measured by the spectrometer.

The organization of the lantern can be divided to two different layers: the photogenic layer and the dorsal layer (the reflecting layer). Light is emitted from photocytes in the photogenic layer. The most striking cytoplasmic feature of the dorsal layer is the presence of numerous urate granules, surrounded by a single-layer membrane. According to the photograph by scanning electronic microscope (SEM), urate granules of adults are uniform and 0.46 to 1.36 μ m in diameter. Urate granules of the dorsal layer occupy over 50% in volume of the adult lantern. The amount of uric acid is measured 5.21% of whole dry body weight by using commercial uric acid assay kit. However, the diameter of urate granules varies from 1.70 to 7.49 μ m in firefly larva. Uric acid is the main nitrogen catabolite of insects. Most fireflies only ingest water or nectar. The high uric acid concentration of adult fireflies may be stored at the larval stage, and gather to form the dorsal layer during the pupal stage.