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## A New Rearing Method for an Aquatic Firefly *Luciola ficta* (Coleoptera: Lampyridae) 【Scientific note】

### 飼養黃緣螢 (*Luciola ficta*) (鞘翅目：螢科) 之新方法【科學短訊】

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Received: 2005/10/12 Accepted: 2006/02/16 Available online: 2006/03/01

#### Abstract

To study the behavior and life cycle efficiently, a new method to rear the aquatic larvae of *Luciola ficta* Olivier and a self-designed apparatus for pupation were developed. The method, termed "fresh meat rearing method", used crushed and freshly cut meat of the water snail *Cipangopaludina chinensis* (Gray) to feed the firefly larvae, which were reared individually in plastic cups. The number of instars varied between five and seven. The overall mortality was 53.75% for the larval stage. Mortality for each instar was highest in the 1st (18.75%) and lowest in the 3rd (1.25%). An apparatus for pupation was made of floral foam and composed of a cover and a platform which was channeled, punched and filled with foam crumbs. The apparatus was not put into the rearing cups until the larvae reach the 5th instar. The landed larvae used the foam crumbs to build cocoons and pupated on the channels, or made covers and pupated within the punched holes. The mortality for climbing larvae and the pupating larvae on these apparatus was 8.75% and 1.25% respectively. The emergence rate was 100% and the adults successfully emerged without damaging their elytra. Sex ratio was 1:1 and the body size of adults was not significantly different from the wild individuals. This new rearing method and self-designed apparatus for pupation present the good approaches of life cycles for aquatic fireflies.

#### 摘要

為有效研究水棲螢火蟲黃緣螢的行為與生活環，本研究發展出一種飼養幼蟲的新方法—「碎肉飼育法」，並設計供化蛹用的裝置。此法以切碎的新鮮田螺肉餵食單隻飼養於塑膠杯的一齡幼蟲至成熟。幼蟲齡期有五到七齡；幼蟲期整體死亡率為53.75%；各齡期死亡率以一齡幼蟲最高(18.75%)，三齡幼蟲最低(1.25%)。化蛹台以插花用泡棉為材料，包含一個化蛹平台與頂蓋，平台上挖出V形溝槽與圓穴，並散置泡棉屑。將化蛹台置入五齡幼蟲之飼養杯中供幼蟲化蛹。離水登陸之幼蟲會利用泡棉屑製成繭而在溝槽上化蛹，或製成圓穴之頂蓋在穴中化蛹。離水階段與化蛹過程之死亡率分別為8.75%與1.25%。成蟲可在平台上成功羽化而不傷及翅鞘，羽化率達100%。飼育出之成蟲性比為1:1，其體型與野生個體間無顯著差異。本新飼養方法與自行設計化蛹台是一種探討水生螢火蟲生活環的新方法。

**Key words:** firefly, *Luciola ficta*, new rearing method, apparatus for pupation

**關鍵詞:** 螢火蟲、黃緣螢、新飼育法、化蛹台

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## 飼養黃緣螢 (*Luciola ficta*) (鞘翅目：螢科) 之新方法

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### 摘 要

為有效研究水棲螢火蟲黃緣螢的行為與生活環，本研究發展出一種飼養幼蟲的新方法——“碎肉飼育法”，並設計供化蛹用的裝置。此法以切碎的新鮮田螺肉餵食單隻飼養於塑膠杯的一齡幼蟲至成熟。幼蟲齡期有五到七齡；幼蟲期整體死亡率為 53.75%；各齡期死亡率以一齡幼蟲最高(18.75%)，三齡幼蟲最低(1.25%)。化蛹台以插花用泡棉為材料，包含一個化蛹平台與頂蓋，平台上挖出 V 形溝槽與圓穴，並散置泡棉屑。將化蛹台置入五齡幼蟲之飼養杯中供幼蟲化蛹。離水登陸之幼蟲會利用泡棉屑製成繭而在溝槽上化蛹，或製成圓穴之頂蓋在穴中化蛹。離水階段與化蛹過程之死亡率分別為 8.75%與 1.25%。成蟲可在平台上成功羽化而不傷及翅鞘，羽化率達 100%。飼育出之成蟲性比為 1:1，其體型與野生個體間無顯著差異。本新飼養方法與自行設計化蛹台是一種探討水生螢火蟲生活環的新方法。

**關鍵詞：**螢火蟲、黃緣螢、新飼育法、化蛹台。

黃緣螢(*Luciola ficta* Olivier)，是台灣產三種水生螢火蟲中最普遍的一種(Ho and Chiang, 1997; Yang, 1998a; Jeng *et al.*, 1999; Ho and Su, 2000)。全世界已記載的螢火蟲種類約 2,000 種(McDermott, 1964)，在亞洲地區目前文獻中有確認幼蟲為水生種類分別為黃緣螢、黃胸黑翅螢(*L. hydrophila* Jeng, Lai and Yang)、條背螢(*L. substriata* Gorham)、源氏螢(*L. cruciata* Motschulsky)、平家螢(*L. lateralis* Motchulsky) 與久米螢(*L. owadai* Satô and Kimura) (Satô and Kimura, 1994; Jeng *et al.*, 2003; Fu *et al.*,

2004)，且多分布於亞洲地區，不及於全世界螢火蟲種類的 1%，應屬相當珍貴稀有(Yeh, 1999)。

在台灣早期的農業時代中，黃緣螢是常見的螢火蟲之一，隨著時代變遷，農藥的大量使用、灌溉溝渠的水泥化、路燈光害、棲地破碎化等因子，影響其存活甚巨，因此野外族群數量已日益減少中(Yang, 1998b; Yeh, 1999; Ho and Chiang, 2002)。Ohba (1981) 曾在苗栗縣通霄附近的水田中採集調查，發現一種水生螢火蟲棲息於水田間的灌溉溝渠，外型類似平家螢，曾將黃緣螢鑑定為黃帶熠螢(*L.*

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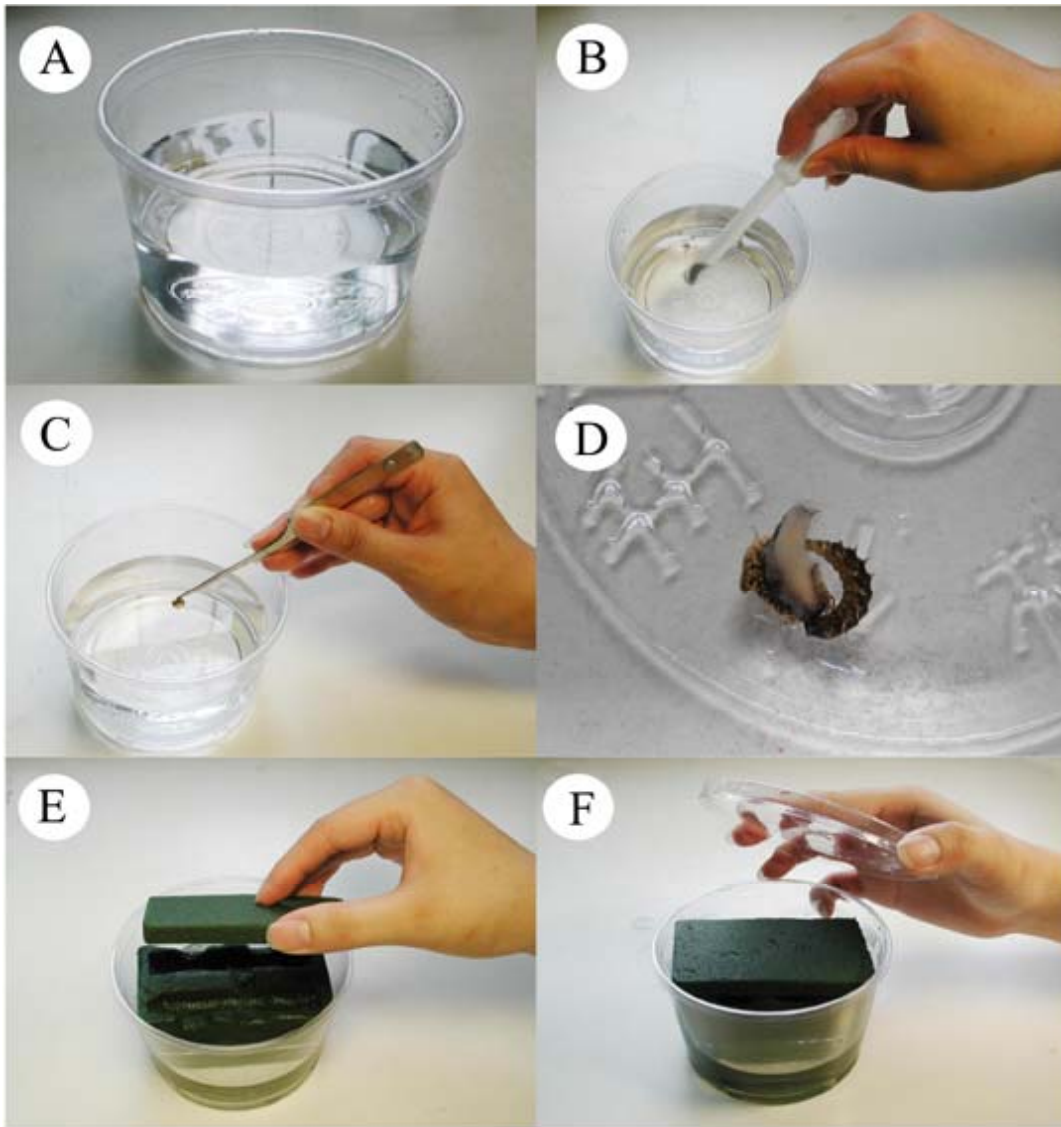
*ovalis* Hope)，曾造成學名引用上之錯誤。經 Lai *et al.* (1998)發表「台灣產螢科名錄」才加以訂正。Jeng *et al.* (2003)亦整理台灣產熠螢屬(*Luciola*)之分類地位，並發表台灣產螢火蟲之新種，曾描述黃綠螢主要分布於中國西南部，此外，福建、貴州、香港等地皆有分布。在台灣黃綠螢成蟲出現於3~10月間，幼蟲可棲息於小溝與淺池，週邊環境水生植物豐盛處(Ho and Chiang, 2002; Jeng *et al.*, 2003)。黃綠螢之形態與棲地特性、棲地管理、食物偏好、保育與復育等相關問題也有學者專家進行探討(Ho and Chiang, 1997, 2002; Yeh, 1999; Lai, 2003)。

在螢火蟲幼蟲飼育方法上，以陸生幼蟲之飼育方法較多，且因食物與環境之差異，許多專家學者發展出不同之方法，如 *Pyraclomena lucifera*、*Luciola discollis*、*Rhagophthalmus ohbai*、*Pyrocoelia analis*、*Lamprigera sp.* 等各類螢火蟲之飼養方法(Kaufmann, 1965; Buschman, 1988; Ohba, 1997; Ohba and Sim, 2000; Ho, 2003)等，皆能對於幼蟲進行飼育工作，且能夠記錄其生活環與行為。而水生螢火蟲之飼育研究以日本產平家螢與源氏螢幼蟲居多，以水族箱、淺塑膠盤等做為飼養容器；又生活環之研究多以集體飼養為主，再以集體方式放入化蛹槽中，俟其化蛹後，將其取出，等待羽化(Ohba, 1973, 1974, 1977, 1990, 1993; Kondo and Tanaka, 1989; Katsuno, 2000)。而黃綠螢幼蟲之飼育主要根據日本飼育源氏螢方法加以改良而成(Ohba, 1973, 1974; Chang, 1994)，曾以幼蟲集體飼育，待蛻皮後，取樣10隻幼蟲，探討幼蟲之生活環(Chang, 1994; Chen and Chen, 1997; Chang and Yang, 1998; Chen, 1999; Yeh, 1999; Ho and Chiang, 2002)。但黃綠螢幼蟲上陸之齡期不一，又上陸時化蛹土繭的

地點不易觀察，基礎生物學較不完整。因此針對黃綠螢幼蟲之生活習性，自行規劃設計幼蟲簡易飼養法與化蛹台，以解決幼蟲上陸化蛹之問題，建立幼蟲單隻飼養模式，易於瞭解與觀察，期能瞭解其生活環及幼蟲上陸化蛹特性，以作為將來水生螢火蟲保育工作之基礎與參考。

採集南投縣埔里鎮獅子頭附近(24°00' N; 121°03' E)黃綠螢作為供試材料，其棲地型態為水溝型，長約60 m寬約2 m，於2001年四月間黃綠螢發生季節，在夜間採集地表上發光之雌蟲，放入裝有潮濕衛生紙的五號封口袋中。隔日攜回研究室，將封口袋中的雌蟲取出，轉置於潮濕黃色海綿(L × W × D = 6.0 cm × 4.0 cm × 0.6 cm)的塑膠樣品瓶(50 ml)內，使其雌蟲產卵於孔隙中，每日換取已產卵的海綿，並將卵以毛筆挑出，作為試驗用蟲卵。

依據 Ho and Chiang (2002)之飼育流程。將10隻雌蟲同一天產下之卵，分別編號排列，俟孵化後將一齡幼蟲以單隻飼養，共計80重覆；一齡幼蟲放入透明塑膠盒中(250 ml，高度6 cm，底部直徑8 cm，開口直徑9.5 cm)，以南投縣集鎮自來水經逆滲過濾系統(reverse osmosis systems；普家康 RO 純水機)處理後，作成飼養幼蟲的水源，其水質特性包括 pH 6.8~7.0、導電度 53.1~56.4  $\mu\text{s/cm}$ 、溶氧量 22.3~24.6%、濁度 0.08 NTU，飼育盒中保持2 cm水位高度。用打碎的田螺(*Cipangopaludina chinensis* (Gray))肉，切成小塊，餵食幼蟲，食餌量約3 mg，隔日先以塑膠吸管將幼蟲體吸起，再將水與未取食完畢的肉塊取出，清潔塑膠盒壁，放入清潔的逆滲透水，保持飼養環境水質的良好，再將幼蟲重新置入。每週於星期一與星期四各餵食一次。盒蓋上打1枚十字紋孔，將塑膠盒蓋好，此方法稱為「碎肉飼育法」，詳如圖一A~D。



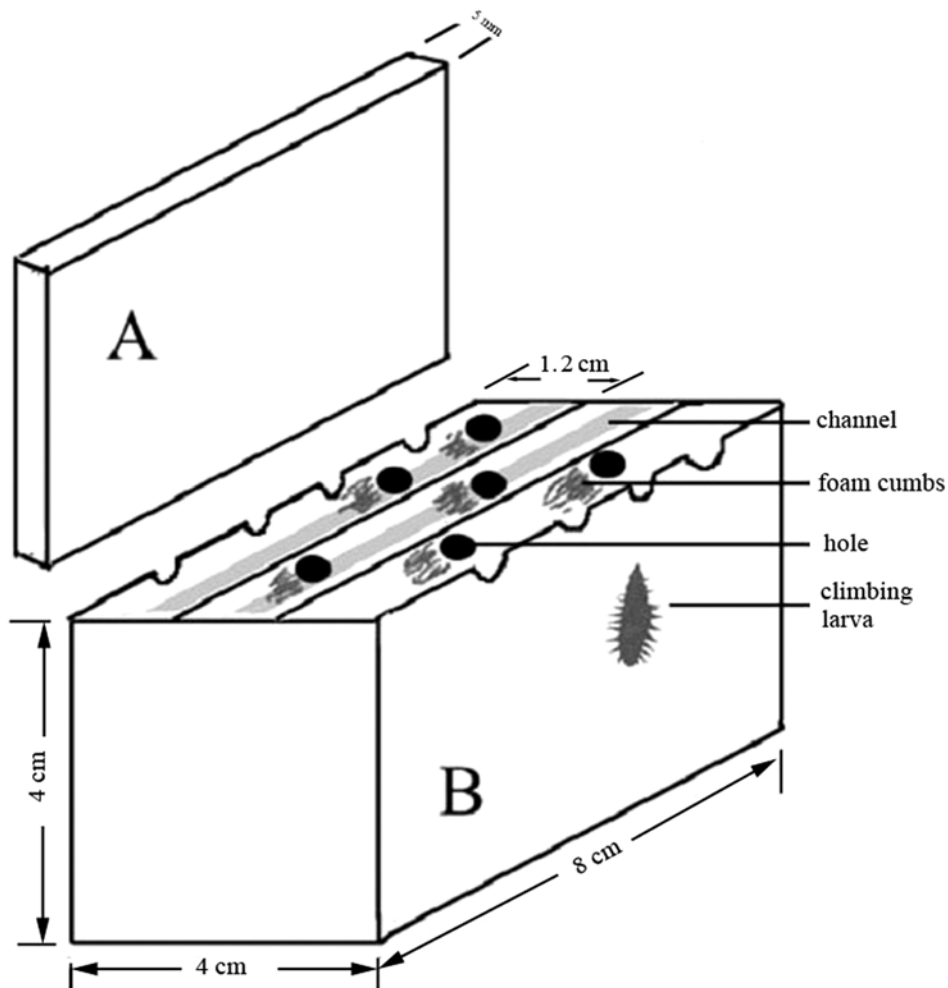
圖一 「碎肉飼育法」飼育黃綠螢幼蟲之步驟(A：幼蟲飼育盒外觀；B：餵食前將幼蟲以吸管吸起；C：置入新鮮的田螺肉；D：幼蟲進行取食；E：成熟幼蟲上陸化蛹台；E：以蓋子將飼育盒蓋上)。

Fig. 1. The design and procedure of "Fresh Meat Rearing Method." A. add clear water in container; B. remove larvae by pipette before feeding; C. put fresh meat of *Cipangopaludina chinensis* (Gray) into the container; D. larvae feeding on the prey; E. put the apparatus for pupation into the container; F. put the cup cover onto the container.

置於室溫 15~30°C、相對濕度 RH = 80 ± 5% 及光照 L : D=10 : 14 環境條件下飼育，放置於陽光不能直射之陰涼處保存。幼蟲飼育進入

五齡蟲之後，再放入上陸化蛹台於塑膠盒中，以供幼蟲躲藏與上陸化蛹之用。

上陸化蛹台(apparatus for pupation)以



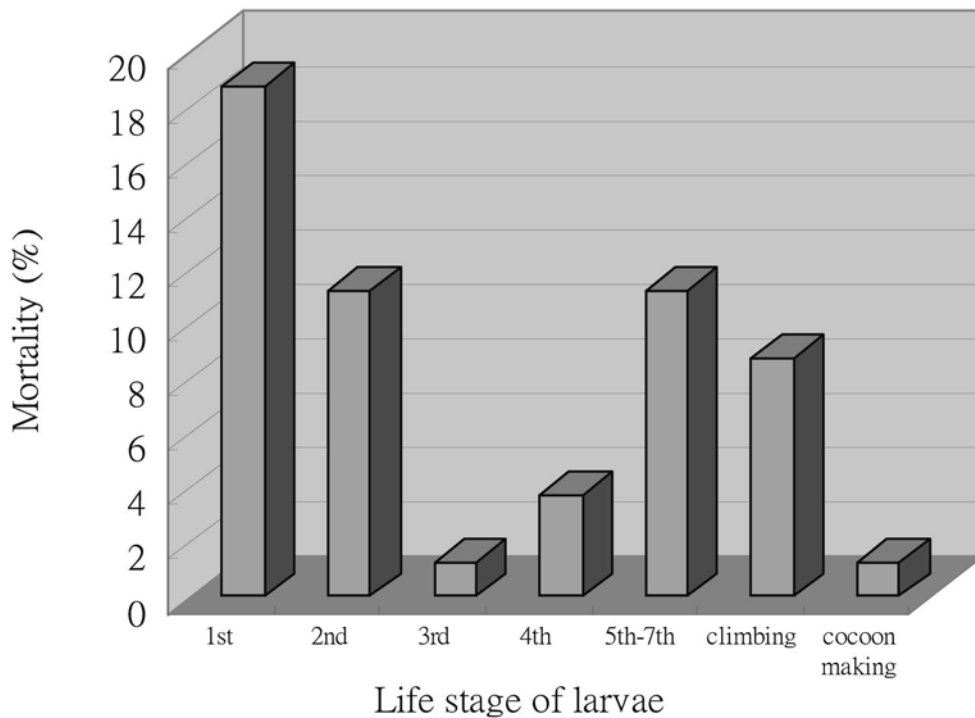
圖二 黃緣螢幼蟲上陸化蛹台以插花棉製成 (A：蓋子；B：化蛹台)。

Fig. 2. Self-designed apparatus made of floral foam for pupation for *L. fita*. (A. cover, B. platform)

插花棉(floral foams)為材料所製，墨綠色，體積大小(L × W × D = 8.0 cm × 4.0 cm × 4.0 cm)能剛好合適於飼養容器，如圖一 E、F 與圖二。其主要之組成為蓋子、化蛹平台、溝槽、孔洞及插花棉碎屑。蓋子可遮掩上陸幼蟲，化蛹平台為主要的化蛹場所，作成 V 字型溝槽(L = 8.0 cm；W = 1.2 cm)，形成較多的孔隙，供上陸幼蟲爬行，並以吸管在溝槽的側方打圓型孔(D = 1.1 cm)，供上陸幼蟲躲藏及

化蛹，以手指將插花棉碎屑碾成粉狀，模擬成自然環境中的泥土，上陸幼蟲可將插花棉碎屑以大顎夾取，形成球狀物，堆砌成蛹室，在上陸的過程中能夠詳細的觀察記錄幼蟲活動、化蛹等行爲，如圖二。

即將上陸的幼蟲會躲在透明塑膠盒與上陸化蛹台的縫隙間，於夜間上陸，爬上化蛹台，進入化蛹台內，找到適當的縫隙間化蛹。多數個體爬進孔洞中，唧插花棉碎屑將孔洞封



圖三 以「碎肉飼育法」飼育黃緣螢幼蟲，於室溫下，各齡期幼蟲之死亡率。

Fig. 3. Mortality of each life stage of *L. fitca* reared using "fresh meat method" under room temperature.

閉，直接在孔洞中化蛹；有些則直接在溝槽唧插花棉碎屑作成土繭化蛹，因此在關閉蓋子時要十分小心，每日以細針將插花棉碎屑小心挑起，檢視幼蟲化蛹與羽化情形，如未化蛹，則小心填回。

以「碎肉飼育法」單隻飼育之幼蟲驗結果從圖三得知，一齡之死亡率 18.75% 最高，二齡死亡率 11.25% 次之，三齡幼蟲死亡率 1.25% 次之最低，四齡幼蟲死亡率 3.75%，五齡至七齡之幼蟲死亡率 11.25%。由於幼蟲至老熟的齡期不一，以「碎肉飼育法」飼育幼蟲至終齡之死亡率可達 53.75%，而存活率雖不是很高的，但對於此幼蟲期長超過一年又肉食性的昆蟲而言，已經是好的結果。Chang (1994) 最早提出論文探討黃緣螢生活史之研究，文中也比較黃

緣螢不同模式的飼育方法，集體飼養容易造成幼蟲發育速率不一，由於密度與競爭，幼蟲期死亡率達 62.7% (Chang, 1994)，且羽化的成蟲容易出現大小不一的現象。

五齡幼蟲後便可上陸化蛹，於上陸幼蟲死亡率 8.75%，造繭幼蟲死亡率 1.25% (圖三)。成熟幼蟲爬上化蛹台的成功率達 100%，但其中有 7 隻幼蟲，皆在找尋化蛹位置的過程中，因不明原因身體軟化而死亡，導致上陸老熟幼蟲死亡率較高，原因值得深入探究。但如順利找尋適當的場所化蛹，僅有 1 隻在化蛹蛻皮過程中死亡，化蛹的成功率 97.23%，蛹羽化成功率達 100%，成蟲無殘翅現象(成蟲前翅與後翅皆能完全伸展)。化蛹台的設計是符合幼蟲上陸、化蛹及羽化的過程，對於其生長發育的過

程影響較小。多數學者專家以淺水型飼育缸、深水型飼育缸與水盤的飼育水生螢火蟲幼蟲，另以長方形水盤中鋪放潮濕之泥炭土及粗石子，而或是在飼育缸內以細沙堆積成斜坡，並保持適當的濕度，供幼蟲上陸之用(Haneda, 1964; Ohba, 1973, 1974, 1977, 1990, 1993; Kondo and Tanaka, 1989; Chang, 1994; Chen and Chen, 1997; Chang and Yang, 1998; Chen, 1999; Yeh, 1999; Ho and Chiang, 2002)。通常幼蟲死亡率高，無法找到化蛹位置，觀察不便，紀錄數據較不容易，也需時常換水，成本上較高。此外長期使用下容器也容易受到病源的感染，影響幼蟲的化蛹。插花棉的成本較低外，使用後的化蛹台經消毒，還可重覆使用，經濟效益較高。

以「碎肉飼育法」飼育完成羽化之雌蟲體長  $9.90 \pm 0.15$  mm ( $n = 16$ )，體寬  $3.18 \pm 0.15$  mm；雄蟲體長  $8.63 \pm 0.45$  mm ( $n = 19$ )，體寬  $2.45 \pm 0.17$  mm。經  $t$ -test 檢定雌雄成蟲性別間體長具顯著差異( $p < 0.01$ )，雌蟲明顯在體型上較雄蟲為大。原棲地所採雌蟲體長  $10.21 \pm 0.76$  mm ( $n = 10$ )，體寬  $3.21 \pm 0.25$  mm；雄蟲體長  $8.69 \pm 0.69$  mm ( $n = 20$ )，體寬  $2.60 \pm 0.24$  mm。以  $t$ -test 檢定「碎肉飼育法」飼育成蟲與野外採成蟲之體長，其差異不顯著( $p > 0.05$ )。經飼育結果雌蟲 16 隻，雄蟲 19 隻，以性比 1:1 之原則，經以 test of goodness of fit 檢定結果，計算之  $X^2$  值  $< X^2_{0.05, 1} = 3.841$ ，其差異不顯著，故推論雌雄蟲性比符合 1:1 之原則。黃緣螢幼蟲之飼育法與化蛹台是一種新模式，可完成其生活環，建議可用於探討水生螢火蟲之生物學與相關行為之研究。

## 誌謝

本研究承蒙特有生物研究保育中心與財團法人中正農業科技社會公益基金會「八九-中基-農-二六」等計畫之經費支持。研究期間特有生物研究保育中心何主任源三、彭副主任國棟及楊主秘吉宗大力支持，鄭明倫先生撥冗指正，鄭組長錫奇與黃組長獻文鼓勵，研究期間研究室張秀姍小姐與陳慧蓉協助飼養始能完成，謹此申謝。

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收件日期：2005年10月12日

接受日期：2006年2月16日

# A New Rearing Method for an Aquatic Firefly *Luciola ficta* (Coleoptera: Lampyridae)

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## ABSTRACT

To study the behavior and life cycle efficiently, a new method to rear the aquatic larvae of *Luciola ficta* Olivier and a self-designed apparatus for pupation were developed. The method, termed “fresh meat rearing method”, used crushed and freshly cut meat of the water snail *Cipangopaludina chinensis* (Gray) to feed the firefly larvae, which were reared individually in plastic cups. The number of instars varied between five and seven. The overall mortality was 53.75% for the larval stage. Mortality for each instar was highest in the 1<sup>st</sup> (18.75%) and lowest in the 3<sup>rd</sup> (1.25%). An apparatus for pupation was made of floral foam and composed of a cover and a platform which was channeled, punched and filled with foam crumbs. The apparatus was not put into the rearing cups until the larvae reach the 5<sup>th</sup> instar. The landed larvae used the foam crumbs to build cocoons and pupated on the channels, or made covers and pupated within the punched holes. The mortality for climbing larvae and the pupating larvae on these apparatus was 8.75% and 1.25% respectively. The emergence rate was 100% and the adults successfully emerged without damaging their elytra. Sex ratio was 1:1 and the body size of adults was not significantly different from the wild individuals. This new rearing method and self-designed apparatus for pupation present the good approaches of life cycles for aquatic fireflies.

**Key words:** firefly, *Luciola ficta*, new rearing method, apparatus for pupation