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Luciola anceyi (Coleoptera: Lampyridae), a Firefly Capable of All-Day Mate-Finding 【Research report】

日夜皆會尋找配偶的大端黑螢 (鞘翅目：螢科) 【研究報告】

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Abstract

The firefly *Luciola anceyi* Olivier, with well-developed photogenic organs and filiform antennae in both sexes, was regarded as a night-active species. Yet it was found to be diurnally active in several localities of Taiwan in 2005 spring. A sampling area in Tainan was selected and the population size was roughly estimated by mark-release-recapture method. Flying males were found abundant during the day, but the recapture rate was low, ranging from 0 to 3%. This implied a high mobility of males in the habitat. Females were not as active as males in day-time flying and had a recapture rate highest at 18.8%, suggesting their lower mobility than males. Therefore, this species appears to be active all-day, using light and chemical cues to find mates both at night and during the day. None of the congeneric, allied, morphologically similar species have been found with such activity periods thus far. This implies that morphological traits may be used as a reference, but not a requirement for identifying the habit of a given firefly species. The already existing classification of firefly habits is discussed and a new criterion proposed.

摘要

大端黑螢 (*Luciola anceyi* Olivier) 兩性成蟲具有大型發光器及絲狀觸角，過去被認為是夜行性的種類，但在2005年春季我們發現其在白天亦非常活躍，且非偶發事件。在台南選取一個樣區，並以標記釋放再捕法推測其族群在調查期間之變動，發現大量雄蟲於日間飛行，但各次再捕率都很低，僅0~3%，反映雄蟲在棲地間的高流動性；日間飛行的雌蟲較雄蟲少，而再捕率最高達18.8%，顯示其流動性較雄蟲低。大端黑螢在白天與夜間皆活躍，並利用光與化學訊號在夜間與白天尋找配偶，同屬近似種類尚未發現類似現象，此顯示形態特徵僅能做為判斷活動習性的參考而非標準。文中對過去之活動習性區分方式提出檢討，並建議新的歸類原則。

Key words: *Luciola anceyi*, firefly, all-day mate-finding, mark-release-recapture, habit classification

關鍵詞: 大端黑螢、螢火蟲、全天尋找配偶、標記釋放再捕法、活動習性區分

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日夜皆會尋找配偶的大端黑螢 (鞘翅目：螢科)

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摘要

大端黑螢(*Luciola anceyi* Olivier)兩性成蟲皆具有大型發光器及絲狀觸角，過去被認為是夜行性的種類，但在 2005 年春季我們發現其在白天亦非常活躍，且非偶發事件。在台南選取一個樣區，並以標記釋放再捕法推測其族群在調查期間之變動，發現大量雄蟲於日間飛行，但各次再捕率都很低，僅 0~3%，反映雄蟲在棲地間的高流動性；日間飛行的雌蟲較雄蟲少，而再捕率最高達 18.8%，顯示其流動性較雄蟲低。大端黑螢在白天與夜間皆活躍，並利用光與化學訊號在夜間與白天尋找配偶，同屬近似種類尚未發現類似現象，此顯示形態特徵僅能做為判斷活動習性的參考而非標準。文中對過去之活動習性區分方式提出檢討，並建議新的歸類原則。

關鍵詞：大端黑螢、螢火蟲、全天尋找配偶、標記釋放再捕法、活動習性區分。

近年來台灣螢科分類學與生活史研究有大幅進展(Ho, 1997; Ho and Jiang, 1997; Ho and Jong, 1997; Ho *et al.*, 1998a, b, 2002, 2003; Jeng *et al.*, 1998a, b, 1999a, b, c, 2000, 2001, 2002, 2003a, b; Lai *et al.*, 1999; Chen, 1999, 2003; Chang *et al.*, 2000; Ho and Chu, 2002; Ho and Huang, 2002; Jeng and Yang 2003)。而依據 Branham and Wenzel (2001)對菊虎總科(Cantharoidea Crowson)親緣關係之研究，將弩螢屬(*Drilaster* Kiesenwetter)與垂鬚螢屬(*Stenocladius* Deyrolle and

Fairmaire)排除於螢科之外；目前共紀錄 9 屬 44 種螢火蟲於台灣與所屬島嶼。

Ohba (1983, 1997, 2004)以日本螢火蟲的生物特性，將兩性溝通模式分為六大類，並對應三種活動型式，分別是日行性(diurnal)、夜行性(nocturnal)與兩行性(crepuscular-active)。日行性對應於兩性溝通模式中的 LB 型，被界定為不發光而單純依賴費洛蒙(pheromone)去發現配偶的種類；夜行性對應兩性溝通模式中的 LC、LL、HP 與 PR 型，具有明顯發光行為且在夜間活動，依賴簡單(HP 型)或複雜的(LC, LL 型)光訊號溝通，或

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再加上化學訊號協助求偶交配(PR 型);兩行性對應於兩性溝通模式中的 CR 型,具有小型的點狀發光器,主要在日間活動,但也會在日落之初時活動,主要依靠化學訊號發現配偶,但在近距離可能也依靠發光來發現配偶。Lall *et al.* (1980)則依照活動時間將北美的種類分為日行性(daytime-active)、夜行性(night-active)與昏行性(twilight-active)三類;其中日行性包含不發光與微弱發光的種類;昏行性與夜行性皆能明顯發光,昏行性在傍晚至入夜時分活動,夜行性則在完全天黑之後開始活動。Lall 與 Ohba 的系統主要差異在前者不與兩性溝通模式對應,單純依照活動時間分類。若依照 Ohba 之歸類標準,則台灣產九個屬的螢火蟲中,熠螢(*Luciola* Laporte de Castelnau)、脈翅螢(*Curtos* Motschulsky)、短角窗螢(*Diaphanes* Motschulsky)、扁螢(*Lamprigera* Motschulsky)為夜行性;櫛角螢(*Vesta* Laporte de Castelnau)與雙櫛角螢(*Cyphonocerus* Kiesenwetter)為兩行性;窗螢(*Pyrocoelia* Gorham)為夜行性與兩行性;鋸角螢(*Lucidina* Gorham)則為日行性與兩行性。由於資料不足,目前尚無法得知 Lall 的系統是否適用於台灣的螢火蟲。然而具有微弱發光器的種類是否真的利用發光在黃昏或夜間求偶並未被證實,因此以發光與否來推論活動型式未必可靠。Lall and Lloyd (1989)推測,由於日行性的無翅雌蟲一般都藏匿於土中或非常隱蔽的微棲所(microhabitat),雄蟲的微弱發光可能是極近距離的辨識訊號,讓雌蟲得知是否為天敵或異性。

熠螢屬種類具有發達的發光器,在雄性具有二至三節,雌性一至二節;觸角絲狀,故若依照形態區分是屬於典型的夜行性螢火蟲。其中的大端黑螢廣泛分布於中國南部、台灣與中南半島,成蟲出現於春季與夏季,夜間常聚集

於樹冠上發光活動,白天則偶爾會發現訪喬木花或停棲於下層植物的個體。2005 年 4 月我們卻發現大量的大端黑螢於白天活動,且並非單獨事件,在台南、屏東與南投地區皆有發現:在台南,成蟲出現於竹林內與邊緣,從上午至夜間成天活動,並在白天交配;在屏東觀察到大批成蟲聚集於野桐(*Mallotus japonicus* (Thunb))飛舞訪花;而南投則發現成蟲在白天於林緣飛行,並且有發光現象,但並未觀察到求偶或交配行為(李榮宗、汪澤宏、陳振祥、鍾奕霆,私人通訊)。

第二作者陳燦榮在 2005/4/24 與 4/28 於台南白河鎮關仔嶺山區選擇一 8×5 公尺平方的竹林棲地進行觀察與標記釋放再捕(Mark-Release-Recapture, 以下簡稱 MRR)實驗,在中午 12:00 時與下午 15:30 時各進行一小時採集,以油漆筆在翅鞘上不同位置標記,於同日下午及夜間 19:30 時進行一小時再捕。白天的取樣僅捕捉飛行中的個體,夜間則任意採集可得的發光個體。4/22 採集時溫度 22.4~25.4°C,相對溼度 85~98%,天氣陰。4/28 在同一地點於中午標記,下午再捕,溫度 23.4~27.7°C,相對溼度 69~86%,天氣陰雨。由於 MRR 在同日進行且僅為粗略估計族群量,故採用 Lincoln Index (Lincoln, 1930)來估算族群量。結果如表一所示。

4/22 的夜間再取樣未發現重複標記的個體。若合併白天兩次標記為單一標記,則估計雄蟲有 1760 隻,雌蟲 350 隻。4/28 下午同作者在 50 公尺外的竹林採到 4/22 中午標記與 4/28 剛標記的雄蟲各一隻。

表一的結果顯示,在白天與夜間的再取樣數以及再捕率(再取樣中有標記之個體數/之前釋放之標記個體數)方面,兩性間具有差異。就再取樣數而言,雄蟲白天的取樣數較夜間為高(31:16),而雌蟲則反之(11:42)。白天有大量的

表一 2005/4/22 與 4/28 在台南縣關仔嶺對大端黑螢進行標記釋放再捕法之結果

Table 1. The results of mark-release-recapture of *Luciola anceyi* at Guanziling, Tainan County in April 22 and 28, 2005

Date	Time	Individuals marked		Individuals recaptured (total number captured)		Estimated population size ¹⁾	
		♂	♀	♂	♀	♂	♀
Apr. 22	12:00	79	16			NA ²⁾ / NA	88 / 224
	15:30	31	11	0 (31)	2 (11)	496	NA
	19:30			1 ³⁾ (16)	3 ⁴⁾ (42)		
Apr. 28	12:00	33	3			462	NA
	15:30			1 (14)	0 (4)		

¹⁾ The population sizes were estimated using Lincoln index (Lincoln, 1930) according to the recapture data at 15:30 / those at 19:30.

²⁾ NA, not available due to 0 recapture.

³⁾ The number of individuals marked at 15:30.

⁴⁾ The number of individuals marked at 12:00.

雄蟲在竹林內飛行，採集容易，但在夜間雄蟲如流星般的發光特性，使得追蹤其飛行軌跡困難而不易捕捉，導致再取樣數低；相反地，白天飛行的雌蟲少，因此採樣數較雄蟲低，而雌蟲在夜間的閃光頻度固定，採集較容易，因此夜間再取樣數較雄蟲高，且為白天雌蟲取樣數的 2.6~3.8 倍。雌蟲日夜取樣數差異可能為原本已經有大量雌蟲停留在樣區內，因為白天未飛行而沒有被取樣，或因雌蟲的移動主要在夜間進行所造成。由於白天觀察到許多停棲在竹子枝葉上的雌蟲，前者可能是主要因素。就再捕率而言，雄蟲之再捕率最高僅 3%，極可能造成偏差(biased)的估計；雌蟲再捕率在 4/22 下午為 12.5%，夜間達 18.8%。雄蟲再捕率低一方面是因為再取樣數低，另一方面可能是由於雄蟲的流動性高，或是向取樣區聚集(遷入)而造成稀釋效果(dilution effect)。由於樣區外的鄰近地點曾採到標記的個體，而白天所採得的飛行雄蟲數量極多，因此推論高流動性的因素較大。而雌蟲的再捕率則顯示其流動性不若雄蟲高。

大端黑螢成蟲在白天飛行，並尋找配偶與

交配。雌蟲一般停棲於竹葉或細枝條上，而雄蟲四處飛行；當偵測到訊息，雄蟲降落在雌蟲附近，快速擺動觸角並步行搜尋雌蟲；雄蟲自後方或側方接近雌蟲，在旁緩緩擺動觸角並靜待約一分鐘後迅速爬上雌蟲，若雌蟲未拒絕則開始進行交尾，反之則可能掙扎一番後雙雙自葉背掉落。他們未依賴發光，而可能以化學訊號(費洛蒙或表皮碳氫化合物)與視覺做為定位與溝通媒介，在燐螢屬中這是目前唯一已知的例子；形態近似的端黑螢(*Luciola praeusta* Kiesenwetter)與邊褐端黑螢(*L. terminalis* Olivier)尚未發現類似的情形。大端黑螢運用光與化學訊號在夜間與白天進行求偶，不屬於 Ohba (1983, 1997, 2004)活動習性歸類中的任何一種，也無法與既有的六種兩性溝通模式對應，是一個全新的活動類型與溝通模式。而“活動習性”顯然需要更精確的定義，例如雌蟲在白天交配不發光而在夜間產卵時發微光，應歸類為日行性或兩行性便有模糊空間。若以尋找配偶(mate finding)時間來界定活動習性，則可以避免一些爭議，例如具有微弱發光器的種類若僅在日間尋找配偶，則歸類為日

間尋找配偶型 (diurnally mate-finding type), 蓋其夜間發光的目的未必用於求偶, 而可能具有警示(warning)或其他目的, 或僅僅是演化遺跡(evolutionary remnant); 全日尋找配偶型(all-day mate-finding type)、黃昏尋找配偶型 (crepuscularly mate-finding type)與夜間尋找配偶型(nocturnally mate-finding type)可依此類推。此一新的發現也說明形態特徵無法做為判斷活動習性的充分條件, 僅能作為參考, 必須確實依賴行為特性做為判斷的標準。

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Luciola anceyi (Coleoptera: Lampyridae), a Firefly Capable of All-Day Mate-Finding

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ABSTRACT

The firefly *Luciola anceyi* Olivier, with well-developed photogenic organs and filiform antennae in both sexes, was regarded as a night-active species. Yet it was found to be diurnally active in several localities of Taiwan in 2005 spring. A sampling area in Tainan was selected and the population size was roughly estimated by mark-release-recapture method. Flying males were found abundant during the day, but the recapture rate was low, ranging from 0 to 3%. This implied a high mobility of males in the habitat. Females were not as active as males in day-time flying and had a recapture rate highest at 18.8%, suggesting their lower mobility than males. Therefore, this species appears to be active all-day, using light and chemical cues to find mates both at night and during the day. None of the congeneric, allied, morphologically similar species have been found with such activity periods thus far. This implies that morphological traits may be used as a reference, but not a requirement for identifying the habit of a given firefly species. The already existing classification of firefly habits is discussed and a new criterion proposed.

Key words: *Luciola anceyi*, firefly, all-day mate-finding, mark-release-recapture, habit classification