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研究簡報

應用電動推剪及旋風分離法收獲基徵草蛉 [*Mallada basalis* (Walker)] 卵粒

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摘要

許北辰、董耀仁、余志儒、林鳳琪、江明耀。2020。應用電動推剪及旋風分離法收獲基徵草蛉 [*Mallada basalis* (Walker)] 卵粒。台灣農業研究 69(3):255–263。

基徵草蛉 [*Mallada basalis* (Walker)] 在台灣為農業害蟲的重要天敵。基徵草蛉的卵粒以卵柄 (egg stalks) 結構附著於平面介質，使卵粒限制於平面分布，耗費收穫人力及占用運送空間，且造成試驗無法大量操作，也增加田間應用的困難度。本研究提出以電動推剪搭配旋風離心器切斷草蛉卵柄並收獲草蛉卵粒，與傳統次氯酸鈉法處理組相較，卵收穫率 (90.2% ± 0.6% vs. 80.0% ± 2.3%)、卵孵化率 (80.8% ± 2.8% vs. 70.0% ± 3.6%) 及成蟲獲得率 (54.2% ± 3.4% vs. 46.7% ± 4.1%) 皆以電動推剪搭配旋風離心器者較佳。兩處理間雖無顯著差異，惟以推剪搭配旋風離心器收獲草蛉卵粒具有速度快、器械體積小、操作便利及安全性高等優點，具有應用於小型之草蛉卵收獲系統之潛力。

關鍵詞：基徵草蛉、卵柄、收穫、推剪、大量飼養。

前言

基徵草蛉 [green lacewing; *Mallada basalis* (Walker)] 屬脈翅目草蛉科 (Neuroptera: Chrysopidae)，其成蟲為植食性，以花蜜、花粉等為食 (Wu 1995)，幼蟲則為肉食性，係蚜蟲、粉蝨、葉蟎等小型害蟲的天敵 (Lee 1994; Wu 1995; Lu & Wang 2006; Chang & Lu 2007; Chen *et al*. 2014; Hsu & Lu 2020)，且可利用人工飼料來大量繁殖 (Cohen 1983; Ma *et al*. 1986; Lee 1994; Ye *et al*. 2017; Hsu & Lu 2020)。應用於農業害物綜合管理 (integrated pest management; IPM)，推薦施放基徵草蛉於如木瓜、草莓、瓜類和茄科等作物，防治如棉蚜 (*Aphis gossypii* Glover)、橘球粉介殼蟲 [*Nipaecoccus filamentosus* (Cockerell)]、銀葉粉蝨 (*Bemisia argentifolii* Bellows & Perring)、潛葉蛾 (*Phyllocnistis citrella* Stainton)、神澤氏葉蟎 (*Tetranychus kanzawai* Kishida) 及二點葉蟎 (*Tetranychus urticae* Koch) 等重要害蟲 (Wu 1992; Chang & Huang 1995; Wu 1995; Lu & Wang 2006; Cheng *et al*. 2010; Chen *et al*. 2014)。

基徵草蛉產卵時，會先以腹部末端於基質表面產生一卵柄 (egg stalk) 構造，再將卵粒附著於物體表面 (圖 1)。草蛉種間之卵柄結構各有不同，此卵柄多為醛類 (aldehyde) 聚合物，其物理結構及氣味成分可在卵孵化前防禦如螞蟻等天敵，或降低同種間自殘的機率 (Eisner *et al*. 1996)。

應用草蛉防治害蟲時，為達淹沒性釋放 (inundative release)，需要快速且均勻的釋放大量卵粒或幼蟲 (Wu 1995; Lu & Wang 2006; Cheng *et al*. 2010; Chen *et al*. 2014)。草蛉卵被卵柄黏附於產卵標的上，應用於葉菜類等低

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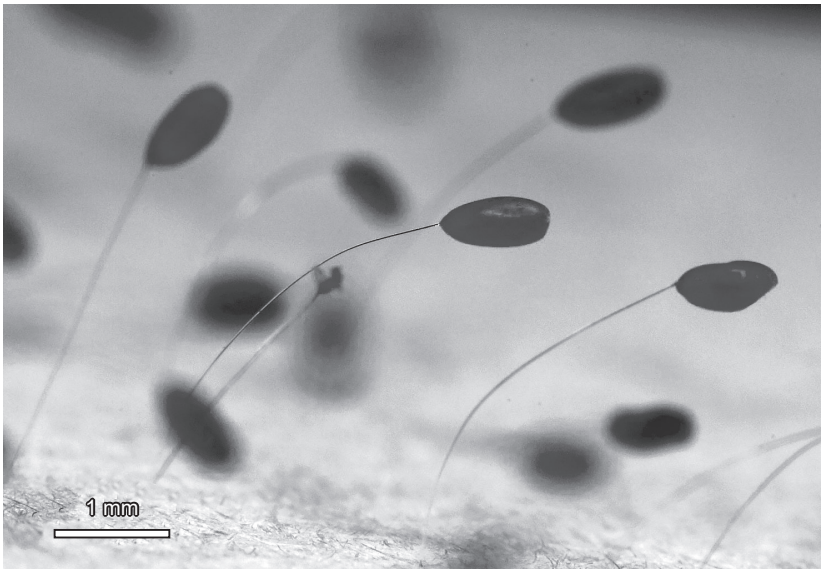

圖 1. 基徵草蛉卵粒藉由卵柄附著於平面，卵柄容易因卵粒的重量而向地面彎曲。

Fig. 1. The eggs of *Mallada basalis* are attached to the plane by the egg stalk, which is easy to bend to the ground due to the weight of the egg.

矮作物時，無法直接以噴布器械散布卵粒，只能將黏附卵粒之紙張拆解為小單張，再將紙張以鐵線、塑膠繩或釘書針等懸掛於田間植株 (Lu & Wang 2006; Cheng *et al*. 2010; Chen *et al*. 2014)。此舉除造成紙張於田間發霉 (Chen *et al*. 2014)，若遇如茄科、瓜科等離地較高的作物，甚至需要各別懸掛，過程耗時耗力，影響農戶的使用意願。卵柄結構亦使卵粒無法集中，當需要做集中操作滯育 (diapause) 或卵期延長 (delayed hatching) 時會降低操作效率 (Bezerra *et al*. 2014)。此外，卵粒被卵柄結構限制於單一維度的平面分布，運送卵粒時為避免損傷，須將紙張設置為立體結構且連帶運送，耗費包裝人力，也消耗載送空間。若可將草蛉卵粒有效率地收穫、集中，可減少商品儲藏空間、降低運輸成本，以及提升應用時的散播均勻度 (Chen *et al*. 2019)。另外，亦可嘗試如氣流和水流噴灑等方法，更快速地於田間操作中釋放卵粒 (Wu 1995)。

草蛉卵柄與卵粒分離的方式，主要有加熱分解、化學溶解 (dissolved) 及物理切斷等方法。Nordlund & Correa (1995a, 1995b) 設計一產卵容器，其分布電熱線 (hot wire) 於產卵面上，加熱後可將卵柄分解熔融，使得卵粒自產卵容器上卸除，並落入收穫系統中。化學溶解法一般以次氯酸鈉 (sodium hypochlorite; NaClO) 溶液為溶劑，將卵柄浸泡於溶劑中使卵柄分解，再將卵以水浴清洗並以紗網過濾回收，存活率可達 30–90% (Krishnamoorthy & Nagarkatti 1981; Nasreen *et al*. 2004; Bezerra *et al*. 2014; Chen *et al*. 2019)。此類溶劑常被應用於溶解昆蟲卵表面的幾丁質構造，但浸泡時間若掌控不當，會直接造成卵表面腐蝕過度，使氯離子進入卵內而造成損傷 (Handler *et al*. 1998)。而浸泡過溶劑的卵，若未即時洗淨且晾乾，卵粒將持續受到溶劑侵蝕，進而引發微生物感染而死亡 (Nordlund & Correa 1995a; Nasreen *et al*. 2004; Bezerra *et al*. 2014)。另外，一般尚有使用尼龍球 (loose ball of nylon netting) 將卵柄拉扯斷裂 (Ridgway *et al*. 1970)，或是刮鬍刀將卵柄切斷的處理方式 (Nasreen *et al*. 2004; Sattar & Abro 2011)，然而此二法皆會使卵柄糾結，甚至造成卵粒直接的損傷 (Nordlund & Correa 1995a)。

本文提出「推剪法」，為一種以電動推剪 (electronic clipper or hair clipper) 搭配旋風分

離法 (cyclonic separation) (Hsiu *et al*. 2019) 之方式，可快速切斷卵柄並收穫大面積的草蛉卵粒，並比較此法與一般次氯酸鈉溶解法，兩者的卵收穫率、孵化率及成蟲獲得率。本研究期望增進草蛉卵粒收穫的效率，並降低操作器械的占用空間。

材料與方法

基徵草蛉飼育

基徵草蛉飼育過程簡述如下：幼蟲用微膠囊人工飼料飼養，並於瓦楞紙片中化蛹。成蟲羽化後，立即收集置入直徑 14 cm × 高 20 cm 的壓克力產卵筒內，以蜂蜜與酵母粉之混合物及沾水棉花餵養，筒內鋪設紙巾供成蟲產卵。每日收取帶有卵粒的紙張，作為卵片備用 (Lee 1994; Hsu & Lu 2020)。

卵粒收穫試驗

推剪法試驗

推剪器動力來源為直流電源 (direct current; DC 24 V) 驅動之直流馬達 (36 W)，並以脈衝信號調控技術來控制刀刃速度。刀頭 (上立儀器有限公司，台灣台中市) 之上刀刃 (blade) 為聚甲醛材質 (polyoxymethylene; POM)，下刀刃為以陽極處理 (anodizing) 之不鏽鋼 (stainless steel)，兩者皆以鐵氟龍 (polytetrafluoroethylene; PTFE) 塗布。本文將測試 3 種不同的推剪器刀頭高度的卵收穫率，試驗流程及旋風分離步驟如圖 2，參考 Hsiu *et al*. (2019) 之作法，使用渦輪扇 (worm gear fan or snail fan) 作為動力源並以雙旋風塔結構將卵粒與雜質分離。試驗時，首先將進氣口靠近推剪器刀口，刀口上方以流量 40 L min^{-1} 進行抽氣使卵柄直立，接著推剪刀刃靠近卵柄基部將卵柄切斷。卵柄斷裂後，會被負壓氣流吸入分離器 (圖 2D)，較重的卵粒被旋風分離並下降留置於分離器底部，而排遺及沙塵隨氣旋上升至分離器頂部隨氣流排出。試驗結束後，計算旋風分離所收穫的卵粒收穫率，並自 3 組剪下的卵粒中各隨機取 30 粒卵 (n = 30)，觀察孵化率及成蟲獲得率。

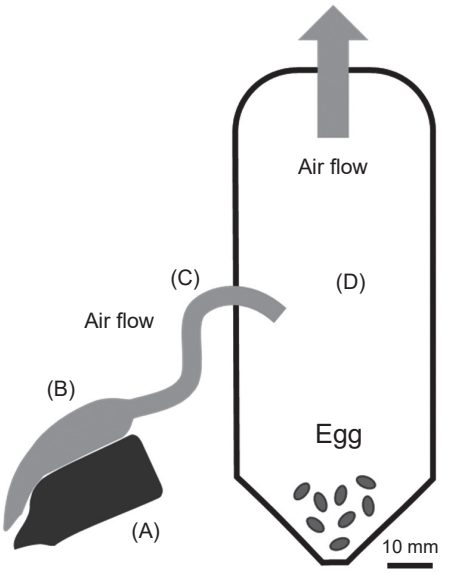

圖 2. 推剪搭配旋風分離器收集基徵草蛉卵粒之構造圖。(A) 推剪將卵之卵柄切斷，並將卵粒由 (B) 空氣驅動之收集器將卵吸入至 (C) 空氣連通管，最終卵粒被 (D) 旋風分離器收集於底部。

Fig. 2. Diagrams of clipper and cyclonic procedure to take the eggs of *Mallada basalis* from substrate. The (A) clipper removes the egg stalk, and a collector driven by (B) air flow inhale the eggs into the (C) connecting tube, and finally these eggs were transported to (D) cyclonic separator.

次氯酸鈉法試驗

由於越高濃度的次氯酸液搭配越長的處理時間，則卵收穫率提高但存活率降低 (Bezerra *et al*. 2014)。本研究依據前測試驗 (附錄)，以不同次氯酸鈉濃度搭配不同處理時間，選出各濃度下卵收穫率與孵化率兩者皆最佳的組合，濃度與時間組合分別選用 1.5% 60 s、3.0% 30 s 及 6.0% 10 s。本試驗首先以剪刀剪取附著草蛉卵粒之卵紙片，接著以鑷子夾取此紙片浸泡於次氯酸鈉溶液中，並計算脫落後的卵粒。以一次過濾水洗淨後乾燥，並自浸泡處理後的卵粒隨機取 30 粒卵 (n = 30)，觀察孵化率及成蟲獲得率。

對照組

以剪刀剪取 30 粒卵 (n = 30)，觀察孵化率及成蟲獲得率。推剪法、次氯酸鈉法及對照

組處理等，皆進行 4 重複。

數據分析

試驗資料以 IBM SPSS Statistics 25 軟體進行統計分析，數據先以變異數同質性檢定 (Levene's test)，若同質性假設通過則以變異數分析 (analysis of variance; ANOVA) 及最小顯著性差異法 (Fisher's least significant difference test; LSD test) 比較 3 種處理間的卵收穫率、孵化率及成蟲獲得率平均值差異。若同質性假設未通過，則以 Welch's ANOVA 及杜納 T3 檢定 (Dunnett's T3 test) 作事後比較 (post hoc test)。

結果與討論

以推剪法及旋風處理法收獲之草蛉卵粒，如圖 3。推剪法與次氯酸鈉法兩種處理結果比較 (表 1)：推剪試驗中以 1 mm 高度之刀頭組別結果最優良，而次氯酸鈉處理組別中以 1.5% 濃度搭配 60 s 處理時間之效果最優。推剪法及次氯酸鈉法處理結果，最優組別比較，卵收穫率分別為 90.2 ± 0.6 vs. 80.0 ± 2.3%，兩組無顯著差異 (Levene's test: $P = 0.048$; Welch's ANOVA: $F_{6, 8.00} = 155.43$, $P < 0.001$; Dunnett's T3 test: $P = 0.135$)，孵化率為 80.8% ± 2.8% vs. 70.0% ± 3.6%，兩組間無顯著差異 (Levene's test: $P = 0.119$; ANOVA: $F_{6, 21.00} = 110.574$, $P < 0.001$; Fisher's LSD test: $P = 0.142$)，成蟲獲得率為 54.2% ± 3.4% vs. 46.7% ± 4.1%，兩組間無顯著差異 (Levene's test: $P = 0.026$; Welch's ANOVA: $F_{6, 8.00} = 849.23$, $P < 0.001$; Dunnett's T3 test: $P = 0.251$)。對照組 (剪刀剪取法) 之卵收穫率、孵化率及成蟲獲得率，則分別為 100.0% ± 0.0%、90.8% ± 1.6% 及 60.8% ± 0.8%。若以 3 種處理組之卵收穫率最優組別：1 mm 推剪法、60 s 次氯酸鈉法及剪刀剪取法相比較操作之時間效率，操作時間分別為 1 s、60 s 及 2–3 min，以推剪法搭配旋風處理法為最佳，次氯酸鈉法次之，而剪刀剪取之對照組最耗費收穫時間。剪刀法雖具最佳的卵收穫率、孵化率及成蟲獲得率，但所耗費之時間成本巨大，不適合應用於實務操作。推剪法搭配旋風離心法收獲草蛉卵粒，相較於次氯酸鈉法有操作時間及空間應用之優勢，且有較佳的卵收穫率、孵化率及成蟲獲得率。

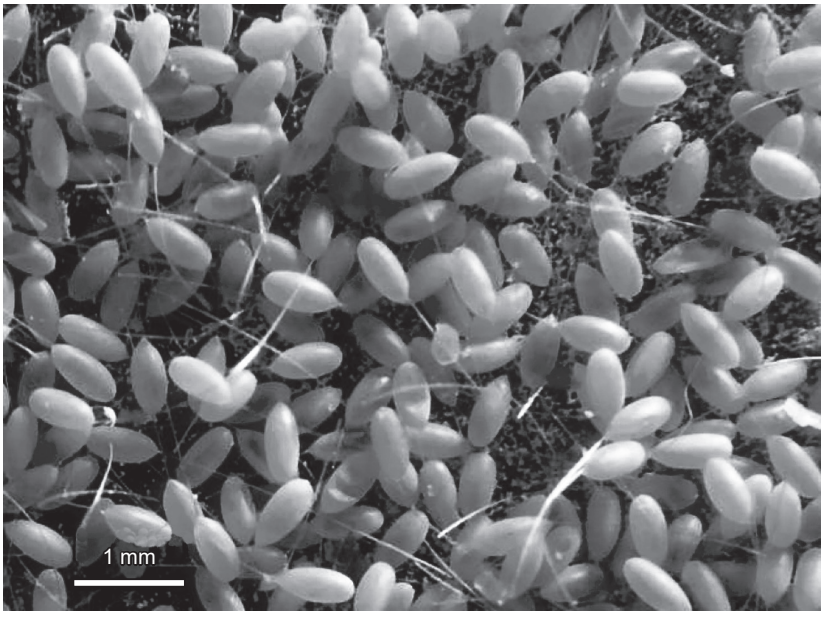

圖 3. 推剪搭配旋風分離法收穫的基徵草蛉卵。

Fig. 3. Eggs of *Mallada basalis* harvested using a hair clipper with cyclonic separation.

表 1. 推剪法搭配次氯酸鈉溶解法取下基徵草蛉卵粒之成功率、孵化率及成蟲獲得率。

Table 1. Egg harvest (%), hatch (%), and egg-adult (%) for removing the egg stalk of *Mallada basalis* using the clipper and sodium hypochlorite method.

Method of removing egg stalk	Eggs harvest % (Mean ± SEM[z])	Hatch % (Mean ± SEM)	Egg-adult % (Mean ± SEM)
Scissors	100.0 ± 0.0 a[y]	90.8 ± 1.6 a	60.8 ± 0.8 a
Clipper with cyclonic separation			
1 mm	90.2 ± 0.6 ab	80.8 ± 2.8 ab	54.2 ± 3.4 ab
2 mm	63.8 ± 4.8 c	70.8 ± 1.6 b	47.5 ± 1.6 b
3 mm	45.8 ± 1.8 d	54.2 ± 4.4 c	35.8 ± 1.6 cd
Sodium hypochlorite solution			
1.5%, 60 s	80.0 ± 2.3 b	70.0 ± 3.6 b	46.7 ± 4.1 bc
3.0%, 30 s	80.1 ± 4.7 b	51.7 ± 3.2 c	33.3 ± 3.0 d
6.0%, 10 s	78.1 ± 5.1 bc	0.3 ± 0.0 d	0.0 ± 0.0 e

[z] SEM: standard error of the mean.
[y] Mean ± SEM within the same column followed by the same letters are not significantly different at the 5% level by least significant difference (LSD) test.

草蛉卵柄易受重力彎曲，使卵粒緊靠底面，本文設計之推剪法先以負壓氣流拉伸卵柄，使卵粒遠離刀刃，避免受上部刀刃撞擊，並將剪下的卵粒立即移除，以避免受二次剪取造成損傷。提前抽風可除去表面髒污，配合以鐵氟龍塗布之刀刃表面，避免灰塵及成蟲的黏性排遺沾黏於刀刃，造成卵柄黏附。本文採用旋風離心法 (Hsiu *et al*. 2019) 來收穫草蛉卵粒，以避免濾網式吸塵易使大量卵粒於濾網處堵塞且擠壓受損，且濾網處的高速氣流易使卵柄產生靜電，導致卵粒彼此沾黏形成叢集 (clump) 而不易分離 (Nordlund & Correa 1995a)。本文推剪法步驟較以往的化學溶解及電熱熔融 (melted) 法簡易，且操作時間極短、安全性高，並且無化學浸泡法所需之液體空間，無尼龍球或刮鬍刀法造成的卵柄糾結現象，也無電熱法之高耗電帶來的安全問題 (Nordlund & Correa 1995a, 1995b; Bezerra *et al*. 2014)，可有效率的收獲草蛉卵粒並縮小占用空間，有機會發展為小體積之自動收穫系統。

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附錄 以不同濃度及處理時間之次氯酸鈉溶解法取下基徵草蛉卵粒之成功率及孵化率。

Appendix Egg harvest (%) and hatch (%) for removing the egg stalk of *Mallada basalis* using the sodium hypochlorite method with different concentrations and treatment durations.

Sodium hypochlorite concentration (%)	Treatment duration (s)	Eggs harvest % (Mean ± SEM[z])	Hatch % (Mean ± SEM)
1.5	10	18.0 ± 2.5 de[y]	84.9 ± 7.9 a
	30	51.3 ± 3.1 d	73.4 ± 5.4 a
	60	73.2 ± 4.5 bc	76.4 ± 3.2 a
3.0	10	46.0 ± 3.8 d	48.5 ± 4.8 b
	30	79.9 ± 3.6 abc	44.8 ± 6.1 bc
	60	86.5 ± 2.6 ab	26.0 ± 4.2 cd
6.0	10	69.8 ± 4.3 c	7.1 ± 2.4 de
	30	89.5 ± 2.0 a	3.5 ± 1.5 e
	60	92.5 ± 2.9 a	3.4 ± 1.5 e

[z] SEM: standard error of the mean.

[y] Mean ± SEM within the same column followed by the same letters are not significantly different at the 5% levels by least significant difference (LSD) test.

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Harvesting of *Mallada basalis* (Walker) Eggs Using a Hair Clipper and Cyclonic Separation

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Abstract

Hsu, P. C., Y. J. Dong, J. Z. Yu, F. C. Lin, and M. Y. Chiang. 2020. Harvesting of *Mallada basalis* (Walker) eggs using a hair clipper and cyclonic separation. J. Taiwan Agric. Res. 69(3):255–263.

Mallada basalis (Walker), commonly called the green lacewing, is beneficial for agricultural pest control in Taiwan. The number of green lacewing eggs distributed on a flat surface is limited by a thin stalk structure. Therefore, removal of the egg stalks requires considerable manpower and transportation space. Moreover, it also limits the applicability of such eggs in large-scale experiments and increases the difficulty of field application. In this study, an electric clipper was used to remove lacewing egg stalks, and the eggs were harvested using a cyclone separator. No significant difference was observed in eggs harvest rate (90.2% ± 0.6% vs. 80.0% ± 2.3%) between clipper and sodium hypochlorite method to harvest eggs of *M. basalis*. However, significant differences were measured in hatching rate (80.8% ± 2.8% vs. 70.0% ± 3.6%) and adult harvest rate (54.2% ± 3.4% vs. 46.7% ± 4.1%). Results showed that the use of hair clipper and cyclonic separation method for lacewing egg harvesting had the advantages of high speed, small instrument size, convenient operation, and high safety. As such, this method provides potential applicability in developing a small harvesting system for green lacewing eggs.

Key words: *Mallada basalis* (Walker), Egg stalk, Harvesting, Clipper, Mass rearing.

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