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藥劑對南美斑潛蠅 (*Liriomyza huidobrensis*) (雙翅目：潛蠅科) 及其臺潛蠅繭蜂 (*Opius caricivorae*) (膜翅目：小繭蜂科) 存活與生育力之影響 [1]

錢景秦 [2,3] 張淑貞 [2]

摘　要

錢景秦、張淑貞。2012。藥劑對南美斑潛蠅 (*Liriomyza huidobrensis*) (雙翅目：潛蠅科) 及其臺潛蠅繭蜂 (*Opius caricivorae*) (膜翅目：小繭蜂科) 存活與生育力之影響。台灣農業研究 61:316–329。

臺潛蠅繭蜂 (*Opius caricivorae* Fischer) 為台灣地區南美斑潛蠅 [*Liriomyza huidobrensis* (Blanchard)] 重要本地種寄生蜂。本文以藥劑浸漬帶有南美斑潛蠅與寄生蜂豆葉之方法，於室內測試歐殺滅 (oxamyl SL)、阿巴汀 (abamectin EC) 及賽滅淨 (cyromazine SL, WP) 等藥劑對南美斑潛蠅及其臺潛蠅繭蜂存活與生育力之影響。結果得知上述三種藥劑均對南美斑潛蠅具顯著致死效果，可供該蠅防治用。歐殺滅與阿巴汀對南美斑潛蠅各蟲期之防治效能，均以卵與幼蟲期最高，存活率為 0%；其次為成蟲期，成蠅接觸上述二種藥劑 24 小時，其間雌蠅存活率、雄蠅存活率、產卵數及取食刻點數，不僅各受到 27.1 與 25.1、40.5 與 38.8、90.3 與 98.6 及 94.6% 與 99.2% 之抑制，尚對之後的雌蠅壽命、雄蠅壽命、子代成蠅數及取食刻點數，各達 50.8 與 67.8、59.8 與 71.7、88.1 與 93.3 及 84.3% 與 93.9% 之抑制。賽滅淨二種劑型 (溶液與可濕性粉劑) 對南美斑潛蠅各蟲期之防治效能一致，均以幼蟲期最高，存活率為 0%；成蟲期次之，成蠅接觸此藥劑不同劑型 24 小時，其間藥劑對成蠅存活率、產卵數及取食刻點數等，雖均無顯著直接影響，但對之後的雌蠅壽命、雄蠅壽命、子代成蠅數及取食刻點數，各達 26.0 與 26.6、39.4 與 43.3、89.6 與 85.1 及 86.2% 與 83.9% 之抑制；卵期影響最小，該劑二種劑型對孵化率之抑制雖僅各達 23.7% 與 25.7%，但對其後第一幼蟲存活率之抑制各達 49.8% 與 45.5%，對第二齡幼蟲存活率之抑制均達 100%。臺潛蠅繭蜂方面，三種藥劑雖均對臺潛蠅繭蜂卵期無顯著毒害，但其後幼蟲至蛹期之存活率均降為 0%。成蜂各接觸三種藥劑 24 小時，其中以阿巴汀最毒，雌、雄蜂存活率各顯著降低 90.0% 與 46.7%；歐殺滅次之，僅顯著降低雌蜂存活率 21.4%；賽滅

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淨二種劑型則對雌、雄蜂存活率均無顯著抑制影響。致死寄主方面，三種藥劑分別與臺潛蠅繭蜂併用，各處理組之致死寄主率均達 100%，單用臺潛蠅繭蜂者則僅 64.8%。生殖力方面，阿巴汀與歐殺滅均顯著各減少 86.2% 與 67.7% 產卵量與 100% 子代成蜂數，賽滅淨二種劑型則僅減少 100% 子代成蜂數。成蜂各接觸三種藥劑 24 小時後，繼之供以未經藥劑處理之南美斑潛蠅幼蟲，結果僅阿巴汀對寄生蜂雌、雄蜂壽命及生育力，各顯著減少 80.7、59.0 及 100%；至於歐殺滅與二種劑型之賽滅淨，無論對臺潛蠅繭蜂之壽命、生育力及子代雌性比均無顯著影響。綜合考慮藥劑對臺潛蠅繭蜂之直接與亞致死影響，由於賽滅淨二種劑型均對南美斑潛蠅具高毒性，但對臺潛蠅繭蜂之毒性較低，因而在寄生蜂安全上，建議在南美斑潛蠅防治中賽滅淨可與臺潛蠅繭蜂配合施用。

關鍵詞：斑潛蠅、南美斑潛蠅、寄生蜂、臺潛蠅繭蜂、藥劑、蟲期。

前　言

南美斑潛蠅 [*Liriomyza huidobrensis* (Blanchard)] 屬雙翅目 (Diptera)、潛蠅科 (Agromyzidae)。最早發生於中美洲與南美洲，1980 年代之後，擴散分布於北美洲 (美國加州)、中美洲與加勒比海、南美洲、歐洲、非洲、亞洲及大洋洲 (夏威夷、關島) 等地 (Anonymous 2006, http://www.cabi.org/cpc/)。南美斑潛蠅之食性為高度多食性，為世界性重要之蔬菜、花卉及糧食作物等之害蟲 (Jiang *et al*. 1997; Wen *et al*. 1998; Zou *et al*. 1998; Chen & Kang 2002; Luo *et al*. 2002; Song *et al*. 2004; Anonymous 2006)。

台灣於 1998 年 11 月首次在雲林縣林內鄉油菜上發現南美斑潛蠅 (Chien & Chang unpublished data)，2000 年登錄為台灣新侵入種 (Shiao & Wu 2000)，至今已分布於台灣中、南部及澎湖、金門、馬祖，危害 6 科、26 種蔬果，偏好溫涼氣候，平地僅在 11 月至翌年 5 月發生，危害冬季蔬菜，為斑潛蠅類在蒸菜、豌豆、萵苣及茼蒿上之優勢種 (40.4–100%) (Chien & Chang unpublished data)。

底比斯釉小蜂 [*Chrysocharis pentheus* (Walker)]、岡崎釉小蜂 [*Closterocerus okazakii* (Kamijo)] 及臺潛蠅繭蜂 (*Opius caricivorae* Fischer) 為台灣地區南美斑潛蠅本地種寄生蜂 (Chien & Chang unpublished data)，其中臺潛蠅繭蜂因其生物習性與族群內在增殖率，致使在 15℃、20℃與 25℃時，對南美斑潛蠅族群分別具有強勢或相當之抑制力 (Chien & Chang 2012a, 2012b, 2012c)。

南美斑潛蠅與臺潛蠅繭蜂之形態、生活史及生命表等相關研究業已完成 (Wen *et al*. 2002; Chien & Chang 2008, 2012a, 2012b, 2012c)。由於行政院農業委員會審定植物保護手冊中，並未列有防治南美斑潛蠅之推薦藥劑，所以本研究參考該手冊中推薦防治番茄斑潛蠅 [*Liriomyza bryoniae* (Kaltenbach)] 藥劑，或在十字花科蔬菜、豆科豆菜類、洋香瓜、茄科果菜、茄科、蕹菜、芹菜、菠菜、菊科蔬菜、瓜類及蔥科葉菜類等作物推薦防治斑潛蠅類之延伸使用藥劑 (Anonymous 2010, http://www.tactri.gov.tw/htdocs/ppmtable/)，及可有效防治蔬菜斑潛蠅 (*Liriomyza sativae* Blanchard) (Chien & Chang 2010) 之殺蟲劑中，選擇歐殺滅溶液 (oxamyl SL)、阿巴汀乳劑 (abamectin EC)、賽滅淨溶液 (cyromazine SL) 及賽滅淨可濕性粉劑 (cyromazine WP)，與各藥劑之推薦濃度，

於室內進行此等藥劑對南美斑潛蠅及其臺潛蠅繭蜂未成熟期與成蟲期之藥效與影響，期能將結果提供該蠅綜合防治之參考。

材料與方法

寄主植物之栽培

參照 Chien & Ku (1996) 於溫室內栽培菜豆苗 (*Phaseolus vulgaris* var. *communis* Aeschers) 之方法，待菜豆苗發育至株高 15–20 cm，本葉 (primary leaf) 葉寬達 7–9 cm 時，即可供室內南美斑潛蠅產卵與以下不帶蟲豆苗浸漬藥劑試驗用。

南美斑潛蠅與寄生蜂之採集

參照 Chien & Chang (2008) 之方法，在雲林縣林內鄉菜豆 (*Phaseolus vulgaris* L.) 上採集被南美斑潛蠅幼蟲危害之葉片，攜回室內並將被害葉放入塑膠盤內，待幼蟲化蛹，將蛹置入一端有紗網覆蓋之壓克力筒內 (直徑 20 cm、高 25 cm)。待南美斑潛蠅與臺潛蠅繭蜂羽化，供做飼育之蟲源。

南美斑潛蠅與臺潛蠅繭蜂之繁殖

參照 Chien & Ku (1996) 飼育非洲菊斑潛蠅 [*Liriomyza trifolii* (Burgess)] 之方法，在室內 25℃定溫下，以株高 15–20 cm、本葉寬 7–9 cm 之菜豆苗供南美斑潛蠅產卵繁殖。臺潛蠅繭蜂之繁殖則參照 Chien & Ku (2001) 與 Chien & Chang (2012a) 之方法，以帶有南美斑潛蠅第三齡幼蟲潛食之罐插菜豆苗，供臺潛蠅繭蜂產卵繁殖。

供試藥劑

供試藥劑與濃度係參照農業委員會農藥技術諮議委員會審定植物保護手冊中，推薦防治番茄斑潛蠅藥劑、或推薦防治斑潛蠅類之延伸使用藥劑 (Anonymous 2010)、及可有效防治蔬菜斑潛蠅 (Chien & Chang 2010) 藥劑中之歐殺滅溶液、阿巴汀乳劑、賽滅淨溶液及賽滅淨可濕性粉劑。各藥劑之施用濃度、化學類別及出品公司詳見表 1。

帶蟲與不帶蟲豆苗之預備

帶有南美斑潛蠅豆苗之預備：參照 Chien & Chang (2010) 之方法，在 25℃定溫下以菜豆苗供南美斑潛蠅產卵 4 小時，然後將本葉內帶有蠅卵之菜豆苗移出，並放置於溫度 25℃、相對濕度 65–85% 及光週期 14L：10D (上午 5 點至下午 7 點間照光) 下之室內繼續飼養，以供後述藥效試驗，包括帶有蠅卵 (產卵後第二日)、或帶有斑潛蠅第三齡幼蟲 (產卵後第六日) 豆苗之試驗材料。所有供試之帶有南美斑潛蠅豆苗祇留有 2 片本葉，真葉 (mature leaf) 均摘除。

帶有臺潛蠅繭蜂豆苗之預備：參照 Chien & Chang (2011) 之方法，在 25℃定溫下先將 4 至 5 株帶有共約 120 隻南美斑潛蠅三齡幼蟲 (產卵後第六日) 之豆苗合插於一個盛水塑膠罐

表 1. 供試藥劑種類、濃度、化學類別及出品公司
Table 1. Chemical insecticides used in this study

Common name and formulation	Dilution factor	Chemical group	Activity	Manufacturer
Oxamyl 10% SL	250	Carbamate	Insecticide, acaricide, nematicide	DuPont Taiwan Ltd., Taipei, Taiwan
Abamectin 2% EC	1000	Avermectin	Insecticide, acaricide, nematicide	Syngenta Taiwan Ltd., Taipei, Taiwan
Cyromazine 8.9% SL	1000	Triazine	Insecticide (insect growth regulator), acaricide	Syngenta Taiwan Ltd., Taipei, Taiwan
Cyromazine 75% WP	4000	Triazine	Insecticide (insect growth regulator), acaricide	Syngenta Taiwan Ltd., Taipei, Taiwan

內 (直徑 4 cm、高 5 cm)，置入內徑 21 cm 之塑膠圓盤，並罩以上述相同大小之壓克力筒，各接入 30 隻已交尾且有產卵經驗之臺潛蠅繭蜂雌蜂，2 小時後供試之南美斑潛蠅幼蟲幾全部被寄生 (Chien & Chang 2012a)，此時將本葉內南美斑潛蠅幼蟲體內帶有蜂卵之菜豆苗移出，供後述藥效試驗。所有供試之帶有寄生蜂蜂卵豆苗祇留有 2 片本葉，真葉均摘除。至於各供試卵之數量，可藉寄生蜂單員 (solitary)、幼蟲至蛹內寄生 (larval-pupal endoparasitism) 之特性 (Chien & Chang 2012a)，由每片豆葉上之南美斑潛蠅幼蟲數先估算寄生蜂之卵數，待南美斑潛蠅老熟幼蟲鑽出豆葉化蛹後之第六日，除以立體顯微鏡 (Wild, Heerbrugg, Switzerland，接目鏡 20×、接物鏡 6×) 透過南美斑潛蠅蛹體計數寄生蜂之前蛹數外，尚解剖已死之南美斑潛蠅蛹，檢視其體內寄生蜂未孵化之卵數與死亡幼蟲數，確認實際供試之蜂卵數。

不帶蟲豆苗之預備：參照 Chien & Chang (2010) 之方法，準備未經南美斑潛蠅雌蠅或臺潛蠅繭蜂雌蜂產卵之相同大小豆苗，做為不帶蟲豆苗之試驗材料。

帶蟲或不帶蟲豆苗浸漬藥劑之處理

參照 Chien & Chang (2010, 2011) 之方法，在 25℃下各將本葉內帶有南美斑潛蠅蠅卵 50–70 粒 (產後第二日) 之單株菜豆苗，或帶有南美斑潛蠅第三齡幼蟲 40–60 隻 (產卵後第六日)、或本葉內南美斑潛蠅幼蟲體內已有臺潛蠅繭蜂蜂卵 30–63 粒 (產後第二日)、或不帶蟲之單株菜豆苗，均齊根剪下浸漬藥液 1 分鐘，再插入盛水試管內，待 30 分鐘豆葉表面之藥液自然風乾後，在距豆苗剪口 5 cm 處以海綿片束紮，並直插入罐蓋上有圓孔之盛水塑膠罐底部，供各項試驗用。另設浸水處理之對照組，其方法與過程與浸藥處理相同，僅豆苗浸漬藥劑時，對照組係以水替代之。

斑潛蠅卵期施藥對其未成熟期存活率之影響

參照 Chien & Chang (2010) 之方法，於 25℃定溫下在帶蟲 (南美斑潛蠅卵) 豆苗浸藥處理後之第三日，記錄南美斑潛蠅第一齡幼蟲數與未孵化蠅卵數，以計算蠅卵之存活率。第四日起，每日記錄南美斑潛蠅各齡幼蟲數、蠅蛹數及成蠅數。另設僅浸水處理之帶蟲 (南美斑潛蠅卵) 豆苗為對照組，其方法與過程與浸藥處理相同。每處理各做 4–6 重複。

斑潛蠅第三齡幼蟲期施藥對其未成熟期存活率之影響

參照 Chien & Chang (2010) 之方法，於 25℃定溫下在帶蟲 (南美斑潛蠅第三齡幼蟲) 豆苗浸藥處理後之第二日，記錄蠅蛹數與死亡斑潛蠅幼蟲數，以計算藥劑對南美斑潛蠅第三齡幼蟲存活率之影響。第十日起，每日記錄羽化之成蠅數，以計算藥劑對蠅蛹存活率之影響。另設僅浸水處理之帶蟲 (南美斑潛蠅第三齡幼蟲) 豆苗為對照組，其方法與過程與浸藥處理相同。每處理各做 4 重複。

藥劑對斑潛蠅成蠅之影響

豆苗浸藥後接成蠅 **24** 小時之處理：參照 Chien *et al.* (2007a) 與 Chien & Chang (2010) 之方法，在 25℃定溫下上午 9 點將南美斑潛蠅二日齡已交尾成蠅 10 對 (羽化後第三日) 置入壓克力筒內，除供應 2 株已浸藥處理後之不帶蟲豆苗供其產卵與取食外，另以蜂蜜供應成蠅食用。24 小時後僅將成蠅移出，記錄雌、雄蠅之存活數；豆苗仍留在原壓克力筒內，距雌蠅與藥劑接觸後之次日、第四日及第四至六日，分別記錄原浸藥豆葉上雌蠅之取食刻點數、子代蠅卵數及子代第一至三齡斑潛蠅幼蟲數。另設僅浸水處理之不帶蟲豆苗為對照組，其方法與過程與浸藥處理相同。每處理各做 4–8 重複。

成蠅接觸藥劑 **24** 小時後存活個體之後續

觀察：參照 Chien & Chang (2010) 之方法，在上述南美斑潛蠅成蠅經接觸 24 小時豆苗藥劑處理後，自存活者中隨機選取 1 對成蠅，置入另一壓克力筒內，每日供應蜂蜜與未經浸藥處理之 1 株不帶蟲豆苗，直至雌蠅死亡為止。然後記錄該蠅之壽命、生育力及取食刻點數。對照組之雌蠅則是選自藥劑試驗中對照組之存活者，其方法與過程與浸藥處理相同。每處理各做 8–28 重複。

寄生蜂卵期施藥對其未成熟期存活率之影響

於 25℃定溫下，距帶蟲 (南美斑潛蠅幼蟲體內有臺潛蠅繭蜂卵者) 豆苗浸藥處理後第二天，收集內已有寄生蜂卵之南美斑潛蠅蛹，置入直徑 9 cm、高 1.5 cm 之塑膠培養皿內。依 Chien *et al.* (2007b) 之方法與臺潛蠅繭蜂之發育 (Chien & Chang 2012a)，7 日後鏡檢記錄各處理組臺潛蠅繭蜂卵之孵化率及其後幼蟲至蛹期之存活率。另設僅浸水處理之對照組，其方法與過程與浸藥處理相同。每處理各做 4–5 重複。

藥劑對寄生蜂成蜂之影響

帶有南美斑潛蠅豆苗浸藥後接蜂 24 小時之處理：參照 Chien *et al.* (2007b) 之方法，在 25℃定溫下，上午 9 點將臺潛蠅繭蜂二日齡已交尾成蜂 10 對 (羽化後第三日) 釋入直徑 20 cm、高 25 cm 壓克力筒內，同時將浸藥後 30 分鐘之帶蟲 (200 隻第三齡南美斑潛蠅幼蟲) 豆苗供其產卵，另以細毛筆將蜂蜜塗於壓克力筒內壁，供成蜂食用。24 小時後移出成蜂，記錄雌、雄蜂之存活數，豆苗仍留在原壓克力筒內，二日後收集南美斑潛蠅蛹，置入直徑 9 cm、高 1.5 cm 之塑膠培養皿內，依 Chien *et al.* (2007b) 之方法與臺潛蠅寄生蜂之習性 (Chien & Chang 2012a)，距雌蜂與藥劑接觸後之 7 日鏡檢記錄寄生蜂卵數，15 日後記錄子蜂數、雌性比、南美斑潛蠅死亡率等。另設僅浸水處理之對照組，其方法與過程與浸藥處理相同。每處理各做 4 重複。南美斑潛蠅死亡率之公式為 [1 – (南美斑潛蠅成蠅數 ÷ 供試南美斑潛蠅幼蟲數)]。

成蜂接觸藥劑 24 小時後存活個體之後續觀察：參照 Chien *et al.* (2007b) 之方法，在上述臺潛蠅繭蜂成蜂經接觸 24 小時帶有南美斑潛蠅豆苗藥膜處理後，自存活成蜂中隨機選取 1 對成蜂，釋入另一直徑 20 cm、高 25 cm 壓克力筒內，每日供應蜂蜜與新鮮未經浸藥處理帶有 30–40 隻第三齡南美斑潛蠅幼蟲之單株罐插豆苗，直至雌蜂死亡為止。然後依 Chien *et al.* (2007b) 之方法，計數該蜂之壽命、生育力及子代雌性比。對照組之雌蜂則是選自藥劑試驗中對照組之存活者，其方法與過程與浸藥處理相同。每處理各做 7–12 重複。

統計分析

各項處理之試驗資料利用 SAS-EG (SAS Enterprise Guide) 4.1 版本統計分析軟體先進行變方分析 (analysis of variance, ANOVA)，再以最小顯著差異性 (least significant difference, LSD) 測驗，在 5% 顯著水準下比較處理間平均值之差異；若遇百分率時，資料先進行角度轉換 (arcsine transformation)，再進行分析。

結　果

斑潛蠅卵期施藥對其未成熟期存活率之影響

供試之三種藥劑與劑型中，以歐殺滅與阿巴汀對南美斑潛蠅卵之藥效最強，存活率為 0%；其次為賽滅淨，不論是溶液或可濕性粉劑之劑型，卵存活率各為 75.0% 與 73.0%，各藥劑與對照組 (98.3%) 均呈顯著差異。若持續觀察孵化幼蟲在原浸藥處理豆葉上之發育，則發現賽滅淨二種劑型 (溶液與可濕性粉劑) 均使南美斑潛蠅第一齡幼蟲之存活率各銳減為 48.1% 與 52.3%，第二齡幼蟲之存活率均銳減

為 0%，劑型間雖無顯著差異，但均與對照組呈顯著差異 (表 2)。

斑潛蠅第三齡幼蟲期施藥對其存活率之影響

供試之三種藥劑與劑型均對南美斑潛蠅第三齡幼蟲有顯著之藥效，其存活率均為 0%，處理間無顯著差異，但均與對照組 (100%) 呈顯著差異 (表 3)。

藥劑對斑潛蠅成蠅之影響

豆苗浸藥後接成蠅 **24** 小時之處理：歐殺滅與阿巴汀對南美斑潛蠅成蠅之藥效影響一致，二種藥劑不但各對雌蠅 (27.1% 與 25.1%) 與雄蠅 (40.5% 與 38.8%) 具顯著致死率、亦顯著各降低雌蠅之產卵量 (90.3% 與 98.6%)、抑制 100% 卵之孵化率及各減少 94.6% 與 99.2% 雌蠅之取食刻點數；同時藥劑對雄蠅之致死率顯著高於雌蠅。賽滅淨二劑型處理組中，成蠅存活率、產卵數及取食刻點數等，雖均與對照組無顯著差異，但其子代第一、二及三齡幼蟲數卻顯著較對照組各銳減 66.7–75.0、98.6 及

表 2. 南美斑潛蠅卵經不同藥劑處理後對卵、幼蟲、蛹及卵至蛹期存活率之影響

Table 2. Effect of treatment of eggs of *Liriomyza huidobrensis* with various insecticides on survival of egg, larval, pupal, and egg to pupal stages [z]

	Survival (%) of the stages of *Liriomyza huidobrensis*						
		Larva					
Insecticides	Egg	1st	2nd	3rd	total	Pupa	Egg to pupa
Oxamyl	0.0 ± 0.0 c [y]	–	–	–	–	–	0.0 ± 0.0 b
Abamectin	0.0 ± 0.0 c	–	–	–	–	–	0.0 ± 0.0 b
Cyromazine SL	75.0 ± 3.2 b	48.1 ± 2.2 b	0.0 ± 0.0 b	–	0.0 ± 0.0 b	–	0.0 ± 0.0 b
Cyromazine WP	73.0 ± 4.6 b	52.3 ± 2.1 b	0.0 ± 0.0 b	–	0.0 ± 0.0 b	–	0.0 ± 0.0 b
CK	98.3 ± 1.7 a	95.9 ± 1.9 a	98.3 ± 1.0 a	100.0 ± 0.0	96.3 ± 2.3 a	64.9 ± 2.5	58.3 ± 3.2 a

[z] One seedling of field bean infested with 50–70 *L. huidobrensis* eggs was dipped in an insecticide solution for 1 min. For untreated control, one seedling infested with 50–70 *L. huidobrensis* eggs was dipped in distilled water. At 30 min after treatment, one seedling was placed in an acrylic cylinder (20 cm diameter × 25 cm height) and kept at 25℃, 65–85% RH and a photoperiod of 14L:10D.

[y] Mean ± standard error (n = 4–6). Means within each column followed by the same letter(s) are not significantly different at 5% level by LSD test. Data were transformed to arcsin-square-root prior to ANOVA.

表 3. 南美斑潛蠅第三齡幼蟲經不同藥劑處理後對幼蟲、蛹及幼蟲至蛹期存活率之影響

Table 3. Effect of treatment of third instar larvae of *Liriomyza huidobrensis* with various insecticides on survival of larval, pupal, and larval to pupal stages [z]

	Survival (%) of the stages of *Liriomyza huidobrensis*		
Insecticides	Larva	Pupa	Larva to pupa
Oxamyl	0.0 ± 0.0 b [y]	–	0.0 ± 0.0 b
Abamectin	0.0 ± 0.0 b	–	0.0 ± 0.0 b
Cyromazine SL	0.0 ± 0.0 b	–	0.0 ± 0.0 b
Cyromazine WP	0.0 ± 0.0 b	–	0.0 ± 0.0 b
CK	100.0 ± 0.0 a	79.6 ± 2.9	79.6 ± 2.9 a

[z] One seedling of field bean infested with 40–60 third-instars of *L. huidobrensis* was dipped in an insecticide solution for 1 min. For untreated control, one seedling infested with 40–60 third-instars of *L. huidobrensis* was dipped in distilled water. At 30 min after treatment, one seedling was placed in an acrylic cylinder (20 cm diameter × 25 cm height) and kept at 25℃, 65–85% RH and a photoperiod of 14L:10D.

[y] Mean ± standard error (n = 4). Means within each column followed by the same letter(s) are not significantly different at 5% level by LSD test. Data were transformed to arcsin-square-root prior to ANOVA.

100%，二劑型處理間無顯著差異 (表 4)。

成蠅接觸藥劑 24 小時後存活個體之後續觀察：各藥劑對南美斑潛蠅之雌蠅與雄蠅壽命均呈顯著減少，就雌蠅壽命而言，以阿巴汀藥效最強，歐殺滅次之，賽滅淨之二種劑型最差，各較對照組顯著減少 67.8、50.8 及 26.0–26.6%，處理間呈顯著差異；雄蠅壽命方面則以歐殺滅與阿巴汀藥效最強，賽滅淨之二種劑型次之，各較對照組顯著減少 59.8–71.7% 與 39.4–43.3%，處理間呈顯著差異；同時各處理組中雄蠅壽命均顯著較雌蠅短。生育力方面，各藥劑對子代第三齡幼蟲數、蛹數及成蠅數之影響，處理間雖均無顯著差異，但卻均顯著較對照組各減少 84.3–91.5、84.3–91.9 及 85.1–93.3%。子代雌性比方面，僅阿巴汀處理組較對照組顯著減少 25.0%，其餘各藥劑均與對照組無顯著差異。取食刻點數方面，各藥劑對雌蠅取食刻點數顯著較對照組減少 83.9–93.9% (表 5)。

寄生蜂卵期施藥對其卵與幼蟲至蛹期存活率之影響

臺潛蠅繭蜂卵經三種不同藥劑與劑型處理

表 4. 南美斑潛蠅成蟲經不同藥劑處理 24 小時內之存活率、子代數及取食刻點數

Table 4. Survival, progeny and feeding stipples of *Liriomyza huidobrensis* adults treated with various insecticides for 24 hours [z]

				No. progeny/10 females					
		Survival of adult (%)			Larva			Survival of egg (%)	No. feeding stipples/10 females
Insecticides	*n*	Female	Male	Egg	1st	2nd	3rd		
Oxamyl	8	72.9 ± 2.9 Ab [y]	57.1 ± 5.2 Bb	7 ± 2 b	0 ± 0 c	–	–	0.0 ± 0.0 c	66 ± 12 b
Abamectin	8	74.9 ± 3.1 Ab	58.8 ± 4.0 Bb	1 ± 0 b	0 ± 0 c	–	–	0.0 ± 0.0 c	10 ± 1 b
Cyromazine SL	5	98.0 ± 2.0 Aa	96.0 ± 2.4 Aa	86 ± 11 a	18 ± 3 b	1 ± 1 b	0 ± 0 b	22.7 ± 5.4 b	1129 ± 136 a
Cyromazine WP	4	100.0 ± 0.0 Aa	95.0 ± 2.9 Aa	78 ± 9 a	24 ± 5 b	1 ± 1 b	0 ± 0 b	29.3 ± 3.5 b	1027 ± 81 a
CK	5	100.0 ± 0.0 Aa	96.0 ± 2.4 Aa	72 ± 7 a	72 ± 7 a	72 ± 7 a	72 ± 7 a	100.0 ± 0.0 a	1215 ± 67 a

[z] One seedling of field bean was dipped in an insecticide for 1 min. For untreated control, one seedling was dipped in distilled water. At 30 min after treatment, 4–5 seedlings were placed in an acrylic cylinder (20 cm diameter × 25 cm height). Ten pairs of 2-day-old adult flies were released into each cylinder. All the treatments were kept at 25℃, 65–85% RH and a photoperiod of 14L:10D.

[y] Mean ± standard error. Means within a column (in small letter) and within a row of survival rate (in capital letter) followed by the same letter(s) are not significantly different at 5% level by LSD test. Percent survival of adult and egg were transformed to arcsin-square-root prior to ANOVA.

表 5. 南美斑潛蠅成蟲經不同藥劑處理 24 小時後之壽命、生育力及取食刻點數

Table 5. Longevity, fertility, female proportion and feeding stipples of *Liriomyza huidobrensis* adults survived from the insecticide treatment for 24 hours [z]

		Longevity (d)		Fertility/female			Female proportion	No. feeding stipples/female
Insecticides	*n*	Female	Male	No. 3rd instars	No. pupae	No. adults		
Oxamyl	20	8.7 ± 1.1 Ac [y]	5.1 ± 0.6 Bc	39 ± 7 b	39 ± 7 b	16 ± 3 b	0.48 ± 0.02 a	555 ± 88 b
Abamectin	28	5.7 ± 0.7 Ad	3.6 ± 0.4 Bc	21 ± 6 b	20 ± 6 b	9 ± 3 b	0.39 ± 0.04 b	216 ± 45 c
Cyromazine SL	9	13.1 ± 1.3 Ab	7.7 ± 1.1 Bb	25 ± 8 b	24 ± 8 b	14 ± 5 b	0.57 ± 0.06 a	488 ± 61 bc
Cyromazine WP	13	13.0 ± 1.2 Ab	7.2 ± 1.2 Bb	29 ± 11 b	29 ± 11 b	20 ± 7 b	0.53 ± 0.03 a	570 ± 128 b
CK	8	17.7 ± 2.2 Aa	12.7 ± 0.5 Aa	248 ± 44 a	248 ± 44 a	134 ± 25 a	0.52 ± 0.03 a	3543 ± 466 a

[z] For each replicate, one pair of 3-day-old adults that had survived from the insecticide treatment for 24 hrs was placed in an acrylic cylinder (20 cm diameter × 25 cm height) and kept at 25℃, 65–85% RH and a photoperiod of 14L:10D. One seedling without insecticide treatment was provided daily.

[y] Mean ± standard error. Means within a column (in small letter) and within a row of longevity (in capital letter) followed by the same letter(s) are not significantly different at 5% level by LSD test.

後，蜂卵之孵化率均達 97.1–100%，與對照組間無顯著差異。若持續觀察孵化幼蟲之發育，臺潛蠅繭蜂幼蟲至蛹期之存活率均為 0%，與對照組間呈顯著差異 (表 6)。

藥劑對寄生蜂成蜂之影響

帶有斑潛蠅豆苗浸藥後接蜂 24 小時之處理：臺潛蠅繭蜂成蜂經三種供試藥劑與劑型處理 24 小時後，就雌蜂存活率而言，以阿巴汀最毒，歐殺滅次之，各較對照組顯著降低 90.0% 與 21.4%，而二種劑型之賽滅淨則無毒，與對照組間無顯著差異；雄蜂存活率方面，僅阿巴汀具毒害，較對照組顯著降低 46.7%，其餘各藥劑與對照組間無顯著差異。致死寄主率方面，三種供試藥劑分別與臺潛蠅繭蜂併用，各處理組之致死寄主率均達 100%，處理間無顯著差異，但均較單用臺潛蠅繭蜂對照組顯著增加 35.2% (表 7)。生殖力方面，阿巴汀與歐殺滅均顯著較對照組各減少 86.2% 與 67.7% 產卵數及 100% 子代成蜂數，二藥劑處理間均無顯著差異，而二種劑型之賽

表 6. 臺潛蠅繭蜂卵經不同藥劑處理後對卵、幼蟲至蛹及卵至蛹期存活率之影響

Table 6. Effect of treatment of eggs of *Opius caricivorae* with various insecticides on survival of egg, larval to pupal, and egg to pupal stages [z]

		Survival (%) of the stages of *Opius caricivorae*		
Insecticides	*n*	Egg	Larva to pupa	Egg to pupa
Oxamyl	4	100.0 ± 0.0 a [y]	0.0 ± 0.0 b	0.0 ± 0.0 b
Abamectin	4	97.1 ± 3.0 a	0.0 ± 0.0 b	0.0 ± 0.0 b
Cyromazine SL	4	100.0 ± 0.0 a	0.0 ± 0.0 b	0.0 ± 0.0 b
Cyromazine WP	4	100.0 ± 0.0 a	0.0 ± 0.0 b	0.0 ± 0.0 b
CK	5	100.0 ± 0.0 a	92.2 ± 2.1 a	92.2 ± 2.1 a

[z] One seedling of field bean infested with 30–63 wasp eggs was dipped in an insecticide solution for 1 min. For untreated control, one seedling infested with 30–63 wasp eggs was dipped in distilled water. At 30 min after treatment, one seedling was placed in an individual acrylic cylinder (20 cm diameter × 25 cm height) and kept at 25℃, 65–85% RH and a photoperiod of 14L:10D.

[y] Mean ± standard error. Means within each column followed by the same letter(s) are not significantly different at 5% level by LSD test. Data were transformed to arcsin-square-root prior to ANOVA.

表 7. 臺潛蠅繭蜂成蟲經不同藥劑處理 24 小時內之存活率、致死寄主率及子代數

Table 7. Survival, host killing and progeny of *Opius caricivorae* adults treated with various insecticides for 24 hours [z]

	Survival of adult wasp (%)			Progeny of wasp/10 females		
Treatment	Female	Male	Host killed (%)/ 10 females	No. eggs	No. adults	Female proportion
Oxamyl + wasp	78.6 ± 6.7 Bb [y]	95.7 ± 4.3 Aa	100.0 ± 0.0 a	42 ± 7 b	0 ± 0 b	–
Abamectin + wasp	10.0 ± 3.2 Bc	53.3 ± 6.7 Ab	100.0 ± 0.0 a	18 ± 2 b	0 ± 0 b	–
Cyromazine SL+ wasp	100.0 ± 0.0 Aa	100.0 ± 0.0 Aa	100.0 ± 0.0 a	113 ± 10 a	0 ± 0 b	–
Cyromazine WP + wasp	100.0 ± 0.0 Aa	100.0 ± 0.0 Aa	100.0 ± 0.0 a	134 ± 25 a	0 ± 0 b	–
Water + wasp	100.0 ± 0.0 Aa	100.0 ± 0.0 Aa	64.8 ± 7.7 b	130 ± 15 a	118 ± 12 a	0.70 ± 0.02

[z] One seedling of field bean infested with 40–50 third-instars of *Liriomyza huidobrensis* was dipped in an insecticide solution for 1 min. For untreated control, one seedling infested with 40–50 third-instars of *L. huidobrensis* was dipped in distilled water. At 30 min after treatment, 4–5 seedlings (200 larvae) were placed in an acrylic cylinder (20 cm diameter × 25 cm height). Ten pairs of 2-day-old adult wasps were released into each cylinder. All the treatments were kept at 25℃, 65–85% RH and a photoperiod of 14L:10D.

[y] Mean ± standard error (n = 4). Means within a column (in small letter) and within a row of survival rate (in capital letter) followed by the same letter(s) are not significantly different at 5% level by LSD test. Percent survival of adult and host killed rate were transformed to arcsin-square-root prior to ANOVA.

滅淨雖不減少薑潛蠅繭蜂子代卵數，但 100% 減少薑潛蠅繭蜂子代成蜂數 (表 7)。

成蜂接觸藥劑 24 小時後存活個體之後續觀察：供試藥劑中僅阿巴汀對薑潛蠅繭蜂雌蜂壽命、雄蜂壽命及生育力有顯著影響，各較對照組減少 80.7、59.0 及 100%；至於歐殺滅與二種劑型之賽滅淨，無論對薑潛蠅繭蜂之壽命、生育力及子代雌性比均無毒害，與對照組間均無顯著差異 (表 8)。

討　論

歐殺滅與阿巴汀因分屬胺基甲酸鹽類 (carbamate) 與土壤微生物代謝產物 (avermectin) 類型之藥劑，二者對昆蟲主要分別作用在乙醯膽鹼酯酶 (acetylcholinesterase) 與 GABA receptor 上，具胃毒、接觸毒及神經毒，對蔬菜斑潛蠅兼具 100% 殺卵與幼蟲效果 (Chien & Chang 2010)；而賽滅淨為昆蟲生長調節劑 (insect growth regulator)，會干擾幼蟲之蛻皮與化蛹 (Bel *et al.* 2000; Kamaruzzaman *et al.* 2006)，因而對蔬菜斑潛蠅無殺卵效果 (Chien & Chang 2010)。本試驗雖亦顯示歐殺滅與阿巴汀對南美斑潛蠅兼具 100% 殺卵與幼蟲效果，但二種劑型 (溶液與可濕性粉劑) 之賽滅淨除對南美斑潛蠅幼蟲之死亡率高達 100% 外，亦對該卵之致死率達 23.7–25.7%。其間賽滅淨對蔬菜斑潛蠅與南美斑潛蠅二種不同蠅卵致死率之差異，未明。另外歐殺滅、阿巴汀及賽滅淨等藥劑因其滲透性強，植保手冊 (Anonymous 2010) 在推薦施用時未建議添加展著劑，因而本試驗均未使用展著劑。

綜合三種供試藥劑對南美斑潛蠅各蟲期之防治程度中，歐殺滅與阿巴汀均以卵與幼蟲期最高，防治率高達 100%，其次者為成蟲期；而賽滅淨二種劑型間 (溶液與可濕性粉劑) 對南美斑潛蠅之防治程度並無顯著差異，均以幼蟲期最高，防治率高達 100%，成蟲期次之，卵期最差。He *et al.* (2006) 亦證實阿巴汀與賽滅淨對南美斑潛蠅第二齡幼蟲之毒力較高，對成蠅毒力較低。

Robb & Parrella (1984)、Chien *et al.* (2007a) 及 Chien & Chang (2011) 曾測試昆蟲生長調節劑施用在非洲菊斑潛蠅與蔬菜斑潛蠅幼蟲或成蠅後，確對其成蠅之生育力具亞致死之影響 (sublethal effect)。本試驗則證實歐殺滅與阿巴汀對南美斑潛蠅成蠅具直接致死影響，而賽滅淨二種劑型 (溶液與可濕性粉劑) 則無；但三種藥劑均對成蠅接觸藥劑 24 小時後之壽命、

表 8. 薑潛蠅繭蜂成蟲經不同藥劑處理 24 小時後之壽命、生育力及雌性比

Table 8. Longevity, fertility and female proportion of *Opius caricivorae* survived from the insecticide treatment for 24 hours [z]

Treatment	*n*	Longevity (d)		Fertility/female	Female proportion
		Female	Male	No. adults	
Oxamyl	11	20.1 ± 2.1 Aa [y]	21.2 ± 1.9 Aa	221 ± 17 a	0.62 ± 0.04 a
Abamectin	7	4.9 ± 0.3 Ab	7.7 ± 2.1 Ab	0 ± 0 b	–
Cyromazine SL	10	20.0 ± 1.9 Aa	18.2 ± 2.3 Aa	228 ± 27 a	0.64 ± 0.04 a
Cyromazine WP	10	22.2 ± 3.6 Aa	21.7 ± 2.4 Aa	194 ± 18 a	0.60 ± 0.01 a
CK	12	25.4 ± 2.6 Aa	18.8 ± 1.3 Ba	242 ± 17 a	0.57 ± 0.02 a

[z] For each replicate, one pair of 3-day-old adult wasps that had survived from the insecticide treatment for 24 hrs was placed in an acrylic cylinder (20 cm diameter × 25 cm height) and kept at 25℃, 65–85% RH and a photoperiod of 14L:10D. Third-instar larvae of *Liriomyza huidobrensis* on a bean seedling without insecticide treatment were placed in the acrylic cylinder on daily basis, 30–40 larvae/seedling/day.

[y] Mean ± standard error. Means within a column (in small letter) and within a row of longevity (in capital letter) followed by the same letter(s) are not significantly different at 5% level by LSD test.

生育力及取食刻點數等具亞致死影響。臺潛蠅繭蜂方面，本試驗亦證實三種藥劑中僅阿巴汀與歐殺滅各對雌蜂之存活抑制率 (90.0% 與 21.4%) 與產卵量抑制率 (86.2% 與 67.7%)，及阿巴汀對雄蜂之存活抑制率 (46.7%) 具直接影響，而賽滅淨二種劑型則無；同時三種藥劑中僅阿巴汀各對雌與雄蜂之壽命抑制率 (80.7% 與 59.0%) 與生育力抑制率 (100%) 具亞致死影響。另外賽滅淨二種劑型雖不影響臺潛蠅繭蜂在已施藥南美斑潛蠅幼蟲上產卵 (表 7)，三種藥劑與劑型亦不影響該蜂卵之孵化 (表 6)，但終因三種藥劑與劑型對南美斑潛蠅幼蟲均具 100% 致死率，致使凡在已施藥南美斑潛蠅幼蟲上寄生之臺潛蠅繭蜂均無成蜂羽化。

植保手冊 (Anonymous 2010) 中雖列有多種蔬菜作物斑潛蠅類之延伸使用藥劑，但卻未有明確防治南美斑潛蠅之推薦藥劑。本試驗證實歐殺滅、阿巴汀及賽滅淨二種劑型 (溶液與可濕性粉劑) 因對南美斑潛蠅幼蟲具 100% 致死率，且各藥劑間無顯著差異，因而此三種藥劑均可推薦該蠅防治用。但若考慮成蠅之取食刻點與幼蟲食痕對寄主植物苗期之影響，則防治南美斑潛蠅之最佳藥劑為歐殺滅與阿巴汀，其次為賽滅淨。

Poe *et al.* (1978)、Waddill (1978)、Trumble & Toscano (1983) 及 Trumble (1985) 等曾建議當使用一種藥劑防治斑潛蠅前，應先測試該藥劑對其寄生蜂之影響，並據此作為使用該藥劑之參考。在印尼，Prijono *et al.* (2004) 證實賽滅淨對當地寄生蜂–異角釉小蜂 [*Hemiptarsenus varicornis* (Girault)]、*Opius* sp.、*Gronotoma micromorpha* (Perkins)，與源自澳洲之異角釉小蜂與潛蠅姬小蜂 [*Diglyphus isaea* (Walker)] 有保育作用，所以賽滅淨可用於斑潛蠅之防治體系，而阿巴汀與殺蟲雙 (dimehypo) 則需小心施用。Chien *et al.* (2007a, 2007b) 證實在台灣防治非洲菊斑潛蠅之有效藥劑雖有六種，但其中僅賽滅淨與其二種重要寄生蜂-異角釉小蜂與華釉小蜂 [*Neochrysocharis formosa* (Westwood)] 之相容性大。防治蔬菜斑潛蠅之有效藥劑雖亦有三種，但其中僅賽滅淨、歐殺滅與岡崎釉小蜂相容性大，賽滅淨與底比斯釉小蜂間相容性大 (Chien & Chang 2011)。本試驗顯示三種藥劑雖對臺潛蠅繭蜂均具毒害，但相較下與該蜂相容性最大者為賽滅淨，其次者為歐殺滅，最毒者為阿巴汀。所以在台灣，對斑潛蠅本地重要寄生蜂最安全之藥劑為賽滅淨。

本試驗顯示賽滅淨對臺潛蠅繭蜂之卵期與成蜂期雖無影響，但其幼蟲期在已施藥寄主幼蟲上寄生時死亡率達 100%，因此在論及施用賽滅淨對臺潛蠅繭蜂之保育時，除應考慮該蜂寄生與產卵策略外, 該蜂壽命與賽滅淨殘效期之配合更是主要因子。臺潛蠅繭蜂寄生方式屬幼蟲至蛹單員內寄生，產卵方式屬共育寄生 (koinobiont) (Chien & Ku 2001)；雌蜂行單產雄性孤雌生殖，交尾前期短 (僅為 1.1 小時)，交尾與否對雌蜂生育力無影響，雄蜂一生交尾次數多達 8–17 次，但 95.5% 雌蜂一生僅交尾 1 次且其子代雌性比即高達 0.62，產卵策略為應變式產卵 (synovigenic) 型式、雌蜂產卵數、過寄生率及對寄主之利用率均顯著受寄主蔬菜斑潛蠅密度之影響 (Chien & Chang 2012a)；雌蜂可在三種斑潛蠅之不同齡期上產卵，但均顯著偏好產卵於寄主第二與三齡幼蟲 (Chien & Chang 2012b)；因此顯示臺潛蠅繭蜂在與寄主長期共同演化中，已發展出其配合寄主發生之高度適應性。賽滅淨田間不同作物上之施藥方式為每 7 日或每 7–14 日施藥一次 (Anonymous 2010)，由此推估賽滅淨其殘效期為 7–14 日。至於臺潛蠅繭蜂壽命則深受溫度、寄主體液及蜂蜜之影響，在無寄主存在、僅供應蜂蜜時，在 10、15、20 及 25℃下，雌蜂壽命各長達 108.4、100.9、43.0 及 35.9 日，雄蜂壽命各達 66.2、47.7、21.7 及 27.2 日；無寄主存在、

亦不餵食時，雌蜂與雄蜂壽命在 25℃下僅各為 3.7 日與 3.5 日；餵水時各為 8.4 日與 3.9 日 (Chien & Chang 2012c)。因而當田間施用賽滅淨防治南美斑潛蠅時，田間若有蜂蜜供應或蜜源植物時，臺潛蠅繭蜂成蜂壽命即可獲得延長並遠超出賽滅淨之殘效期，以致該蜂有機會獲得良好保育，進而發揮其對南美斑潛蠅之抑制力。

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Effect of Insecticides on Survival and Fertility of *Liriomyza huidobrensis* (Diptera: Agromyzidae) and Its Parasitoid, *Opius caricivorae* (Hymenoptera: Braconidae)[1]

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Abstract

Chien, C. C. and S. C. Chang. 2012. Effect of insecticides on survival and fertility of *Liriomyza huidobrensis* (Diptera: Agromyzidae) and its parasitoid, *Opius caricivorae* (Hymenoptera: Braconidae). J. Taiwan Agric. Res. 61:316–329.

Opius caricivorae Fischer is an important species of native parasitoid of leafminer *Liriomyza huidobrensis* (Blanchard) in Taiwan. In this study, seedlings of field beans (*Phaseolus vulgaris* var. *communis* Aeschers) treated with insecticides (oxamyl SL, abamectin EC, cyromazine SL, or cyromazine WP) were used to determine effect of insecticides on survival and fertility of leafminer (*L. huidobrensis*) and its parasitoid (*O. caricivorae*) at different development stages under laboratory conditions. Results showed that all the insecticides (oxamyl, abamectin, cyromazine SL and cyromazine WP) had significant ($P < 0.05$) lethal effects on *L. huidobrensis* and could be used in the control of leafminer. The highest lethal effect of oxamyl and abamectin was at the egg and larval stages with a survival rate of 0%, and the second most effective period was at the adult stage. When adult flies were treated with either oxamyl or abamectin for 24 hours, the female survival rate, male survival rate, number of eggs and number of feeding stipples decreased by 25.1–27.1, 38.8–40.5, 90.3–98.6 and 94.6–99.2%, respectively. The female longevity, male longevity, adult progeny and number of feeding stipples after treatment for 24 hours also decreased by 50.8–67.8, 59.8–71.7, 88.1–93.3 and 84.3–93.9%, respectively. The highest lethal effect of the two cyromazine formulations was at the larval stage with a survival rate of 0% and the second most effective period was at the adult stage. Treatment of adult flies with each of the two cyromazine formulations for 24 hours resulted in no significant reduction in female survival rate, male survival rate, number of eggs, and feeding stipples. However, both formulations reduced female longevity, male longevity, adult progeny and number of feeding stipples after treatment for 24 hours by 26.0–26.6, 39.4–43.3, 85.1–89.6 and 83.9–86.2%, respectively. The two cyromazine formulations had least effect on the egg stage of *L.*

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huidobrensis with 23.7–25.7% reduction of egg hatching rate and larval mortality rate of 45.5–49.8% for the 1st instar and 100% for the 2nd instar. All the insecticides had no lethal effect on the egg stage of the parasitoid *O. caricivora*, but they were lethal on larval to pupal stages of this wasp with a survival rate of 0%. Abamectin was the most toxic insecticide on the wasp among the insecticides tested. When adult wasps were treated with insecticide for 24 hours, the survival rates of female and male decreased 90.0% and 46.7%, respectively, for the treatment of abamectin; the survival rate of female decreased 21.4% for the treatment of oxamyl. The percentage of hosts (*L. huidobrensis*) killed by the combined treatment of insecticide and wasps was 100%, compared to 64.8% killed by the treatment of wasps alone. After the adult wasps were treated with either abamectin or oxamyl, the number of eggs and progeny of adult wasps decreased by 67.7–86.2% and 100%, respectively, compared to the decrease of 0% in number of eggs and 100% of progeny of adult wasps by the treatment of cyromazine. When adult wasps were treated with each of the three insecticides for 24 hours and released on untreated bean seedlings infested with hosts (*L. huidobrensis*) daily, abamectin caused a reduction in longevity of female and male wasps by 80.7% and 59.0%, and fertility of wasps by 100%. However, no effect was observed on longevity, fertility, and female proportion of wasps when oxamyl and two formulations of cyromazie were used. For the direct and sublethal effects of insecticides on *L. huidobrensis* and *O. caricivorae*, cyromazine either in SL (solution liquid) or WP (wettable powder) is highly toxic to leafminer but is least toxic to wasps (*O. caricivorae*) and, therefore, combined application of cyromazine and wasps in the control program of *L. huidobrensis* is commended.

Key words: Leafminer, *Liriomyza huidobrensis*, Parasitoid, *Opius caricivorae*, Insecticide, Development Stages.