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研究報告

慣行與永續農法對水稻田瓢蟲之影響

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摘要

本研究呈現 2014–2020 年於嘉義縣溪口農場及雲林縣雲林分場農業試驗田區，調查不同農耕下田區之瓢蟲種類及數量之結果。於溪口農場及雲林分場黃色黏板分別調查到 11 種及 12 種瓢蟲，其中六條瓢蟲是數量最多之瓢蟲，分別占所調查到瓢蟲數量之 83.1% 及 79.2%。慣行農耕及永續農耕田區調查到瓢蟲數量及種類數沒有差異。水稻田與落花生田調查到瓢蟲數量與種類數並無差異，但二期作落花生田調查到瓢蟲種類顯著少於一期作水稻田。溪口農場慣行農耕及永續農耕田區比較，噴施殺蟲劑明顯降低農友操作田區瓢蟲種類及數量。本試驗結果顯示，六條瓢蟲於慣行農耕、永續農耕及農友操作田區，均是最優勢的捕食性天敵，這項資訊有助於未來研究人員發展水稻害蟲生物防治策略，降低農民對化學農藥的依賴，但是在此之前應避免隨意使用化學農藥，以利保育六條瓢蟲這些重要的捕食性天敵。

關鍵詞：水稻田、慣行農耕、永續農耕、瓢蟲、長期生態研究。

前言

水稻 (*Oryza sativa* Linnaeus) 是世界上重要糧食作物之一，全世界有超過 50% 人口以稻米作為每日所需要熱量主要來源 (Counce *et al*. 2000; Maclean *et al*. 2002; Coats 2003)。研究顯示部分瓢蟲種類是水稻田重要害蟲天敵 (Rekha *et al*. 2009; Shanker *et al*. 2013a) 主要捕食蚜蟲。Shanker *et al*. (2018b) 於室內研究試驗中，以褐飛蝨 (*Nilaparvata lugens* Stal)、白背飛蝨 (*Sogatella furcifera* Hovarth) 及綠葉蟬 (*Nephotettix* spp.) 等重要水稻害蟲之三齡若蟲測試，發現八條瓢蟲 (*Harmonia octomaculata* Fabricius)、六條瓢蟲 (*Cheilomenes sexmaculata* Fabricius)、波紋瓢蟲 (*Coccinella transversalis* Fabricius) 及橙瓢蟲 (*Micraspis discolor* Fabricius) 之成蟲及三齡幼蟲皆有取食行為。

捕食者在害蟲管理上的生態角色往往被低估，但目前研究顯示捕食者在農業生態系中，在調節害蟲族群功能上扮演重要的角色，藉由管理捕食者的族群數量與豐度，有可能大幅降低害蟲的族群數量 (Symondson *et al*. 2002; Shanker *et al*. 2018a)。蚜蟲、粉蝨、薊馬、介殼蟲、飛蝨、葉蟬及蟎類等是農作物重要小型害蟲，由於世代短、繁殖率高，容易族群爆發對作物造成嚴重危害，捕食性瓢蟲於自然界中常伴隨上述這些害蟲並調節其族群發展 (Omkar & Harsur 2020)。前人研究在水稻生態環境中的瓢蟲如橙瓢蟲 (*M. discolor* Fabricius) 等時常發生的捕食者，有助於壓制水稻田害蟲族群密度 (Rekha *et al*. 2009; Shanker *et al*. 2013a)。

水稻田瓢蟲族群易受農田操作模式影響，特別是噴施化學藥劑，Anitha *et al*. (2020) 於印度水稻田調查研究結果，橙瓢蟲隸屬之兼

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食瓢蟲屬 (*Micraspis*) 瓢蟲於有機農耕水稻田平均調查數量為 32.41 隻，於無處理水稻田為 30.48 隻，而農友慣行操作水稻田則為 16.10 隻，顯示瓢蟲族群多寡顯著受農民操作方式影響。為明瞭台灣地區水稻田發生瓢蟲種類及不同操作下對瓢蟲影響，2014–2020 年間於嘉義縣溪口農場及雲林縣雲林分場進行，調查不同耕作制度下對水稻田發生瓢蟲種類、數量及影響。

材料與方法

本試驗分別於行政院農業委員會農業試驗所嘉義分所溪口農場 (23°34'N, 120°24'E, 8.0 ha) 及台南區農業改良場雲林分場 (23°37'58.5"N, 120°28'34.3"E, 7.0 ha) 農業試驗田區，依照農業試驗所之長期生態農業調查研究操作手冊 (https://lter.tari.gov.tw/) 進行慣行農耕 (conventional agroecosystem; CA) 與永續農耕 (sustainable agroecosystem; SA) 田區之瓢蟲調查試驗，試驗田區包括雙期作水田 (水稻「台南 11 號」) 及水旱輪作田 (落花生「台南 14 號」)。慣行農耕蟲害管理方法為不定期檢視田間害蟲發生情形，並根據現況擬訂防治藥劑種類及施藥適期，於水稻栽培期間發生重要害蟲如飛蝨及縱捲葉蟲時，綜合考量各害蟲發生情形，全期最多施藥 1 次。肥料管理一期作：氮肥 150–180 kg ha^{-1}，磷肥 (P_2O_5) 及鉀肥 (K_2O) 依肥力診斷推薦施用；二期作：氮肥 125–160 kg ha^{-1}，磷肥 (P_2O_5) 及鉀肥 (K_2O) 依肥力診斷推薦施用。蟲害管理部分，永續農耕為原則上不施任何藥劑防治害蟲，但害蟲發生嚴重，可能造成無產量收成之虞時，即以慣行農耕害蟲管理方法，進行施藥防治，全期最多施藥 1 次。肥料管理部分，則以當地的氣候條件為基礎，並參考前作之殘留土壤的養分量及前季或歷年的產量紀錄資料，利用模式估計並配合營養診斷技術及節約措施，調整生長期的施肥量。農友操作田區，蟲害管理方法為於水稻一期作期間平均共施用蟲害防治藥劑 3–4 次，二期作期間則平均施用水稻蟲害防治藥劑 4–5 次。

於 2014–2020 年間進行瓢蟲種類調查，慣行農耕與永續農耕田區瓢蟲調查，方法為選定 3 塊慣行農耕田，面積總計為 1.51 ha，及 3 塊永續農耕田，面積總計為 1.52 ha，每一試驗田各設立 2 支 T 型支架 (T 型支架橫桿長 120 cm、距離地面高度為 150 cm)，每個支架設立於試驗田中間前、後兩邊，距離田埂 20 m 處，支架上懸掛 1 張黃色黏板 (33 cm × 28 cm)，上述資材均購自振詠興業 (台灣台中市)。每 2 星期將黃色黏板收回並掛上新黏板，並參考 Yao & Tao (1972) 及 Yu & Wang (1999) 之檢索與圖鑑，於實驗室內檢視並記錄黏板上所捕獲瓢蟲的種類與數量。水田及旱田之田區瓢蟲調查，方法為選定 3 塊水稻田及 3 塊落花生田，調查方式同上。農藥對瓢蟲影響調查試驗為於 2017–2018 年，一期水稻種植時期，分別選定 3 塊溪口農場慣行農耕田 (未施用殺蟲劑)、永續農耕田 (未施用殺蟲劑) 及農友操作田區進行瓢蟲種類及數量調查，調查方法同上。

試驗所得各項資料，慣行農耕、永續農耕與農友操作田區每片黃色黏板平均瓢蟲種類及數量比較；溪口農場及雲林分場調查，每片黃色黏板瓢蟲平均數量比較等資料先以 SAS-EG (Version 7.1) 統計分析軟體，進行變方分析 (analysis of variance; ANOVA) 後，再以最小顯著差異性測驗 (least significant difference test; LSD test) 分析其差異顯著性。慣行農耕及永續農耕調查，每片黃色黏板瓢蟲平均數瓢蟲種類及數量、水稻田及落花生田調查每片黃色黏板平均瓢蟲種類及數量等資料，則以 *t*-test 分析平均值間是否存在差異。

結果

2014–2020 年於溪口農場及雲林分場以黃色黏板分別調查到 11 種及 12 種瓢蟲，分別是六條瓢蟲 [*C. sexmaculata* (Fabricius)]、六星瓢蟲 [*Oenopia formosana* (Miyatake)]、七星瓢蟲 (*Coccinella septempunctata* Linnaeus)、龜紋瓢蟲 [*Propylaea japonica* (Thunberg)]、橙瓢蟲 [*M. discolor* (Fabricius)]、錨紋瓢蟲 [*Lemnia biplagiata* (Swartz)]、波紋瓢蟲 (*C. transversalis* Fabricius)、赤星瓢蟲 [*Lemnia saucia* (Mulsant)]、八條瓢蟲 [*H. octomacu-*

lata (Fabricius)]、大 13 星瓢蟲 [*Synonycha grandis* (Thunberg)]、孟氏隱唇瓢蟲 (*Cryptolaemus montrouzieri* Mulsant) 及柯氏素菌瓢蟲 (*Illeis koebelei* Timberlake)，其中溪口農場於 2014–2020 年未調查到孟氏隱唇瓢蟲 (表 1)。

2014–2020 年於溪口農場慣行農耕及永續農耕，一期水稻田、二期水稻田及二期落花生田調查到瓢蟲數量沒有差異 (表 2)。雲林分場慣行農耕及永續農耕，一期水稻田、二期水稻田及二期落花生田調查到瓢蟲數量亦沒有差異

表 1. 2014–2020 年溪口農場及雲林分場瓢蟲種類。

Table 1. Species of lady beetles of Sikou farm and YuinLin branch station from 2014–2020.

	Mean number of lady beetle (Mean ± SE)[z]	
Species/location	Sikou farm	YuinLin branch farm
Cheilomenes sexmaculata	2.13 ± 0.24 a	1.92 ± 0.35 a
Oenopia formosana	0.01 ± 0.00 c	0.01 ± 0.00 de
Coccinella septempunctata	0.02 ± 0.01 c	0.01 ± 0.00 de
Propylaea japonica	0.02 ± 0.01 c	0.01 ± 0.00 de
Micraspis discolor	0.18 ± 0.07 b	0.02 ± 0.01 de
Lemnia biplagiata	0.10 ± 0.04 b	0.04 ± 0.01 cd
Coccinella transversalis	0.01 ± 0.01 c	0.02 ± 0.01 de
Lemnia saucia	0.07 ± 0.01 c	0.16 ± 0.04 b
Harmonia octomaculata	0.01 ± 0.01 c	0.02 ± 0.01 de
Synonycha grandis	0.01 ± 0.00 c	0.02 ± 0.01 de
Cryptolaemus montrouzieri	0.00 ± 0.00 c	0.01 ± 0.00 e
Illeis koebelei	0.13 ± 0.03 b	0.08 ± 0.02 bc

[z] For each column, means followed by the same letter are not significantly different at $P < 0.05$ (Fisher's protected least significant difference test).

表 2. 2014–2020 年溪口農場慣行農耕與永續農耕田區瓢蟲數量。

Table 2. Number of lady beetles of Sikou farm in conventional agriculture (CA) and sustainable agriculture (SA) fields from 2014–2020.

	Mean number of lady beetle (Mean ± SE)[z]					
	First crop season paddy		Second crop season paddy		Second crop season peanut	
Species/period	CA	SA	CA	SA	CA	SA
Cheilomenes sexmaculata	2.51 ± 0.24	2.25 ± 0.23	2.18 ± 0.70	1.73 ± 0.50	1.94 ± 0.62	1.99 ± 0.58
Oenopia formosana	0.02 ± 0.01	0.01 ± 0.00	0.01 ± 0.01	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Coccinella septempunctata	0.02 ± 0.01	0.01 ± 0.00	0.01 ± 0.01	0.03 ± 0.02	0.02 ± 0.01	0.02 ± 0.01
Propylaea japonica	0.02 ± 0.01	0.01 ± 0.01	0.01 ± 0.01	0.03 ± 0.03	0.01 ± 0.01	0.00 ± 0.00
Micraspis discolor	0.31 ± 0.11	0.37 ± 0.19	0.06 ± 0.03	0.02 ± 0.01	0.04 ± 0.03	0.00 ± 0.00
Lemnia biplagiata	0.13 ± 0.05	0.10 ± 0.03	0.10 ± 0.06	0.10 ± 0.05	0.00 ± 0.00	0.01 ± 0.01
Coccinella transversalis	0.01 ± 0.01	0.01 ± 0.01	0.01 ± 0.01	0.01 ± 0.01	0.03 ± 0.03	0.02 ± 0.01
Lemnia saucia	0.08 ± 0.01	0.08 ± 0.03	0.04 ± 0.02	0.04 ± 0.01	0.02 ± 0.01	0.00 ± 0.00
Harmonia octomaculata	0.01 ± 0.01	0.01 ± 0.00	0.00 ± 0.00	0.01 ± 0.01	0.00 ± 0.00	0.00 ± 0.00
Synonycha grandis	0.01 ± 0.00	0.01 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Cryptolaemus montrouzieri	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Illeis koebelei	0.24 ± 0.05	0.20 ± 0.05	0.03 ± 0.01	0.02 ± 0.01	0.02 ± 0.02	0.02 ± 0.01

[z] For each row, the asterisk indicates a significant difference from the control at $P < 0.05$ (t-test).

(表 3)。溪口農場及雲林分場慣行農耕及永續農耕，一期水稻田、二期水稻田及二期落花生田調查到瓢蟲種類數均無差異 (表 4)。

2014–2020 年於溪口農場二期水稻及落花生田調查到瓢蟲數量沒有顯著差異，一期水稻田調查到之橙瓢蟲及柯氏素菌瓢蟲發生數量顯著多於二期水稻田，其餘瓢蟲數量無差異。溪口農場一期水稻田調查到之六星瓢蟲、橙瓢蟲、錨紋瓢蟲、赤星瓢蟲及柯氏素菌瓢蟲顯著多於二期落花生田 (表 5)。

2014–2020 年於雲林分場二期水稻及落花生田調查到瓢蟲數量亦沒有顯著差異。雲林分場一期水稻田調查到之柯氏素菌瓢蟲發生數量顯著多於二期水稻田及二期落花生田，其餘瓢蟲數量均無顯著差異 (表 6)。

2014–2020 年於溪口農場二期水稻及落花生田調查到瓢蟲種類無顯著差異。溪口農場一期水稻田與二期水稻田調查到瓢蟲種類數無差異，一期水稻田調查到瓢蟲種類數顯著高於二期落花生田。雲林分場二期水稻及落花生田調查到瓢蟲種類數無顯著差異，雲林分場一期水稻田調查到瓢蟲種類顯著高於二期落花生田 (表 7)。

2017–2018 年一期水稻，農友操作田區調查到六條瓢蟲數量、橙瓢蟲數量及瓢蟲種類均顯著少於溪口農場慣行農耕區及永續農耕區 (表 8、表 9)。

表 3. 2014–2020 年雲林分場慣行農耕與永續農耕田區瓢蟲數量。

Table 3. Number of lady beetles of YuinLin branch station in conventional agriculture (CA) and sustainable agriculture (SA) fields from 2014–2020.

	Mean number of lady beetle (Mean ± SE)[z]					
	First crop season paddy		Second crop season paddy		Second crop season peanut	
Species/period	CA	SA	CA	SA	CA	SA
Cheilomenes sexmaculata	1.56 ± 0.23	1.23 ± 0.17	1.60 ± 0.26	1.34 ± 0.23	3.61 ± 1.85	2.55 ± 1.11
Oenopia formosana	0.01 ± 0.01	0.03 ± 0.02	0.01 ± 0.01	0.01 ± 0.01	0.00 ± 0.00	0.01 ± 0.01
Coccinella septempunctata	0.02 ± 0.01	0.01 ± 0.01	0.01 ± 0.01	0.00 ± 0.00	0.01 ± 0.01	0.00 ± 0.00
Propylaea japonica	0.01 ± 0.00	0.01 ± 0.00	0.00 ± 0.00	0.01 ± 0.01	0.00 ± 0.00	0.01 ± 0.01
Micraspis discolor	0.02 ± 0.02	0.02 ± 0.01	0.00 ± 0.00	0.02 ± 0.01	0.01 ± 0.01	0.01 ± 0.01
Lemnia biplagiata	0.07 ± 0.02	0.03 ± 0.00	0.02 ± 0.01	0.04 ± 0.02	0.03 ± 0.01	0.02 ± 0.02
Coccinella transversalis	0.03 ± 0.01	0.02 ± 0.01	0.01 ± 0.01	0.02 ± 0.02	0.02 ± 0.02	0.01 ± 0.01
Lemnia saucia	0.24 ± 0.07	0.20 ± 0.06	0.20 ± 0.07	0.11 ± 0.04	0.10 ± 0.04	0.10 ± 0.06
Harmonia octomaculata	0.00 ± 0.00	0.01 ± 0.01	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.02 ± 0.02
Synonycha grandis	0.03 ± 0.02	0.02 ± 0.01	0.02 ± 0.01	0.00 ± 0.00	0.00 ± 0.00	0.01 ± 0.01
Cryptolaemus montrouzieri	0.01 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Illeis koebelei	0.20 ± 0.06	0.10 ± 0.05	0.02 ± 0.01	0.01 ± 0.00	0.02 ± 0.01	0.01 ± 0.01

[z] For each row of crop season, the asterisk indicates a significant difference from the control at $P < 0.05$ (*t*-test).

表 4. 2014–2020 年溪口農場與雲林分場慣行農耕與永續農耕田區瓢蟲種類數。

Table 4. Lady beetle species number of Sikou farm and YuinLin branch station in conventional agriculture (CA) and sustainable agriculture (SA) fields from 2014–2020.

	Mean lady beetle species (Mean ± SE)[z]					
	First crop season paddy		Second crop season paddy		Second crop season peanut	
Location/period	CA	SA	CA	SA	CA	SA
Sikou farm	6.71 ± 0.36	6.43 ± 0.53	5.00 ± 0.76	4.29 ± 0.68	2.86 ± 0.63	2.43 ± 0.30
YuinLin branch station	7.43 ± 0.75	6.71 ± 0.42	4.43 ± 0.69	4.00 ± 0.44	3.71 ± 0.18	3.86 ± 0.46

[z] For each row, the asterisk indicates a significant difference from the control at $P < 0.05$ (*t*-test).

表 5. 2014–2020 年溪口農場水田與旱田田區瓢蟲數量。

Table 5. Number of lady beetles of Sikou farm in lowland and upland fields from 2014–2020.

	Mean number of lady beetle (Mean ± SE)[z]					
	Second crop season		First crop season	Second crop season	First crop season	Second crop season
Species/period	Lowland	Upland	Lowland	Lowland	Lowland	Upland
Cheilomenes sexmaculata	1.96 ± 0.59	1.96 ± 0.60	2.28 ± 0.17	1.96 ± 0.59	2.28 ± 0.17	1.96 ± 0.60
Oenopia formosana	0.00 ± 0.00	0.00 ± 0.00	0.02 ± 0.01	0.00 ± 0.00	0.02 ± 0.01[y]	0.00 ± 0.00
Coccinella septempunctata	0.02 ± 0.01	0.02 ± 0.01	0.02 ± 0.01	0.02 ± 0.01	0.02 ± 0.01	0.02 ± 0.01
Propylaea japonica	0.02 ± 0.02	0.01 ± 0.01	0.02 ± 0.01	0.02 ± 0.02	0.02 ± 0.01	0.01 ± 0.01
Micraspis discolor	0.04 ± 0.02	0.02 ± 0.01	0.30 ± 0.13[y]	0.03 ± 0.02	0.30 ± 0.13[y]	0.02 ± 0.01
Lemnia biplagiata	0.10 ± 0.05	0.01 ± 0.00	0.13 ± 0.05	0.10 ± 0.05	0.13 ± 0.05[y]	0.01 ± 0.00
Coccinella transversalis	0.01 ± 0.01	0.02 ± 0.02	0.01 ± 0.01	0.01 ± 0.01	0.01 ± 0.01	0.02 ± 0.02
Lemnia saucia	0.04 ± 0.01	0.01 ± 0.01	0.11 ± 0.02	0.04 ± 0.01	0.11 ± 0.02[y]	0.01 ± 0.01
Harmonia octomaculata	0.01 ± 0.00	0.00 ± 0.00	0.01 ± 0.01	0.01 ± 0.00	0.01 ± 0.01	0.00 ± 0.00
Synonycha grandis	0.00 ± 0.00	0.00 ± 0.00	0.01 ± 0.01	0.00 ± 0.00	0.01 ± 0.01	0.00 ± 0.00
Cryptolaemus montrouzieri	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Illeis koebelei	0.03 ± 0.01	0.02 ± 0.01	0.22 ± 0.05[y]	0.03 ± 0.01	0.22 ± 0.05[y]	0.02 ± 0.01

[z] Mean numbers captured per yellow sticky paper.
[y] A significant difference from the control at $P < 0.05$ (*t*-test).

表 6. 2014–2020 年雲林分場水田與旱田田區瓢蟲數量。

Table 6. Number of lady beetles of YuinLin branch station in lowland and upland fields from 2014–2020.

	Mean number of lady beetle (Mean ± SE)[z]					
	Second crop season		First crop season	Second crop season	First crop season	Second crop season
Species/period	Lowland	Upland	Lowland	Lowland	Lowland	Upland
Cheilomenes sexmaculata	1.50 ± 0.23	3.08 ± 1.47	1.52 ± 0.18	1.50 ± 0.23	1.52 ± 0.18	3.08 ± 1.47
Oenopia formosana	0.01 ± 0.01	0.01 ± 0.01	0.02 ± 0.01	0.01 ± 0.01	0.02 ± 0.01	0.01 ± 0.01
Coccinella septempunctata	0.01 ± 0.00	0.01 ± 0.00	0.02 ± 0.01	0.01 ± 0.00	0.02 ± 0.01	0.01 ± 0.00
Propylaea japonica	0.01 ± 0.00	0.01 ± 0.01	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.01
Micraspis discolor	0.01 ± 0.01	0.01 ± 0.01	0.02 ± 0.01	0.01 ± 0.01	0.02 ± 0.01	0.01 ± 0.01
Lemnia biplagiata	0.03 ± 0.01	0.03 ± 0.01	0.02 ± 0.01	0.03 ± 0.01	0.02 ± 0.01	0.03 ± 0.01
Coccinella transversalis	0.02 ± 0.02	0.01 ± 0.01	0.02 ± 0.01	0.02 ± 0.02	0.02 ± 0.01	0.01 ± 0.01
Lemnia saucia	0.17 ± 0.06	0.10 ± 0.04	0.19 ± 0.04	0.17 ± 0.06	0.19 ± 0.04	0.10 ± 0.04
Harmonia octomaculata	0.00 ± 0.00	0.01 ± 0.01	0.01 ± 0.01	0.00 ± 0.00	0.01 ± 0.01	0.01 ± 0.01
Synonycha grandis	0.01 ± 0.01	0.00 ± 0.00	0.03 ± 0.02	0.01 ± 0.01	0.03 ± 0.02	0.00 ± 0.00
Cryptolaemus montrouzieri	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Illeis koebelei	0.01 ± 0.01	0.02 ± 0.01	0.16 ± 0.02[y]	0.01 ± 0.01	0.16 ± 0.02[y]	0.02 ± 0.01

[z] Mean numbers captured per yellow sticky paper.
[y] A significant difference from the control at $P < 0.05$ (*t*-test).

表 7. 2014–2020 年溪口農場與雲林分場水田與旱田田區瓢蟲種類數。

Table 7. Lady beetle species number of Sikou farm and YuinLin branch station in lowland and upland fields from 2014–2020.

	Mean lady beetle species (Mean ± SE)[z]					
	Second crop season		First crop season	Second crop season	First crop season	Second crop season
Location/period	Lowland	Upland	Lowland	Lowland	Lowland	Upland
Sikou farm	5.71 ± 0.92	3.71 ± 0.64	7.29 ± 0.57	5.71 ± 0.92	7.29 ± 0.57[y]	3.71 ± 0.64
YuinLin branch station	5.57 ± 0.57	4.71 ± 0.29	7.36 ± 0.63	5.57 ± 0.57	7.36 ± 0.63[y]	4.71 ± 0.29

[z] Mean numbers captured per yellow sticky paper.
[y] A significant difference from the control at $P < 0.05$ (*t*-test).

表 8. 溪口農場慣行農耕、永續農耕及農友操作 2017–2018 年之一期作水稻田瓢蟲數量。

Table 8. Number of lady beetles r of Sikou farm conventional agriculture (CA), sustainable agriculture (SA) and farmer practiced treatment in first crop season paddy from 2017–2018.

	Mean number of lady beetle (Mean ± SE)[z]		
Species/treatment	CA	SA	Farmer practiced
Cheilomenes sexmaculata	2.82 ± 0.38 a	2.64 ± 0.65 a	1.50 ± 0.09 b
Oenopia formosana	0.00 ± 0.00 a	0.01 ± 0.01 a	0.00 ± 0.00 a
Coccinella septempunctata	0.00 ± 0.00 a	0.00 ± 0.00 a	0.00 ± 0.00 a
Propylaea japonica	0.02 ± 0.02 a	0.00 ± 0.00 a	0.00 ± 0.00 a
Micraspis discolor	0.68 ± 0.24 a	0.92 ± 0.25 a	0.00 ± 0.00 b
Lemnia biplagiata	0.09 ± 0.02 a	0.05 ± 0.02 a	0.11 ± 0.02 a
Coccinella transversalis	0.01 ± 0.01 a	0.00 ± 0.00 a	0.00 ± 0.00 a
Lemnia saucia	0.04 ± 0.02 a	0.03 ± 0.02 a	0.02 ± 0.02 a
Harmonia octomaculata	0.00 ± 0.00 a	0.01 ± 0.01 a	0.00 ± 0.00 a
Synonycha grandis	0.01 ± 0.01 a	0.01 ± 0.01 a	0.00 ± 0.00 a
Cryptolaemus montrouzieri	0.00 ± 0.00 a	0.00 ± 0.00 a	0.00 ± 0.00 a
Illeis koebelei	0.32 ± 0.18 a	0.19 ± 0.12 a	0.14 ± 0.05 a

[z] For each row, means followed by the same letter are not significantly different at $P < 0.05$ (Fisher's protected least significant difference test).

表 9. 溪口農場慣行農耕、永續農耕及農友操作 2017–2018 年之一期作水稻田瓢蟲種類數。

Table 9. Species number of lady beetles of Sikou farm conventional agriculture (CA), sustainable agriculture (SA) and farmer practiced treatment in first crop season paddy from 2017–2018.

Treatment	Mean lady beetle species (Mean ± SE)[z]
CA	6.25 ± 0.49 a
SA	5.50 ± 0.65 a
Farmer practiced	3.25 ± 0.25 b

[z] Means followed by the same letter are not significantly different at $P < 0.05$ (Fisher's protected least significant difference test).

討論

Sharma *et al*. (2017) 於印度希馬喬邦 (Joshimath) 調查研究中指出，六條瓢蟲是希馬喬邦中優勢瓢蟲之一，廣布於亞溫帶區、亞熱帶區、乾燥溫帶區及濕溫帶區等不同農業氣候區中幾乎所有的農作生產系統中。本研究 2014–2020 年於嘉義縣溪口農場及雲林縣雲林分場調查結果，六條瓢蟲亦為最優勢瓢蟲，分別占 2014–2020 年所調查到瓢蟲數量之 83.1% 及 79.2% (表 1)，溪口農場次優勢瓢蟲為橙瓢蟲、柯氏素菌瓢蟲及錨紋瓢蟲。雲林分場次優

勢瓢蟲為赤星瓢蟲及柯氏素菌瓢蟲，顯示出地區差異性。

研究指出六條瓢蟲可捕食螺旋粉蝨 (*Aleurodicus dispersus* Russell)、吹綿介殼蟲 (*Icerya purchasi* Maskell)、柑桔木蝨 (*Diaphorina citri* Kuwayama)、桑木蝨 (*Paurocephala psylloptera* Grawford) 及稻麥蚜 [*Acyrthosiphon pisum* (Harris)] 等 60 種蚜蟲 (Chen *et al*. 2009)。Biwash *et al*. (2019) 於印度西孟加拉省農業及園藝作物生態系中調查瓢蟲種類多樣性，六條瓢蟲於水稻田中主要捕食白翅褐脈葉蟬 [*Cofana spectra* (Distant)]。Shanker *et al*. (2018b) 於室內研究顯示六條瓢蟲成蟲每日可捕食 2.35–4.60 隻褐飛蝨 [*Nilaparvata lugens* (Stal)] 及 3.12–3.87 隻白背飛蝨 [*Sogatella furcifera* (Hovarth)]，三齡幼蟲每日可捕食 1.16 隻褐飛蝨及 2.40 隻白背飛蝨。上述結果顯示六條瓢蟲是水稻及農業害蟲重要天敵，採取適度保育六條瓢蟲等捕食性天敵措施，有助於壓制水稻田害蟲族群 (Kundoo & Khan 2017; Karenina *et al*. 2019)。

肥料是作物生長系統中與土壤品質有關之重要因子，進而影響作物生長及害蟲族群 (Rowen *et al*. 2019)。研究顯示化學肥料促進作物生長，且使作物本身之植體特性利於害蟲生長發育，增加的害蟲族群提升對天敵吸引 (Garratt *et al*. 2010; Duchovskienė *et al*. 2012)。惟本試驗 2014–2020 年於溪口農場及雲林分場調查結果顯示，六條瓢蟲及其餘瓢蟲的種類及數量，於慣行農耕及永續農耕田區間並無顯著差異 (表 2–4)。確切原因目前尚未明瞭，推測可能為溪口農場及雲林分場慣行農耕及永續農耕田區，肥料使用差別並未對作物及害蟲發生產生顯著影響。

瓢蟲可分為窄幅分布種類及可適應極寬廣或極端的環境條件的種類，其中特定作物型態會吸引特定瓢蟲，表現出瓢蟲於不同季節對棲所偏好，尤其微氣候是影響瓢蟲棲所偏好的重要因子 (Iperti 1999; Zahoor *et al*. 2003)。本試驗 2014–2020 年於溪口農場及雲林分場調查結果顯示，比較二期作水田及旱田間瓢蟲發生的數量及種類數均無差異，顯示於當期作雖因作物種類不同 (水稻及落花生) 並未顯著影響瓢蟲發生種類及數量；於不同期作間，柯氏素菌瓢蟲調查數量於溪口農場及雲林分場一期作均顯著高於二期作，顯示出季節差異性；橙瓢蟲調查數量於溪口農場一期農田作均顯著高於二期作，六星瓢蟲、錨紋瓢蟲及赤星瓢蟲調查數量於溪口農場一期作水稻田數量顯著高於二期作落花生田數量，惟在雲林分場，上述瓢蟲於不同期作及作物間數量並無差異，顯示出地區不同差異 (表 5–7)。

溪口農場及雲林分場二期作水田調查到瓢蟲數量少於一期作水田，二期作落花生田瓢蟲數量更顯著少於一期作水田，二期作瓢蟲種類較少有可能會影響對害蟲生物防治效果。前人研究顯示，於小範圍田區中增加植物多樣性，低強度的雜草管理，有助於提高捕食者對植食性害蟲的壓制效果 (Shanker *et al*. 2013b; Dassou & Tixier 2016)。許多雜草已知可作為瓢蟲棲息處所，於其中瓢蟲產卵、取食花粉、花蜜及替代食餌 (Kranz *et al*. 2002)，作為保育生物防治措施，利用這些雜草可以增加田區瓢蟲數量 (Wäckers & van Rijn 2012)。藉由上述保育生物防治措施，維持田區自然發生天敵族群，可有效防止害蟲族群爆發，同時減少殺蟲劑使用及降低其對環境傷害 (Boreau de Roincé *et al*. 2012)。

研究顯示不同的田間操作明顯影響瓢蟲族群，特別是農藥使用，在防治害蟲同時也殺死瓢蟲。Sharanappa *et al*. (2019) 於印度 Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS) 農業研究試驗田研究顯示，噴施化學農藥明顯降低水稻田中瓢蟲數量，與未施藥對照區 (1.32 隻瓢蟲/株水稻) 相比，有機磷藥劑 (monocrotophos) 處理區瓢蟲數量僅有 0.63 隻/株水稻。Ngin *et al*. (2017) 於柬埔寨水稻田研究亦顯示，隨著用藥次數增加，水稻田捕食性天敵數量愈減少，水稻田施用藥劑次數 3 次及 4 次，瓢蟲等捕食性天敵數量顯著少於施用藥劑 1 次及 2 次之水稻田。本試驗於 2017–2018 年，比較溪口農場未施用化學農藥之一期作永續農耕及慣行農耕水稻田與農友操作水稻田瓢蟲數量及種類，結果亦顯示農友操作水稻田調查到平均瓢蟲種類、

六條瓢蟲及橙瓢蟲數量 (3.25, 1.50, 0.00) 均顯著少於溪口農場永續農耕水稻田 (6.25, 2.64, 0.92) 及慣行農耕水稻田 (5.50, 2.82, 0.68) (表 8、表 9)，顯示噴施農藥對水稻田發生瓢蟲數量及種類造成嚴重影響。

本研究提出了嘉義及雲林地區水稻田瓢蟲種類清單，並顯示六條瓢蟲是數量最多的捕食性瓢蟲天敵，這研究為將來的工作人員提供了有用的訊息，可以為制定該地區作物蟲害生物強化行動管理策略，亦有助於減少農民對化學農藥的依賴。本研究未來也將對六條瓢蟲進行進一步的生物生態學研究。但是在此之前應避免隨意使用化學農藥來保育六條瓢蟲這些重要的捕食性天敵。

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Effects of Conventional and Sustainable Farming Practices on Lady Beetles in Paddy Fields

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A field survey was conducted during 2014–2020 for lady beetles in different types of farming fields in Chiayi County Sikou farm and Yunlin County YuinLin branch Station. Results showed that 11 and 12 lady beetles were captured with yellow sticky paper in Sikou farm and YuinLin branch Station, respectively. Among lady beetles, *Cheilomenes sexmaculata* (Fabricius) was the most dominant lady beetle in all types of framing fields, occupying 83.1% and 79.2% of the total lady beetle number separately. There was no difference in lady beetle species and quantity between conventional and sustainable agroecosystem fields and also between second crop season lowland paddy and upland groundnut fields. Significantly fewer lady beetle species in second crop season upland fields than first crop season paddy. Insecticide application significantly reduced lady beetle species and quantity in farmer-practiced fields compared with no chemical-treated conventional agriculture and sustainable agriculture fields in Sikou farm. The results of our tests showed that *C. sexmaculata* was the most dominant lady beetle in different types of farming fields. This study presents useful information for future workers to develop biological control strategies for paddy pests, which will be useful in reducing the farmers' dependence on harmful chemical pesticides. However, there is a need to conserve *C. sexmaculata* these important beetles by avoiding the indiscriminate use of chemical pesticides.

Key words: Paddy, Conventional agroecosystem, Sustainable agroecosystem, Lady beetle, Long-term ecological research.

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