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研究報告

台灣慣行與有機農作環境中瓢蟲種類組成差異

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摘要

董耀仁、楊婉秀、許北辰、李奇峰、曾美容、張仁育、陳琦玲、石憲宗。2023。台灣慣行與有機農作環境中瓢蟲種類組成差異。台灣農業研究 72(4):343–358。

本研究呈現 2020–2022 年於麻豆文旦園等 11 個農業樣區，以黃色黏蟲紙調查不同農耕田區瓢蟲科 (Coccinellidae) 種類之結果。總計調查分別隸屬於 8 個亞科、11 族、32 屬之 68 種瓢蟲，其中以瓢蟲亞科 (Coccinellinae) 瓢蟲族 (Coccinellini) 有 26 種瓢蟲物種數量最多。六條瓢蟲 (*Cheilomenes sexmaculata* (Fabricius, 1781))、變斑隱勢瓢蟲 (*Cryptogonus orbiculus* (Gyllenhal, 1808))、黃瓢蟲 (*Illeis koebelei* Timberlake, 1943)、龜紋瓢蟲 (*Propylea japonica* (Thunberg, 1781)) 及台南方瓢蟲 (*Sasajiscymnus tainanensis* (Ohta, 1929)) 等 5 種瓢蟲於 11 個農業樣區中均有發現。水稻不同農耕田區之主要優勢瓢蟲為橙瓢蟲 (*Micraspis discolor* (Fabricius, 1798)) 與六條瓢蟲；果園不同農耕田區主要優勢瓢蟲分別為變斑隱勢瓢蟲、台南方瓢蟲、六條瓢蟲及中黑小瓢蟲 (*Scymnus centralis* Kamiya, 1965)。有機農耕果園較慣行農耕果園擁有較高的瓢蟲物種數與數量；水稻不同農耕田區，瓢蟲發生種類與數量差異不一致。於調查的 11 個農業樣區中，有 9 個有機農耕田區其瓢蟲多樣性較慣行農耕田區高。本研究結果提供各樣區的瓢蟲種類與最優勢的瓢蟲資訊，可供當地制定作物害蟲生物防治管理策略時參考。其中，台南方瓢蟲在所有農業樣區中都有分布，且同時是多個農業樣區中的優勢瓢蟲，其害蟲生物防治潛力值得進一步研究。

關鍵詞：瓢蟲、農業樣區、慣行農耕、有機農耕、長期生態研究。

前言

瓢蟲 (英文俗名為 ladybird、ladybug 或 lady beetle) 為鞘翅目 (Coleoptera)、瓢蟲科 (Coccinellidae) 的昆蟲，全世界約有 6,000 種，依其食性可區分為捕食性、植食性及菌食性 (Seago *et al*. 2011; Patil & Gaikwad 2019)。往昔研究顯示在自然界中 90% 的瓢蟲種類為捕食性，可捕食植物重要害蟲，包括蟎類、蚜蟲、薊馬、介殼蟲、木蝨、飛蝨、葉蟬及鱗翅目的卵與初齡幼蟲等，具調節其族群發展的功能，故被視為益蟲，屬於作物害蟲整合管理計畫措施的重要防治資材之一 (Symondson *et al*. 2002; Giorgi *et al*. 2009; Megha *et al*. 2015; Kundoo & Khan 2017; Shanker *et al*. 2018; Pervez *et al*. 2020)。1996 年芬蘭將七星瓢蟲 (*Coccinella septempunctata* (Linnaeus, 1758)) 列為國蟲 (national insect)，色彩繽紛的瓢蟲也是芬蘭有機產品常見的標誌 (https://finland.fi/life-society/iconic-finnish-nature-symbols-stand-out/)，可見捕食性瓢蟲的重要地位。

瓢蟲受重視的原因，不僅因為牠們常被當作生物防治天敵，還因為牠們的取食多樣性與

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適應不同棲地，足以反映當地氣候環境與害蟲發生狀況，使瓢蟲被公認可作為環境的生物指標；瓢蟲極易遭受人類農業操作行為影響，如田區噴施殺蟲劑或殺草劑會降低瓢蟲多樣性，田區周圍保存綠籬與開花植物等友善天敵保育措施可增加瓢蟲族群數量 (Iperti 1999; Zahoor *et al*. 2003; Wäckers & van Rijn 2012)。

光復後，台灣有數篇關於瓢蟲種類調查報告或彙整資料，例如：Chang (1956) 在中部與南部調查蔗田與果園並整理日人標本，共記錄 22 種瓢蟲，Tao & Yao (1972) 確認 16 種捕食蚜蟲的瓢蟲種類，Hsu *et al*. (2022) 調查嘉義與雲林的水稻田瓢蟲共記錄 12 種；台灣農作物害蟲天敵名錄則記錄 25 屬 39 種瓢蟲 (Chen *et al*. 2009)，Lin & Yu (2021) 在其所著瓢蟲圖鑑中指出台灣有 236 種瓢蟲，於台灣物種名錄中則記載 65 屬 240 種瓢蟲 (Chung & Shao 2022)。

為釐清台灣農業生態系的瓢蟲種類，本研究在 2020–2022 年間，於台南麻豆文旦園、苗栗西湖文旦園、花蓮瑞穗文旦園、新竹峨眉桶柑園、高雄燕巢印度棗園、台東卑南番荔枝園、南投埔里百香果園、台東池上水稻田、花蓮富里與玉里水稻田，以及苗栗苑裡水稻田等 11 處農業長期生態樣區，以黃色黏蟲紙調查各樣區之瓢蟲種類與族群變化，釐清台灣農業生態系統不同農耕措施之瓢蟲組成差異程度，配合未來長期持續調查與系統化的分析，期為我國建立可反映不同農業環境與其各類農耕措施的指標性瓢蟲種類。

材料與方法

本研究調查之有機農耕田區，係依有機農業促進法第一章第三條規定：『三、有機農業：指基於生態平衡及養分循環原理，不施用化學肥料及化學農藥，不使用基因改造生物及其產品，進行農作、森林、水產、畜牧等農產品生產之農業。』慣行農耕田區則指農友施用化學肥料與噴施化學農藥以進行作物與病蟲害管理。

2020–2022 年間調查包括台南麻豆文旦園等 11 處農業樣區，各樣區名稱與其衛星定位資訊詳列於表 1。所有監測樣站以黃色黏蟲紙進行瓢蟲調查，調查頻度 (表 1) 如下：

水稻於第一期作與第二期作之分蘗期前後進行調查，第一期作約於 4 月分，第二期作約於 9–10 月分，調查之農耕田區類型分為慣行與有機，每類型田區分為 4 小區，每小區面積為 0.1–0.4 ha，放置 4 張黃色黏蟲紙，設置方法如同果樹樣區。各期作調查 2 wk，每次黏蟲紙置放 1 wk，若遇豪大雨或高溫影響昆蟲流失，隨即更新，調查時段仍需足 2 wk。果樹依生育期於開花期、小果期、中果期及採收期分別進行調查，每年調查 4 次。黃色黏蟲紙每次懸掛為期 2 wk，連續調查 2 次。慣行栽培區與有機栽培區之 4 個小區，各小區逢機選擇 4 株作物，每株設置 1 張黃色黏蟲紙。設置方法為使用黑色格網 (格網長寬：36 cm × 28 cm) + 黃色黏蟲紙，綁在距地基部 1.2–1.3 m 高的主幹上 (圖 1)，或吊掛於樹枝上、或直接在果樹下方架設竹竿。回收時在田間將黃色黏蟲紙覆蓋保鮮膜，記錄瓢蟲的數量。上述資材均購自振詠興業 (台灣台中市)。

瓢蟲數量，先將每個樣區中同年採樣的瓢蟲數量加總 (Annual cumulative number)，並以 mean ± *SE* 表示。各樣區之間的年度總量以 *t*-test 分析其差異顯著性，包括各農業樣區中，最優勢瓢蟲個體數量、瓢蟲種類數量、以及瓢蟲總個體數量在慣行與有機農耕田區間的差異。各農業樣區瓢蟲的生物多樣性指數則選用 Chao 1 與 Shannon-Weaver (Kim *et al*. 2017)。為避免採樣不足在調查上呈現偏差，Chao 1 為利用已採得多個樣本內之物種分布情形，預測該區充分採樣可能的物種豐度，其比值愈高，待發現的物種越多，估計值也越大；Shannon-Weaver 多樣性指標同時考量物種數和物種均勻度，愈豐富均勻的群集，指標數值愈高，亦具有較高的多樣性。上述 2 項多樣性指數以 PAST 4.13 (Hammer *et al*. 2001) 軟體進行計算，各樣區之多樣性指數以 *t*-test 分析其差異顯著性。統計分析均以 Microsoft Excel 軟體進行操作。

表 1.　各調查樣區作物、位置與時程。

Table 1. Crops, location and survey period of each monitoring station.

Locality	Crop	Code[z]	Farming type	Coordinate	Cultivation process (time of survey)			
					1	2	3	4
Miaoli County, Yuanli Township	Rice	YR	Organic	24.380353N, 120.705621E 24.380519N, 120.705430E 24.380631N, 120.705227E 24.381051N, 120.704417E	Maximum tillering stage	Maximum tillering stage	Paddy drying period	Paddy drying period
			Conventional	24.378230N, 120.696870E 24.377880N, 120.697330E 24.377990N, 120.697540E 24.378403N, 120.697230E	(April)	(September)	(May to June)	(October to November)
Miaoli County, Xihu Township	Pomelo	XP	Organic	24.532812N, 120.779784E 24.533458N, 120.779078E 24.547711N, 120.771362E	Flowering stage	Young fruit stage	Mid-fruit stage	Harvesting period
			Conventional	24.541624N, 120.783180E 24.541621N, 120.783404E 24.548906N, 120.765511E	(April)	(June)	(July)	(August)
Hsinchu County, Emei Township	Tankan	ET	Organic	24.689152N, 121.035055E 24.689047N, 121.035358E 24.688595N, 121.035365E 24.688801N, 121.034907E	Flowering stage	Young fruit stage	Mid-fruit stage	Harvesting period
			Conventional	24.686521N, 121.011614E 24.685424N, 121.011129E 24.687309N, 121.010011E 24.683930N, 121.013255E	(April)	(June)	(August)	(December)
Nantou County, Puli Township	Passion fruit	PP	Organic	23.987698N, 120.951547E 23.987817N, 120.951244E 23.903076N, 120.961061E 23.902105N, 120.961285E	Flowering stage	Young fruit stage	Mid-fruit stage	Harvesting period
			Conventional	24.043155N, 120.928164E 24.043165N, 120.928537E 23.902857N, 120.960905E 23.903362N, 120.961170E	(April)	(June)	(August)	(October)
Tainan City, Madou District	Pomelo	MP	Organic	23.144716N, 120.230993E 23.150968N, 120.226392E 23.202122N, 120.247573E 23.194814N, 120.247224E	Flowering stage	Young fruit stage	Mid-fruit stage	Harvesting period

表 1. 各調查樣區作物、位置與時程。(續)

Table 1. Crops, location and survey period of each monitoring station. (continued)

Locality	Crop	Code[z]	Farming type	Coordinate	Cultivation process (time of survey) 1	2	3	4
			Conventional	23.145256N, 120.230738E 23.151961N, 120.233641E 23.202121N, 120.247239E 23.194912N, 120.246206E	(April)	(June)	(July)	(August)
Kaohsiung City, Yanchao District	Jujube	YJ	Organic	22.771424N, 120.335748E 22.773791N, 120.334799E 22.774300N, 120.334652E 22.780247N, 120.328120E	Flowering stage	Young fruit stage	Mid-fruit stage	Harvesting period
			Conventional	22.770677N, 120.335624E 22.770298N, 120.335828E 22.770458N, 120.335381E 22.780712N, 120.325730E	(September)	(October)	(December)	(January)
Hualien County, Fuli Township	Rice	FR	Organic	23.170712N, 121.264241E	Maximum tillering stage	Maximum tillering stage	Paddy drying period	Paddy drying period
			Conventional	23.172189N, 121.262125E	(April)	(September)	(May to June)	(October to November)
Taitung County, Chishang Township	Rice	CR	Organic	23.092210N, 121.218910E 23.091290N, 121.220460E 23.092060N, 121.220840E	Maximum tillering stage	Maximum tillering stage	Paddy drying period	Paddy drying period
			Conventional	23.096220N, 121.215970E 23.092680N, 121.215540E 23.090540N, 121.209680E 23.098460N, 121.207430E	(April)	(September)	(May to June)	(October to November)
Taitung County, Beinan Township	Sugar-apple	BS	Organic	22.834430N, 121.095480E 22.842780N, 121.094160E 22.849980N, 121.008540E 22.840550N, 121.101320E	Maximum tillering stage	Maximum tillering stage	Paddy drying period	Paddy drying period
			Conventional	22.846180N, 121.087620E 22.848740N, 121.084790E 22.834340N, 121.093290E 22.831110N, 121.090180E	(April)	(September)	(May to June)	(October to November)

表 1. 各調查樣區作物、位置與時程。(續)

Table 1. Crops, location and survey period of each monitoring station. (continued)

Locality	Crop	Code[z]	Farming type	Coordinate	Cultivation process (time of survey)			
					1	2	3	4
Hualien County, Yuli Township, Ceroh Tribe	Rice	YUR	Organic	23.447174N, 121.393555E 23.446947N, 121.393872E 23.449429N, 121.397979E 23.455473N, 121.402310E 23.456656N, 121.381532E	Maximum tillering stage	Maximum tillering stage	Paddy drying period	Paddy drying period
			Conventional	23.450590N, 121.396706E 23.450955N, 121.395676E 23.450296N, 121.400425E 23.449523N, 121.400985E 23.458473N, 121.382067E				
Hualien County, Yuli Township, Olalip Tribe	Pomelo	YP	Organic	23.510089N, 121.390830E 23.511996N, 121.395446E 23.548905N, 121.392892E 23.548541N, 121.396226E	Flowering stage	Young fruit stage	Mid-fruit stage	Harvesting period
			Conventional	23.504307N, 121.393696E 23.508642N, 121.392785E 23.510239N, 121.398667E 23.514154N, 121.394150E	(April)	(June)	(July)	(August)

[z] YR: Yuanli rice; XP: Xihu pomelo; ET: Emei Tankan; PP: Puli passion fruit; MP: Madou pomelo; YJ: Yancho Indian jujube; FR: Fuli rice; CR: Chishang rice; BS: Beinan sugar-apple; YUR: Yuli rice; YP: Yuli pomelo.

圖 1. 黃色黏蟲紙設置示意圖。
Fig. 1. Illustration of yellow sticky paper setting.

結果

2020–2022 年間於 11 處農業樣區共採獲與鑑定 68 種瓢蟲，分別隸屬於 8 個亞科、11 族及 32 屬，其中以瓢蟲亞科 (Coccinellinae) 瓢蟲族 (Coccinellini) 有 26 種瓢蟲數量最多；其次為小毛瓢蟲亞科 (Scymninae) 小毛瓢蟲族 (Scymnini) 有 19 種瓢蟲；食植瓢蟲亞科 (Epilachninae) 食植瓢蟲族 (Epilachnini) 共調查到 8 種瓢蟲及小艷瓢蟲亞科 (Sticholotidinae) 小艷瓢蟲族 (Sticholotidini) 共調查到 6 種瓢蟲，以上 4 個亞科的物種占全部調查到瓢蟲種類的 86.8% (表 2)。

本研究調查所獲之 68 種瓢蟲，於所有農業樣區均有分布者共計 5 種，包括六條瓢蟲 (*Cheilomenes sexmaculata* (Fabricius, 1781))、變斑隱勢瓢蟲 (*Cryptogonus orbiculus* (Gyllenhal, 1808))、黃瓢蟲 (*Illeis koebelei* Timberlake, 1943)、龜紋瓢蟲 (*Propylea japonica* (Thunberg, 1781)) 及台南方瓢蟲 (*Sasajiscymnus tainanensis* (Ohta, 1929))，其中黃瓢蟲為食菌性瓢蟲，其餘 4 種均為肉食性瓢蟲；在 68 種瓢蟲中，台灣三色瓢蟲 (*Amida tricolor formosana* Kurisaki, 1920)、黑澤隱勢瓢蟲 (*Cryptogonus kurosawai* Sasaji, 1968)、太田隱勢瓢蟲 (*Cryptogonus ohtai* Sasaji, 1968)、杜虹十星瓢蟲 (*Epilachna crassimala* Li, 1961)、五斑廣盾瓢蟲 (*Platynaspidius quinquepunctatus* Miyatake, 1961)、棕色方瓢蟲 (*Sasajiscymnus fuscus* (Yang, 1971))、圓斑方瓢蟲 (*Sasajiscymnus orbiculatus* (Yang, 1971))、弧斑方瓢蟲 (*Sasajiscymnus parenthesis* (Weise, 1923)) 及台灣豔瓢蟲 (*Sticholotis taiwanensis* Miyatake, 1982) 等 9 種瓢蟲為台灣特有種瓢蟲 (Chung & Shao 2022)，其中杜虹十星瓢蟲為植食性瓢蟲，其餘 8 種瓢蟲均為肉食性瓢蟲 (表 2)。

分析各農業樣區中，慣行操作田區與有機操作田區，各自最優勢瓢蟲種類，於水稻樣區中，除苑裡水稻樣區 (慣行與有機田區) 優勢瓢蟲為六條瓢蟲外，其餘水稻樣區 (慣行與有機田區) 優勢瓢蟲均為橙瓢蟲 (*Micraspis discolor* (Fabricius, 1798))。果樹樣區中，主要優勢瓢蟲除變斑隱勢瓢蟲 (西湖有機文旦、埔里百香果)、六條瓢蟲 (麻豆有機文旦) 及中黑小瓢蟲 (*Scymnus centralis* Kamiya, 1965，峨眉有機桶柑) 外，其餘果樹樣區主要優勢瓢蟲均為台南方瓢蟲 (表 3、圖 2)。

比較各樣區不同農耕類型其田區之瓢蟲物種數與數量，於果樹樣區中，有機園區均較慣行園區擁有更多的瓢蟲物種數與數量，玉里有機文旦園、峨眉有機桶柑園及埔里有機百香果園瓢蟲物種數，均顯著高於慣行園區；西湖有機文旦園、麻豆有機文旦園、燕巢有機印度棗園及卑南有機番荔枝園之瓢蟲數量，均顯著高於慣行園區。於水稻樣區中，有機田區之瓢蟲物種數與數量不一定多於慣行田區 (表 4)。

比較各農業樣區其慣行與有機田區間瓢蟲

表 2. 各農業樣區調查所得瓢蟲種類及其分類群。

Table 2. The species of Coccinellidae and taxa surveyed in each monitoring station of Coccinellidae.

Scientific name	Chinese common name	Detection[z]										
		XP	MP	YP	ET	YJ	BS	PP	YUR	FR	CR	YR
Chilocorinae												
Chilocorini												
Chilocorus shirozui Sasaji, 1968	台灣唇瓢蟲						★					
Platynaspidini												
Platynaspidius maculosus (Weise, 1910)	四斑廣盾瓢蟲	★		★	★	★			★	★	★	
P. quinquepunctatus Miyatake, 1961	五斑廣盾瓢蟲	★	★	★	★	★	★		★	★		
Coccidulinae												
Coccidulini												
Cryptolaemus montrouzieri Mulsant, 1853	孟氏隱唇瓢蟲	★	★		★		★		★		★	★
Noviini												
Rodolia cardinalis (Mulsant, 1850)	澳洲瓢蟲	★	★	★		★		★				★
R. okinawensis Miyatake, 1959	小紅瓢蟲	★	★	★	★	★	★	★	★	★	★	★
Coccinellinae												
Coccinellini												
Alloneda osawai Sasaji, 1986	十斑奇瓢蟲	★										
Calvia muiri (Timberlake, 1943)	四斑裸瓢蟲							★				
Cheilomenes sexmaculata (Fabricius, 1781)	六條瓢蟲	★	★	★	★	★	★	★	★	★	★	★
Coccinella septempunctata Linnaeus, 1758	七星瓢蟲							★		★		★
Co. transversalis Fabricius, 1781	波紋瓢蟲		★						★		★	
Co. bowringii Crotch, 1874	八斑盤瓢蟲										★	
Co. inaequalis (Fabricius, 1775)	九星瓢蟲	★										
Co. itoi Sasaji, 1982	四斑黃盤瓢蟲				★							
Harmonia dimidiata (Fabricius, 1781)	小十三星瓢蟲	★			★							
Ha. octomaculata (Fabricius, 1781)	八條瓢蟲		★					★	★	★	★	★
Illeis koebelei Timberlake, 1943	黃瓢蟲	★	★	★	★	★	★	★	★	★	★	★
Lemnia biplagiata (Swartz, 1808)	錨紋瓢蟲	★			★		★	★	★	★	★	★
L. circumusta (Mulsant, 1850)	紅紋瓢蟲	★			★							
L. circumvelata Mulsant, 1850	周緣盤瓢蟲				★							
L. saucia (Mulsant, 1850)	赤星瓢蟲	★	★		★	★			★	★		
Micraspis discolor (Fabricius, 1798)	橙瓢蟲	★	★	★	★	★	★		★	★	★	★
Oenopia formosana (Miyatake, 1965)	六星瓢蟲	★	★		★		★	★				
Oe. sauzeti Mulsant, 1866	黃緣巧瓢蟲				★				★			
Olla v-nigrum (Mulsant, 1866)	楔斑溜瓢蟲		★				★			★	★	
Phrynocaria unicolor (Fabricius, 1792)	紅星盤瓢蟲	★			★							
Propylea japonica (Thunberg, 1781)	龜紋瓢蟲	★	★	★	★	★	★	★	★	★	★	★

表 **2.** 各農業樣區調查所得瓢蟲種類及其分類群。(續)

Table 2. The species of Coccinellidae and taxa surveyed in each monitoring station of Coccinellidae. (continued)

Scientific name	Chinese common name	Detection[z]										
		XP	MP	YP	ET	YJ	BS	PP	YUR	FR	CR	YR
Synona consanguinea Poorani, Slipinski, Booth, 2008	紅胸黑瓢蟲	★			★							
Epilachninae												
Epilachnini												
Epilachna chinensis (Weise, 1912)	中華食植瓢蟲	★		★								
E. crassimala Li, 1961	杜虹十星瓢蟲	★										
E. maxima (Weise, 1898)	大食植瓢蟲								★			
Henosepilachna boisduvali (Mulsant, 1850)	蘭嶼茄十二星瓢蟲	★										
He. pusillanima (Mulsant, 1850)	茄十二星瓢蟲	★										
He. subfasciata (Weise, 1923)	半帶裂臀瓢蟲						★					
He. vigintioctomaculata (Motschulsky, 1857)	馬鈴薯瓢蟲	★										
He. vigintioctopunctata (Fabricius, 1775)	茄二十八星瓢蟲	★	★	★	★			★	★	★	★	★
Serangiini												
Serangium yasumatsui (Sasaji, 1967)	鐘角瓢蟲				★							
Microweiseinae												
Ortaliini												
Amida tricolor formosana Kurisaki, 1920	台灣三色瓢蟲	★		★	★		★		★		★	
Ortaliinae												
Aspidimerini												
Aspidimerus esakii Sasaji, 1968	四斑隱脛瓢蟲			★			★					
Scymninae												
Cryptogonus horishanus (Ohta, 1929)	台灣隱勢瓢蟲	★										
Cr. kurosawai Sasaji, 1968	黑澤隱勢瓢蟲	★		★								
Cr. ohtai Sasaji, 1968	太田隱勢瓢蟲	★				★						
Cr. orbiculus (Gyllenhal, 1808)	變斑隱勢瓢蟲	★	★	★	★	★	★	★	★	★	★	★
Scymnini												
Axinoscymnus nigripennis Kamiya, 1965	黑翅斧瓢蟲	★	★	★	★	★	★				★	
Nephus tagiapatus (Kamiya, 1961)	中斑彎葉毛瓢蟲		★				★					
Sasajiscymnus fuscus (Yang, 1971)	棕色方瓢蟲				★	★	★		★	★		
Sa. ohtai (Yang et Wu, 1972)	太田方瓢蟲						★					
Sa. orbiculatus (Yang, 1971)	圓斑方瓢蟲			★			★			★		
Sa. parenthesis (Weise, 1923)	弧斑方瓢蟲	★			★	★	★					
Sa. quinquepunctatus (Weise, 1923)	五班方瓢蟲	★		★	★							
Sa. seboshii (Ohta, 1929)	獨斑方瓢蟲						★					
Sa. tainanensis (Ohta, 1929)	台南方瓢蟲	★	★	★	★	★	★	★	★	★	★	★

表 **2.** 各農業樣區調查所得瓢蟲種類及其分類群。(續)

Table 2. The species of Coccinellidae and taxa surveyed in each monitoring station of Coccinellidae. (continued)

Scientific name	Chinese common name	Detection[z]										
		XP	MP	YP	ET	YJ	BS	PP	YUR	FR	CR	YR
Scymnus centralis Kamiya, 1965	中黑小瓢蟲			★	★					★		
Sc. fascatus Boheman, 1858	棕色毛瓢蟲	★										
Sc. hoffmanni Weise, 1879	黑襟毛瓢蟲			★			★	★	★	★		★
Sc. nubilus Mulsant, 1850	雲小毛瓢蟲				★							
Sc. ovimaculatus Sasaji, 1968	卵斑小瓢蟲					★						
Sc. posticalis Sicard, 1912	後斑小瓢蟲	★			★		★	★	★	★		★
Sc. quadrillum Motschulsky, 1858	四斑小瓢蟲	★	★		★	★	★			★		
Sc. shirozui Kamiya, 1965	彎葉小瓢蟲						★					
Sc. yangi Yu et Pang, 1993	內囊小瓢蟲	★		★	★	★	★	★	★	★	★	
Stethorus aptus Kapur, 1948	黑囊食蟎瓢蟲			★					★			
Sticholotidinae												
Sticholotidini												
Jauravia limbata Motschulsky, 1858	黃環豔瓢蟲	★	★	★	★	★	★	★				
Nesolotis shirozui Sasaji, 1967	九斑尼豔瓢蟲	★										
Pharoscymnus taoi Sasaji, 1967	台毛豔瓢蟲	★	★									
Sticholotis formosana Weise, 1923	麗豔瓢蟲			★	★		★	★	★		★	
St. hirashimai Sasaji, 1968	褐背艷瓢蟲			★								
St. taiwanensis Miyatake, 1982	台灣豔瓢蟲					★						

[z] XP: Xihu pomelo; MP: Madou pomelo; YP: Yuli pomelo; ET: Emei Tankan; YJ: Yancho Indian jujube; BS: Beinan sugar-apple; PP: Puli passion fruit; YUR: Yuli rice; FR: Fuli rice; CR: Chishang rice; YR: Yuanli rice. ★ Expressed lady beetle detected in this monitoring station.

之多樣性，有機果園除西湖文旦園外，其餘樣區有機果園瓢蟲多樣性指數 Chao1 與 Shannon-Weaver 均高於慣行果園。水稻樣區中，有機田區瓢蟲之多樣性不一定高於慣行田區 (表 5)。

討論

台灣瓢蟲種類從 Chang (1956) 調查之 22 種瓢蟲，迄今已記錄 230 種以上 (Lin & Yu 2021)。但對於台灣農田中的瓢蟲種類，一直未有長期連續的調查資料。本研究在 2020–2022 年間於 11 個農業樣區 (表 1) 的調查，共計發現 68 種瓢蟲，約占現有台灣瓢蟲種類的 28.3%，未來持續調查應還可能發現更多的瓢蟲種類。在 68 種瓢蟲種類中植食性瓢蟲有 8 種，其餘 60 種瓢蟲則為捕食性與菌食性，約占調查到瓢蟲種類之 88.2%，此比例與全世界瓢蟲種類中約 90% 為捕食性瓢蟲相近 (表 2) (Kundoo & Khan 2017)。

Sundareswari *et al*. (2019) 於 2018–2019 年間於印度薩圖爾 (Sattur) 鎮，檸檬與水稻等不同農業田區，以手動捕捉方式，調查作物與田區雜草上的瓢蟲種類，調查結果以瓢蟲亞科的瓢蟲種類與數量最多。本研究調查結果中，瓢蟲亞科的物種最多，共有 26 種瓢蟲；其次為小毛瓢蟲亞科，共有 19 種瓢蟲。本試驗調查的 11 個農業樣區中，以瓢蟲亞科瓢蟲種類最多的樣區，有埔里百香果等 7 個樣區，小毛瓢蟲亞科瓢蟲種類數最多的則有卑南番荔枝等 4 個樣區 (表 2)。瓢蟲亞科瓢蟲的食餌甚為多樣化，包括蚜蟲、木蝨、飛蝨及葉蟬等害蟲。小毛瓢蟲亞科瓢蟲食餌則包括蚜蟲、介

表 3.　各農業樣區中有機與慣行田區優勢瓢蟲。

Table 3.　Dominant lady beetle species of organic fields and conventional fields respective in each monitoring station.

Sample area	Farming type	Scientific name	Prey/Reference[z]	Annual mean cumulative number	*t*-test
Xihu pomelo	Organic	*Cryptogonus orbiculus*	Aphids, mealybugs/1, 5, 6	1661.0 ± 122.7	t = -21.99, df = 4 P < 0.05
	Conventional	*Sasajiscymnus tainanensis*	Carnivorous/4	52.0 ± 3.1	
Madou pomelo	Organic	*Cheilomenes sexmaculata*	Aphids, leafhoppers, *Opisina*, planthoppers/1, 2	248.0 ± 86.7	t = -2.15, df = 6 P = 0.089
	Conventional	*Sa. tainanensis*	Carnivorous/4	75.5 ± 24.2	
Yuli pomelo	Organic	*Sa. tainanensis*	Carnivorous/4	19.0 ± 9.2	t = -1.42, df = 6 P = 0.2066
	Conventional	*Sa. tainanensis*	Carnivorous/4	5.5 ± 2.3	
Emei Tankan	Organic	*Scymnus centralis*	Aphids, armored scales/3	126.5 ± 49.2	t = 0.45, df = 6 P = 0.6784
	Conventional	*Sa. tainanensis*	Carnivorous/4	138.5 ± 21.8	
Yancho Indian jujube	Organic	*Sa. tainanensis*	Carnivorous/4	122.0 ± 54.8	t = -1.82, df = 6 P < 0.05
	Conventional	*Sa. tainanensis*	Carnivorous/4	21.0 ± 9.4	
Beinan sugar-apple	Organic	*Sa. tainanensis*	Carnivorous/4	327.3 ± 135.8	t = -0.7, df = 6 P = 0.5117
	Conventional	*Sa. tainanensis*	Carnivorous/4	196.8 ± 128.8	
Puli passion fruit	Organic	*Cry. orbiculus*	Aphids, mealybugs/1, 5, 6	92.0 ± 90.0	t = -0.72, df = 6 P = 0.4972
	Conventional	*Cry. orbiculus*	Aphids, mealybugs/1, 5, 6	34.2 ± 34.2	
Yuli rice	Organic	*Micraspis discolor*	Aphids, leafhoppers, *Opisina*, planthoppers/1, 2	173.2 ± 51.6	t = -2.05, df = 8 P < 0.05
	Conventional	*M. discolor*	Aphids, leafhoppers, *Opisina*, planthoppers/1, 2	65.4 ± 10.0	
Fuli rice	Organic	*M. discolor*	Aphids, leafhoppers, *Opisina*, planthoppers/1, 2	20.0 ± 2.2	t = 3.03, df = 6 P < 0.05
	Conventional	*M. discolor*	Aphids, leafhoppers, *Opisina*, planthoppers/1, 2	33.3 ± 3.8	
Chishang rice	Organic	*M. discolor*	Aphids, leafhoppers, *Opisina*, planthoppers/1, 2	66.7 ± 4.3	t = -1.45, df = 5 P = 0.2649
	Conventional	*M. discolor*	Aphids, leafhoppers, *Opisina*, planthoppers/1, 2	47.8 ± 12.4	
Yuanli rice	Organic	*Ch. sexmaculata*	Aphids, mites, psyllids, whiteflies, scales/1, 2	7.3 ± 1.7	t = 0.31, df = 6 P = 0.7676
	Conventional	*Ch. sexmaculata*	Aphids, mites, psyllids, whiteflies, scales/1, 2	8.3 ± 2.8	

[z] Reference: 1. Ahmad (2004); 2. Chen *et al*. (2009); 3. Dai *et al*. (2011); 4. Lin & Yu (2021); 5. Mayadunnage *et al*. (2007); 6. Saengyot & Burikam (2011).

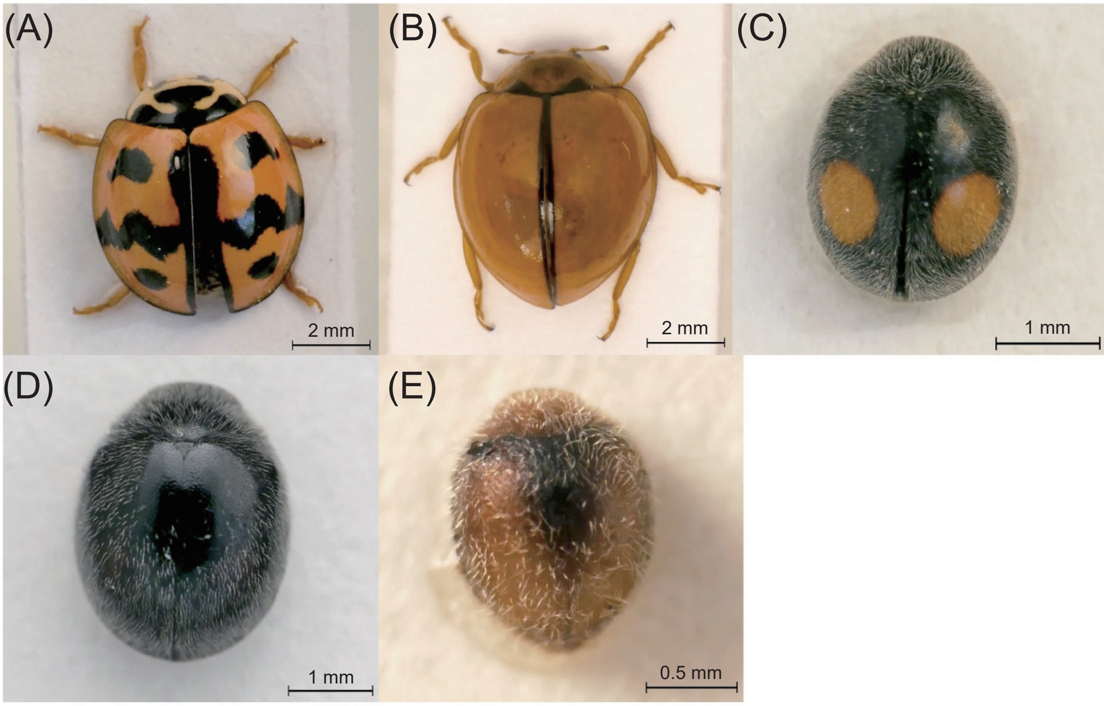

圖 2. 各農業樣區最優勢瓢蟲種類，分別為 (A) 六條瓢蟲 (*Cheilomenes sexmaculata* (Fabricius, 1781))；(B) 橙瓢蟲 (*Micraspis discolor* (Fabricius, 1798))；(C) 變斑隱勢瓢蟲 (*Cryptogonus orbiculus* (Gyllenhal,1808))；(D) 台南方瓢蟲 (*Sasajiscymnus tainanensis* (Ohta, 1929))；(E) 中黑小瓢蟲 (*Scymnus centralis* Kamiya, 1965)。

Fig. 2. The dominant lady beetles in each agricultural sampling station: (A) *Cheilomenes sexmaculata* (Fabricius, 1781); (B) *Micraspis discolor* (Fabricius, 1798); (C) *Cryptogonus orbiculus* (Gyllenhal, 1808); (D) *Sasajiscymnus tainanensis* (Ohta,1929); and (E) *Scymnus centralis* Kamiya, 1965.

表 4. 各農業樣區瓢蟲種類數與累積調查數量。

Table 4. Lady beetle species number and mean cumulative number in each monitoring station.

	Number of species/Mean (± *SE*)		Annual mean cumulative number (± *SE*)	
Agricultural sample area/crop	CC[z]	OC[y]	CC	OC
Xihu pomelo	19.7 (3.2)	25.0 (1.5)	273.0 (66.7)	2,272.3 (157.2)*
Madou pomelo	9.0 (0.9)	12.0 (1.2)	188.3 (62.1)	485.0 (104.3)*
Yuli pomelo	6.0 (0.4)	10.8 (1.3)*	17.0 (5.7)	71.8 (37.5)
Emei Tankan	16.8 (0.9)	20.5 (1.2)*	214.5 (26.1)	432.5 (54.5)
Yancho Indian jujube	5.8 (1.3)	9.3 (1.1)	31.3 (11.4)	214.5 (60.2)*
Beinan sugar-apple	9.0 (2.5)	14.0 (1.8)	231.0 (145.6)	540.8 (170.4)*
Puli passion fruit	5.8 (0.9)	1.0 (1.7)*	47.4 (39.2)	182.7 (70.7)
Yuli rice	10.4 (1.0)	9.2 (0.6)	173.8 (40.0)	243.4 (49.8)
Fuli rice	11.3 (0.5)	9.8 (0.8)	72.3 (3.4)*	60.3 (1.7)
Chishang rice	7.8 (0.9)	11.7 (0.9)*	113.0 (23.0)	145.0 (39.0)
Yuanli rice	5.8 (0.6)	8.0 (2.2)	18.8 (5.0)	18.5 (2.7)

[z] CC: conventional cultivated.
[y] OC: organic cultivated.
* Asterisk indicated a significant difference for each parameter within each row, with $P < 0.05$ (*t*-test).

表 5. 各農業樣區瓢蟲多樣性指數。

Table 5. Diversity index of ladybeetles in each monitoring station.

	Diversity index			
	Chao1		Shannon-Weaver	
Agricultural sample area/crop	CC[z]	OC[y]	CC	OC
Xihu pomelo	32.19	49.20	2.429	1.489
Madou pomelo	14.00	18.75	1.486	1.612*
Yuli pomelo	24.35	26.47	2.094	2.152
Emei Tankan	33.99	34.00	1.496	2.132
Yancho Indian jujube	10.25	30.98*	1.164	1.252
Beinan sugar-apple	23.50	30.00	0.737	1.542
Puli passion fruit	14.99	17.50	1.117	1.383*
Yuli rice	29.32	14.25	1.692	1.060
Fuli rice	27.46	16.20	1.843	1.888
Chishang rice	14.00	17.50	1.425	1.492
Yuanli rice	9.33	13.99	1.640	2.122*

[z] CC: conventional cultivated.
[y] OC: organic cultivated.
* Asterisk indicated a significant difference for each parameter within each row, with $P < 0.05$ (*t*-test).

殼蟲及葉蟎等 (Chen *et al*. 2009; Giorgi *et al*. 2009)。上述各類食餌昆蟲，各自均為 11 個不同農業樣區之作物害蟲。影響瓢蟲存在的重要原因為是否有食餌存在，捕食性瓢蟲於自然界中常伴隨上述這些害蟲存在 (Pervez *et al*. 2020)。

本研究調查結果顯示，不同農業樣區所調查到的瓢蟲物種數量均不相同，最多瓢蟲物種數的樣區 (西湖文旦，40 種瓢蟲)，調查到瓢蟲物種數是最少瓢蟲物種數樣區 (苑裡水稻，15 種瓢蟲) 的 2.7 倍，即使同為芸香科果樹的文旦樣區，調查到的瓢蟲物種數亦有差異 (西湖 40 種；麻豆 18 種；玉里 25 種) (表 3)，造成此種差異的原因目前尚未確認。前人研究指出，瓢蟲的分布能力與環境適應性，依種類差異有所不同，影響瓢蟲存在的因子眾多，包括環境中的生物與非生物因子等，不同的作物型態與季節差異，甚至是微氣候均可能是影響瓢蟲棲所偏好的重要因子 (Iperti 1999; Zahoor *et al*. 2003; Pervez *et al*. 2020)。

水稻樣區中，台灣東部地區池上、富里及玉里水稻田，有機農耕或慣行農耕水稻田，數量最多的瓢蟲均為橙瓢蟲；但在西部地區苑裡水稻田，有機農耕或慣行農耕水稻田，數量最多的瓢蟲則為六條瓢蟲 (表 4)。Hsu *et al*. (2022) 以黃色黏蟲紙，2014–2020 年間於台灣西部地區嘉義縣溪口農場與雲林縣雲林分場，調查慣行農耕與永續農耕水稻田之瓢蟲種類與數量，結果亦顯示六條瓢蟲是數量最多之瓢蟲，分別占調查到瓢蟲種類之 83.1% 與 79.2%。比較上述研究結果顯示，台灣東、西部水稻田優勢瓢蟲存在差異性，詳細原因目前未知，仍待進一步研究。果樹樣區中，慣行農耕田區除埔里百香果外，最優勢瓢蟲均為台南方瓢蟲，關於台南方瓢蟲之食性，Lin & Yu (2021) 書中敘明其為肉食性瓢蟲，Dai *et al*. (2011) 調查茶園生態系統中瓢蟲種類，與台南方瓢蟲同為小毛瓢蟲屬內的多種瓢蟲，其食餌主要為茶園蚜蟲類與盾介殼蟲類。有機農耕田區中，最優勢瓢蟲呈現不同差異，於西湖文旦園與埔里百香果園為變斑隱勢瓢蟲，麻豆文旦園為六條瓢蟲，峨眉桶柑園則為中黑小瓢蟲，其餘玉里文旦園、燕巢印度棗園及卑南番荔枝園均為台南方瓢蟲 (表 3)。台南方瓢蟲在所有

農業樣區中均有分布，同時為多個農業樣區優勢瓢蟲 (表 3)，其害蟲生物防治潛力值得進一步研究。瓢蟲具有同生態功能群個體間相互捕食現象 (Intraguild predation)，此現象可能導致生態系統中瓢蟲群落改變 (Gardiner *et al*. 2011)，不同農業樣區中優勢瓢蟲不同，真正原因還需進一步研究確認。

前人研究中，有機農耕一般較慣行農耕，似乎可以維持較高的天敵多樣性，原因來自於有機農耕操作採用較有利於害蟲天敵措施，例如不使用化學合成農藥 (Theiling & Croft 1988; Gabriel *et al*. 2006; Rundlöf & Smith 2006; Winqvist *et al*. 2011; Puech *et al*. 2014)。惟本研究結果，所有樣區中有機農耕田區瓢蟲多樣性指數、物種數及數量，並非均較慣行田區高，真正的影響因子仍待進一步探討 (表 4、表 5)。Bengtsson *et al*. (2005) 分析不同研究報告中，有關有機農業對生物多樣性與物種豐度的影響，其結果顯示有 16% 的研究報告表示有機農業對物種豐富度有負面影響，推測可能原因包括不同昆蟲分類群間對有機農耕操作的反應不同、地景生態環境因素及未考量有機農耕與慣行農耕田區，農友實際採用田間操作方式 (有機農耕經常性去除田區開花雜草 vs. 慣行農耕於田區與四周維持開花植物與綠籬等) 對害蟲天敵的影響 (Bianchi *et al*. 2006; Fahrig *et al*. 2011; Vasseur *et al*. 2013)。

本研究提出了 2020–2022 年於台灣 11 個農業樣區，慣行農耕田與有機農耕田，瓢蟲種類之調查結果，並顯示各樣區瓢蟲種類與最優勢的瓢蟲，這研究為將來的研究人員與農友提供了有用的資訊，可以為當地制定作物害蟲生物防治管理策略，有助於減少農友對化學合成農藥的依賴。本研究未來仍將持續於台灣農業生態樣區瓢蟲調查，藉由累積長期調查資料，除釐清不同農耕操作方式與環境生態因子對瓢蟲群落之影響外，同時可提供政府與農友決策之依據。

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Differences in Lady Beetle Species Composition between Conventional and Organic Farming Environments in Taiwan

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Abstract

Dong, Y. J., W. H. Yang, P. C. Hsu, C. F. Lee, M. J. Tseng, J. Y. Chang, C. L. Chen, and H. T. Shih. 2023. Differences in lady beetle species composition between conventional and organic farming environments in Taiwan. J. Taiwan Agric. Res. 72(4):343–358.

This study presents the results of a survey of different lady beetle species in field areas under various agricultural practices using the yellow sticky paper method in 11 agricultural monitoring stations, including the Madou pomelo fruit orchard, from 2020 to 2022. A total of 68 lady beetle species belonging to 8 subfamilies, 11 tribes, and 32 genera were identified, among which the subfamily Coccinellinae and tribe Coccinellini had the highest number of species, with 26 species of lady beetles. Five species of lady beetle- *Cheilomenes sexmaculata* (Fabricius, 1781), *Cryptogonus orbiculus* (Gyllenhal, 1808), *Illeis koebelei* (Timberlake, 1943), *Propylea japonica* (Thunberg, 1781), and *Sasajiscymnus tainanensis* (Ohta, 1929), had the widest distribution and were found in all 11 agricultural monitoring stations. The dominant lady beetle species in different rice fields were *Micraspis discolor* (Fabricius, 1798) and *Ch. sexmaculata*. In fruit orchards under different farming practices, the dominant lady beetle species were *Cr. orbiculus*, *Sa. tainanensis*, *Ch. sexmaculata*, and *Scymnus centralis* Kamiya, 1965. Organic fruit orchards demonstrated a higher diversity and quantity of lady beetles compared to conventionally cultivated orchards. The occurrence of lady beetle species and their quantities varied in different rice fields. Among the 11 agricultural monitoring stations surveyed, 9 organic monitoring stations had higher lady beetle diversity than conventionally monitoring stations. These findings revealed the species composition of lady beetles and identified the dominant species in various agricultural regions. Notably, *Sa. tainanensis* exhibited the broadest distribution and was the predominant species across most areas. These results will be useful in the development and implementation of future biological control management programs.

Key words: Lady beetle, Agricultural monitoring stations, Conventional cultivated, Organic cultivated, Long term ecological research.

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