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Study of the Storage and Oviposition-Regulating Capability of *Hemiptarsenus varicornis* (Hymenoptera: Eulophidae) 【Research report】

異角釉小蜂 (*Hemiptarsenus varicornis*) (膜翅目：釉小蜂科) 之貯存與產卵調節能力 【研究報告】

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Abstract

In this study, we investigated the suitable life stages and conditions for storage of the wasp, *Hemiptarsenus varicornis* (Girault). The wasp's oviposition-regulating capability after storage was also determined. Results showed that there was a significant difference in the percent emergence between 1-day-old pupae stored at 8°C for 1-2 weeks (% emergence = 71.2-73.4%) and the control (% emergence = 96%). However, the percent emergence did not decrease if the 1-day-old pupae were stored at 10°C for 1-5 weeks. Emerged from the pupae previously stored at 10°C for 1-4 weeks, and followed by rearing at 25°C with honey and host (*Liriomyza trifolii* (Burgess)), the wasps were not affected by the storage conditions in their adult longevity in both sexes and offspring sex ratio. However, the wasp's host-killing capability and offspring production decreased by 44.3-54.7% and 55.9-69.2%, respectively, compared to those of the control. Adults were fed only with honey at between 15 and 30°C for various time periods for the study of storage conditions. It was found that mean adult longevity was the highest under the 15°C storage conditions with the female and male longevity of 44.7 and 42.3 days, respectively. In addition, the survival rate still reached 80% after the female and male had been stored for 38 and 37 days, respectively. After the end of the storage periods, wasps were kept at 25°C with both honey and hosts to evaluate their capability of host-killing and offspring production. The results revealed that the host-killing capability and fertility of the wasps were not influenced after the adults had been stored at 15°C for 10 days. Although adult longevity, host-killing capability, and female progeny proportion were not affected, the total offspring production decreased significantly after adult wasps had been stored at 15°C for 20-30 days or 25°C for 10-15 days. Maintaining a high fertility of the wasp is essential to rearing *H. varicornis* for mass production. For this purpose, suitable conditions to store the colony according to priority are (1) female wasps at 15°C for 10 days, (2) female wasps at 15°C for 20-30 days or 25°C for 10-15 days and (3) 1-day-old pupae at 10°C for 1-4 weeks. With the field release of *H. varicornis* as a bioinsecticide, the primary concern is the host-killing capability of the wasp. As such, the storage conditions can be less restrictive as (1) female wasps at 15°C for 10-30 days or 25°C for 10-15 days, and (2) female wasps at 15°C for 40 days or 1-day-old pupae at 10°C for 1-4 weeks. Female wasp has an ability to self-regulate oviposition in response to different storage conditions. Under the storage conditions at 15°C for 10 days, female *H. varicornis* shows a comparable daily oviposition pattern to that of the control. Although the oviposition schedules and the occurrence and persistence of the peak oviposition period were similar to the control under other storage conditions, the number of daily eggs laid by the wasp at its peak oviposition period was lower than that of the control.

摘要

本文探討異角釉小蜂 (*Hemiptarsenus varicornis* (Girault)) 貯存之蟲期與條件及雌蜂經貯存後之產卵調節能力。結果得知第一日齡蛹在 8°C 下經貯存 1~2 週後在 25°C 下之羽化率即下降為 71.2~73.4%，與對照組之 96.0% 呈顯著差異。而第一日齡蛹在 10°C 下經貯存 1~5 週後在 25°C 下之羽化率卻高達 91.7~99.0%，與對照組無顯著差異，且彼等初羽化成蜂移入 25°C 定溫並每日供應寄主非洲菊斑潛蠅 (*Liriomyza trifolii* (Burgess)) 與純蜂蜜時，其雌、雄蜂壽命與子代雌性比雖不受蜂蛹低溫貯存 1~4 週之影響，但其致死寄主總數與子蜂數卻受彼等蜂蛹低溫貯存之影響，較對照組各減少 44.3~54.7% 與 55.9~67.2%。成蜂在 15~30°C 下僅以純蜂蜜餵食時，以 15°C 時雌、雄蜂壽命最長，其實測值各為 44.7 與 42.3 日，且雌、雄蜂各貯存至 38 與 37 日時，其存活率仍高達 80%。同時發現雌蜂在 15 或 25°C 下餵食純蜂蜜待貯存期滿移入 25°C 定溫且每日供應寄主與純蜂蜜後，僅雌蜂在 15°C 下貯存 10 日者，其生育力 (fertility) 與致死寄主能力與對照組無顯著差異；而雌蜂在 15 或 25°C 下各貯存 20~30 或 10~15 日者，其壽命、致死寄主總數及子代雌性比等雖與對照組無顯著差異，但其子蜂數卻顯著較對照組各減少 39.2~43.6% 與 31.4~33.3%。總之，室內繁殖異角釉小蜂時之貯存條件較嚴，其中以雌蜂在 15°C 下餵食純蜂蜜貯存 10 日者為最適，其次為雌蜂在 15 或 25°C 下餵食純蜂蜜各貯存 20~30 或 10~15 日，再次為第一日齡蛹在 10°C 下貯存 1~4 週。但田間以生物藥劑方式釋放異角釉小蜂時，其貯存之條件可較繁殖時為寬，其中以雌蜂在 15 或 25°C 下餵食純蜂蜜各貯存 10~30 或 10~15 日為最適，其次為雌蜂在 15°C 下餵食純蜂蜜貯存 40 日或第一日齡蛹在 10°C 下貯存 1~4 週。另雌蜂經貯存後再遇寄主時確具產卵調節能力，其中以 15°C 下隔離寄主 10 日者之日寄生型式與對照組最為近似，其他各處理組之開始產卵日期、產卵高峰期之發生與持續期雖與對照組略同，但彼等產卵高峰期間之日產卵寄生數卻較對照組降低。

Key words: *Hemiptarsenus varicornis*, *Liriomyza trifolii*, storage, host-killing capability, oviposition-regulating capability

關鍵詞: 異角釉小蜂、非洲菊斑潛蠅、貯存、致死寄主能力、產卵調節能力

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異角釉小蜂 (*Hemiptarsenus varicornis*) (膜翅目：釉小蜂科) 之貯存與產卵調節能力

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摘 要

本文探討異角釉小蜂 (*Hemiptarsenus varicornis* (Girault)) 貯存之蟲期與條件及雌蜂經貯存後之產卵調節能力。結果得知第一日齡蛹在 8°C 下經貯存 1~2 週後在 25°C 下之羽化率即下降為 71.2~73.4%，與對照組之 96.0% 呈顯著差異。而第一日齡蛹在 10°C 下經貯存 1~5 週後在 25°C 下之羽化率卻高達 91.7~99.0%，與對照組無顯著差異，且彼等初羽化成蜂移入 25°C 定溫並每日供應寄主非洲菊斑潛蠅 (*Liriomyza trifolii* (Burgess)) 與純蜂蜜時，其雌、雄蜂壽命與子代雌性比雖不受蜂蛹低溫貯存 1~4 週之影響，但其致死寄主總數與子蜂數卻受彼等蜂蛹低溫貯存之影響，較對照組各減少 44.3~54.7% 與 55.9~67.2%。成蜂在 15~30°C 下僅以純蜂蜜餵食時，以 15°C 時雌、雄蜂壽命最長，其實測值各為 44.7 與 42.3 日，且雌、雄蜂各貯存至 38 與 37 日時，其存活率仍高達 80%。同時發現雌蜂在 15 或 25°C 下餵食純蜂蜜待貯存期滿移入 25°C 定溫且每日供應寄主與純蜂蜜後，僅雌蜂在 15°C 下貯存 10 日者，其生育力 (fertility) 與致死寄主能力與對照組無顯著差異；而雌蜂在 15 或 25°C 下各貯存 20~30 或 10~15 日者，其壽命、致死寄主總數及子代雌性比等雖與對照組無顯著差異，但其子蜂數卻顯著較對照組各減少 39.2~43.6% 與 31.4~33.3%。總之，室內繁殖異角釉小蜂時之貯存條件較嚴，其中以雌蜂在 15°C 下餵食純蜂蜜貯存 10 日者為最適，其次為雌蜂在 15 或 25°C 下餵食純蜂蜜各貯存 20~30 或 10~15 日，再次為第一日齡蛹在 10°C 下貯存 1~4 週。但田間以生物藥劑方式釋放異角釉小蜂時，其貯存之條件可較繁殖時為寬，其中以雌蜂在 15 或 25°C 下餵食純蜂蜜各貯存 10~30 或 10~15 日為最適，其次為雌蜂在 15°C 下餵食純蜂蜜貯存 40 日或第一日齡蛹在 10°C 下貯存 1~4 週。另雌蜂經貯存後再遇寄主時確具產卵調節能力，其中以 15°C 下隔離寄主 10 日者之日寄生型式與對照組最為近似，其他各處理組之開始產卵日期、產卵高峰期之發生與持續期雖與對照組略同，但彼等產卵高峰期間之日產卵寄生數卻較照組降低。

關鍵詞：異角釉小蜂、非洲菊斑潛蠅、貯存、致死寄主能力、產卵調節能力

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前 言

異角釉小蜂 (*Hemiptarsenus varicornis* (Girault)) 分布於東半球之熱帶與暖帶及美國、夏威夷、薩摩亞、臺灣、中國大陸廣東等地 (Kerrich, 1968; Minkenberg and van Lenteren, 1986; Boucek, 1988; Lin and Wang, 1992; Murphy and LaSalle, 1999; Zeng *et al.*, 1999)。寄主範圍包括雙翅目潛蠅科之非洲菊斑潛蠅 (*Liriomyza trifolii* (Burgess))、番茄斑潛蠅 (*L. bryoniae* (Kaltenbach))、蔬菜斑潛蠅 (*L. sativae* (Blanchard))、紫苑斑潛蠅 (*L. pusilla* Meigen) 及菜豆蛇潛蠅 (*Ophiomyia phaseoli* (Tryon)) 等 (Kerrich, 1968; Boucek, 1988; Del, 1989; Lee, 1990; Lin and Wang, 1992)。在臺灣中部非洲菊園內，該蜂不僅為非洲菊斑潛蠅之本地種優勢寄生蜂 (Chien and Ku, 1998)，且由其生物性顯示為有效寄生蜂 (Lin and Wang, 1992; Chien and Ku, 2001a, b; Chien and Ku, 2002; Chien *et al.*, 2004)。進行害蟲生物防治時，為配合害蟲之發生，常需貯存天敵以備適時釋放，如此天敵之貯存蟲期與條件即為害蟲生物防治成敗的關鍵之一。然異角釉小蜂貯存之相關資料有限，僅知該蜂壽命除受溫度影響外，尚受蜂蜜與其寄主體液之影響 (Chien *et al.*, 2004)。另外當寄主缺乏時，寄生蜂是否具有產卵調節能力，亦為評估有效寄生蜂之要件之一。為增進異角釉小蜂對非洲菊斑潛蠅生物防治之利用，乃進行本試驗，探討異角釉小蜂最適之貯存蟲期與條件及該蜂之產卵調節能力，冀能提供該蜂貯存技術與保育措施之參考。

材料與方法

一、寄主植物、寄主昆蟲及寄生蜂之飼育

本試驗所用之非洲菊斑潛蠅蟲源、寄主植物菜豆 (*Phaseolus vulgaris* var. *communis* Aeschers) 苗及寄主非洲菊斑潛蠅之繁殖方法，如 Chien and Ku (1996) 所述。異角釉小蜂之蟲源與繁殖方法，則如 Chien and Ku (2001a, b) 所述。即以帶有第三齡非洲菊斑潛蠅幼蟲潛食之罐插菜豆苗，繁殖異角釉小蜂。

二、寄生蜂寄生致死寄主與取食致死寄主之區分

本試驗中區分寄主幼蟲被異角釉小蜂寄生或取食後之致死徵狀，係依 Chien and Ku (2001a, b) 所述，被寄生者體黃色、外形鬆馳拉長但仍保持原來之飽滿、消化管內無暗綠色之內容物、呈深度麻痺狀態；被取食者體黃褐色、外形伸長體扁且萎縮、消化管內仍殘有暗綠色之內容物、傷口處留有乾涸之體液。

三、低溫貯存蜂蛹對蛹期發育之影響

先將在 25°C 下繁殖之第一日齡蜂蛹每 30 個裝入 7×1.5 cm 之指形管內，然後將其分別移入 8 與 10°C 之定溫箱內，各貯存 1、2、3 及 4 週與 1、2、3、4、5、6、8 及 9 週，待各處理貯存期滿後，將內有蜂蛹之指形管取出移至 25°C 定溫下，其中 8°C 之各處理組僅記錄成蜂之羽化率，而 10°C 之各處理組則記錄蜂蛹之發育日數與成蜂之羽化率。另設一未經低溫貯存之對照組。各進行 3~4 重複。

四、低溫貯存蜂蛹對成蜂生育力 (fertility) 與致死寄主能力之影響

利用前項蜂蛹經 10°C 低溫貯存 1、3、4、6 及 8 週後正常羽化之成蜂為試材。在 25°C 定溫下，將初羽化之一對雌、雄蜂引入

21×12 cm 之玻璃筒，每日早上 7 點，各處理以細毛筆將純蜂蜜塗於玻璃筒內壁，並供應 1 株內有 40~50 隻寄主第三齡幼蟲潛食之罐插菜豆苗，直至供試蜂死亡為止。試驗期間，每日將各處理所更換下內有被寄生寄主之菜豆苗移至 25℃ 下飼育直至子代成蜂羽化，並依 Chien and Ku (2001a) 之方法，於接蜂後次晨，先利用透光法計數雌蜂對寄主幼蟲之致死總數（寄生致死數與取食致死數），6 日後，再分別記錄雌蜂對寄主幼蟲之寄生數（寄生蜂蛹數）與取食寄主數（致死寄主總數－寄生蜂蛹數）及寄生致死寄主與取食致死寄主之比例等；待寄生蜂死亡後記錄成蜂壽命；子蜂羽化後再記錄雌蜂與雄蜂數及雌性比（♀/(♀ + ♂)）。亦設一未經低溫貯存之對照組。各進行 4~20 重複。

五、溫度對成蜂貯存時壽命與存活率之影響

先將於 25℃ 下初羽化之成蜂每 10 對引入 10×3 cm 之玻璃管內，再將玻璃管分別放入 15、20、25 及 30℃ 等不同溫度之定溫箱，每日以細毛筆將純蜂蜜塗於玻璃管內壁供其取食，並記錄成蜂之壽命與日存活率，各進行 5 重複。

六、成蜂貯存對其生育力與致死寄主能力之影響

先將在 25℃ 下初羽化之成蜂每 10 對引入 10×3 cm 之玻璃管，再將玻璃管分別放置在 15 與 25℃ 之定溫下，15℃ 時各貯存 10、20、30 及 40 日，25℃ 時各貯存 10 與 15 日，期間每日以細毛筆將純蜂蜜塗於玻璃管內壁餵食。待各處理組成蜂貯存時間期滿後，移置 25℃ 定溫下，將其中一對雌、雄蜂引入 21×12 cm 之玻璃筒，各處理組每日如上項所述供應純蜂蜜與 1 株內有 40~50 隻

寄主第三齡幼蟲潛食之罐插菜豆苗，直至供試蜂死亡為止。試驗期間，每日將各處理組所更換下內有被寄生寄主之菜豆苗移至 25℃ 下飼育直至子代成蜂羽化，且依 Chien and Ku (2001a) 之方法，記錄各處理組成蜂之壽命、子蜂數、子代雌性比（♀/(♀ + ♂)）、致死寄主總數、寄生致死寄主數、取食致死寄主數及寄生致死寄主數與取食致死寄主數之比例等。亦設一未經貯存之對照組。各進行 4~11 重複。

七、雌蜂之產卵與取食調節能力

利用材料與方法第六項試驗中之材料與方法，探測雌蜂當僅供應純蜂蜜、無寄主存在時產卵與取食寄主之調節能力。試驗期間，每日將各處理組所更換下內有被寄生寄主之菜豆苗移至 25℃ 下飼育直至子代成蜂羽化，且依 Chien and Ku (2001a) 之方法，記錄各處理組雌蜂每日之產卵寄生數與取食寄主數。亦設一未經貯存之對照組。各進行 4~11 重複。

八、統計分析

各項試驗資料利用 SPSS (Statistical Products and Services Solutions) 軟體先進行變方分析，再以最小顯著差 (LSD) 法或 t 值測試法檢測，並採 $p \leq 0.05$ 顯著水準比較處理間之差異性。利用迴歸分析法顯示寄生蜂之各測試項目 (\hat{y})，如蛹期、羽化率、雌蜂與雄蜂之壽命、雌蜂致死寄主總數、雌蜂寄生致死寄主數、雌蜂取食致死寄主數、雌蜂寄生致死寄主數與取食致死寄主數之比例、子蜂數及雌性比等與貯存期 (x) 之關係，並採 $p < 0.05$ 之顯著水準進行迴歸之變異數分析。當 $\hat{y} = b_0 + b_1x + b_2x^2$ 時， \hat{y} 最大值之求法，係以 $x = -b_1/2b_2$ 代入前項公式求得 (Neter and Wasserman, 1974)。

結 果

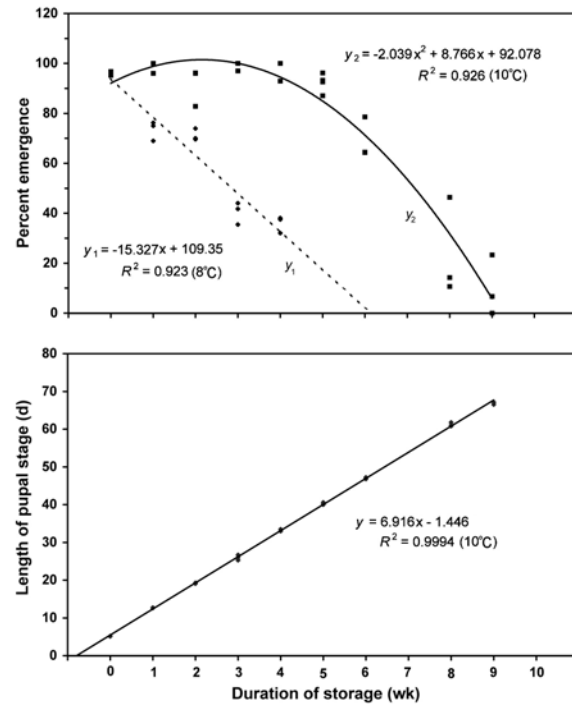
一、低溫貯存蜂蛹對蛹期發育之影響

第一日齡蜂蛹在 8 或 10°C 貯存時之羽化率與蜂蛹貯存期各呈顯著之直線或二次迴歸關係 (圖一)。蜂蛹在 8°C 經貯存 1~4 週後之羽化率不僅均顯著較對照組降低, 亦與蜂蛹在 10°C 經貯存 1~4 週後各處理組之羽化率呈顯著差異; 但蜂蛹在 10°C 經貯存 1~5 週後之羽化率仍維持在 92.3~99.0%, 與對照組均無顯著差異 (表一)。顯示就羽化率而言, 異角釉小蜂第一日齡蜂蛹之最適貯存條件為在 10°C 下貯存 1~5 週。

10°C 下異角釉小蜂內含貯存時間之蛹期雖隨蜂蛹貯存期之延長而顯著增加, 兩者呈顯著之直線迴歸關係 (圖一)。但蜂蛹在 10°C 貯存期中幾乎停滯發育, 蜂蛹經 10°C 貯存 1~8 週後移至 25°C 下, 所需羽化日數未見顯著減少, 僅貯存 9 週者之羽化日數縮短為 3.8 日, 與對照組呈顯著差異 (表一)。

二、蜂蛹貯存對釉小蜂壽命、生育力及致死寄主能力之影響

第一日齡蜂蛹經 10°C 低溫貯存後, 在 25°C 定溫、每日供應 40~50 隻寄主第三齡幼蟲與純蜂蜜時, 其成蜂壽命、或子蜂數、或子代雌性比等均與蜂蛹貯存期呈顯著之二次迴歸關係, 雌、雄蜂壽命之最大估測值為蜂蛹在 10°C 下各冷存 3.2 與 2.9 週後之 31.7 與 22.5 日 (圖二)。蜂蛹冷存 3~4 週時雌、雄蜂壽命雖顯著較對照組延長; 但蜂蛹冷存 1~8 週後之子蜂數卻較對照組顯著減少 44.1~84.3%; 雌性比方面, 僅蜂蛹冷存 3 與 8 週者其值各降為 0.46 與 0.09, 與對照組呈顯著差異 (表二)。



圖一 異角釉小蜂蜂蛹經 8 或 10°C 貯存 0 至 9 週後在 25°C 下之羽化率與蛹期。

Fig. 1. Percent emergence and length of the pupal stage (including storage duration) of *Hemiptarsenus varicornis* at 25°C after pupae had been stored at 8 or 10°C for 0 to 9 weeks. Regression lines drawn for relationships where $p < 0.05$.

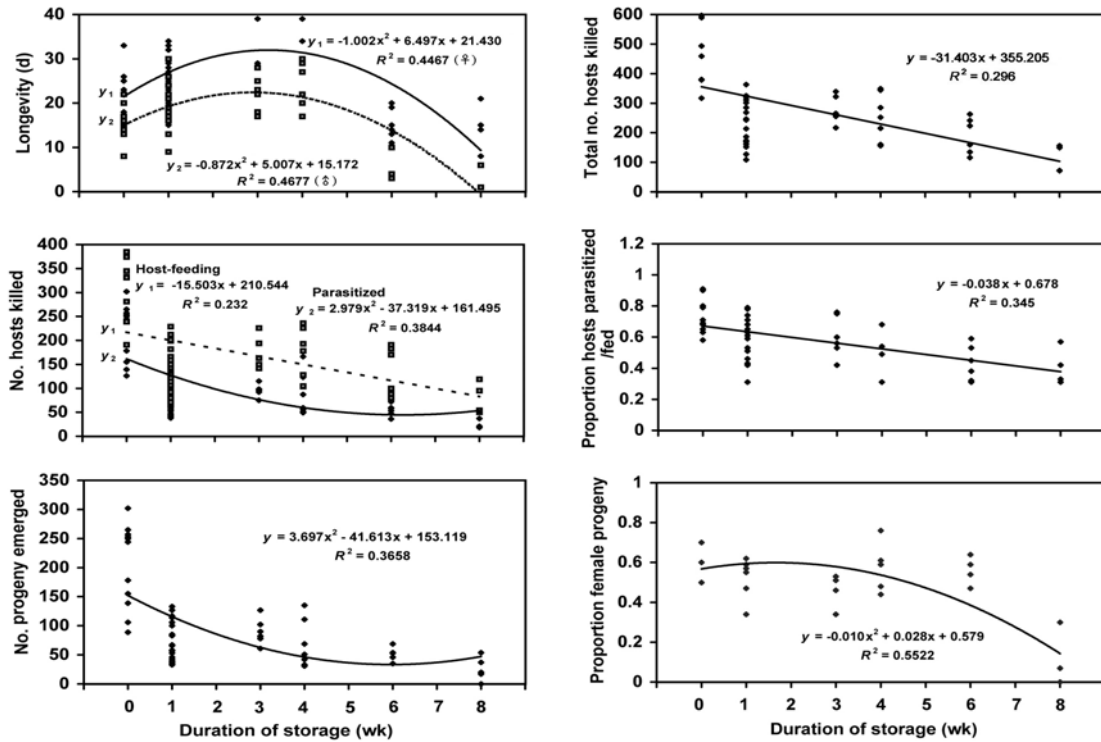
雌蜂一生致死寄主總數與取食致死寄主數及寄生致死寄主數與取食致死寄主數之比例、或寄生致死寄主數等, 與蜂蛹貯存期各呈顯著之直線、或二次迴歸關係 (圖二)。蜂蛹冷存 1~8 週後, 不僅各處理組雌蜂之致死寄主總數、寄生致死寄主數及取食致死寄主數均顯著較對照組各減少 55.7~77.5%、50.5~84.3% 及 39.7~72.1%, 同時雌蜂一生寄生致死寄主數與取食致死寄主數之比例亦顯著由對照組之 0.73:1 降為 0.41~0.60:1 (表二)。

表一 異角袖小蜂蛹經 8 與 10°C 下貯存 0 至 9 週後在 25°C 下之羽化率與蛹期

Table 1. Percent emergence and length of the pupal stage ($\bar{x} \pm SE$) of *Hemiptarsenus varicornis* at 25°C after pupae had been stored at 8 and 10°C for 0 to 9 weeks

Duration of storage (wk)	Percent emergence		Length of pupal stage at 10°C (d)	
	8°C	10°C	Storage duration included	Storage duration excluded
1	73.4 ± 2.2Bb ¹⁾	98.7 ± 1.3Aa	12.6 ± 0.1h	5.6 ± 0.1a
2	71.2 ± 1.4Bb	91.7 ± 4.4Aa	19.2 ± 0.1g	5.2 ± 0.1a
3	40.4 ± 2.5Bc	99.0 ± 1.0Aa	26.0 ± 0.4f	5.2 ± 0.2a
4	35.9 ± 1.9Bc	97.6 ± 2.4Aa	32.3 ± 0.2e	5.3 ± 0.2a
5	-	92.3 ± 1.9a	40.3 ± 0.1d	5.3 ± 0.1a
6	-	69.1 ± 4.7b	47.0 ± 0.1c	5.0 ± 0.1a
8	-	23.8 ± 11.4c	61.2 ± 0.3b	5.2 ± 0.3a
9	-	10.0 ± 6.9c	66.8 ± 0.3a	3.8 ± 0.3b
Control	96.0 ± 0.5Aa	96.0 ± 0.5Aa	5.2 ± 0.1i	5.2 ± 0.1a

¹⁾ Means within each row followed by the same uppercase letter are not significantly different at $p \leq 0.05$ (t -test). Means within each column followed by the same lowercase letter are not significantly different at $p \leq 0.05$ (LSD). Percentages of emergence were transformed to arcsine \sqrt{x} prior to the ANOVA test.



圖二 異角袖小蜂蛹經 10°C 貯存 0 至 8 週後在 25°C 下成蟲之壽命、生育力及致死寄主能力。

Fig. 2. Longevity, fertility, and host-killing capability of *Hemiptarsenus varicornis* adults at 25°C after pupae had been stored at 10°C for 0 to 8 weeks. Regression lines drawn for relationships where $p < 0.05$.

表二 異角釉小蜂蛹經 10°C 貯存 0 至 8 週後在 25°C 下成蜂之壽命、生育力及致死寄主能力

Table 2. Longevity, fertility, and host-killing capability ($\bar{x} \pm SE$) of *Hemiptarsenus varicornis* adults at 25°C after pupae had been stored at 10°C for 0 to 8 weeks

Duration of storage (wk)	n	Longevity (d)		No. progeny produced/♀		No. hosts killed/♀			
		Female	Male	No. of adult emerged	Proportion of female	Parasitized (A)	Feeding (B)	Total	A/B
1	20	25 ± 1b ¹⁾	19 ± 1bc	72 ± 8bc	0.54 ± 0.04ab	85 ± 8bc	140 ± 11bc	225 ± 17b	0.59 ± 0.03b
3	6	36 ± 3a	22 ± 2ab	90 ± 9b	0.46 ± 0.04b	104 ± 10b	173 ± 13b	277 ± 19b	0.60 ± 0.04b
4	7	36 ± 2a	25 ± 2a	67 ± 15bc	0.55 ± 0.05ab	84 ± 17bcd	167 ± 21b	252 ± 30b	0.51 ± 0.06bc
6	6	15 ± 1c	6 ± 2d	52 ± 5bc	0.57 ± 0.03ab	54 ± 5cd	135 ± 21bc	190 ± 25c	0.43 ± 0.05c
8	4	13 ± 2c	4 ± 3d	32 ± 9c	0.09 ± 0.07c	33 ± 8d	80 ± 17c	112 ± 23c	0.41 ± 0.06c
Control	11	22 ± 2b	15 ± 1c	204 ± 22a	0.62 ± 0.02a	210 ± 19a	287 ± 21a	497 ± 38a	0.73 ± 0.04a

¹⁾ Means within each column followed by the same letter are not significantly different at $p \leq 0.05$ (LSD).

三、溫度對成蜂貯存時壽命與存活率之影響

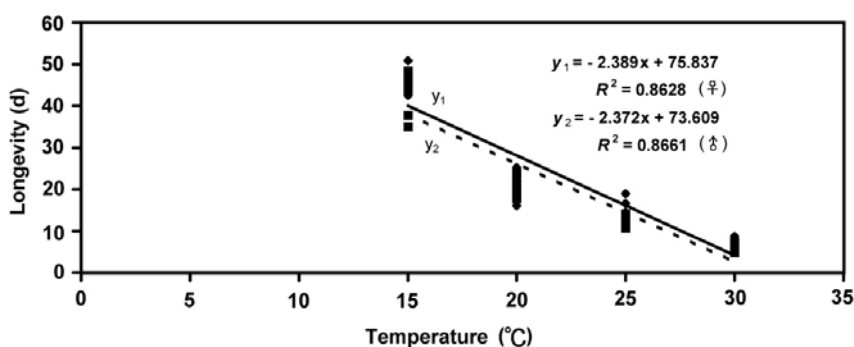
異角釉小蜂在 15~30°C 定溫、僅以純蜂蜜餵食時，雌、雄蜂壽命均隨溫度之上升而縮短，兩者呈顯著之直線迴歸關係（圖三）。成蜂各日齡存活率亦隨貯存期內溫度之上升而降低，在 15°C 下雌、雄蜂各貯存 38 與 37 日後之存活率仍高達 80%；而雌、雄蜂在 20、25 及 30°C 下各貯存 18、11~12 及 4~5 日後之存活率即低於 80%（圖四）。

四、成蜂貯存對其壽命、生育力及致死寄主能力之影響

在 25°C 定溫、每日供應 40~50 隻寄主

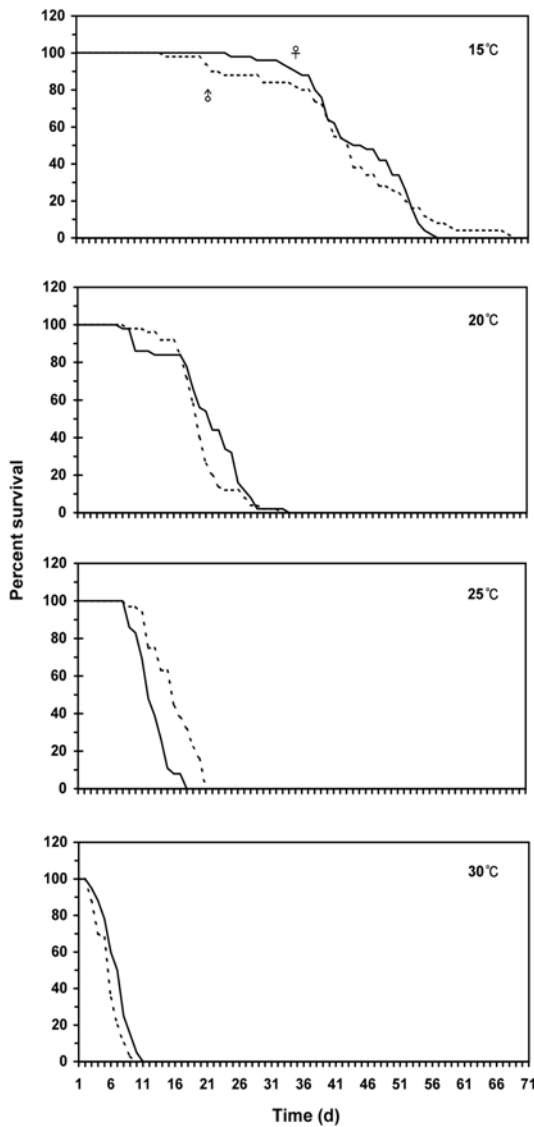
第三齡幼蟲與純蜂蜜時，不論異角釉小蜂曾在 15 或 25°C 下貯存，雌蜂壽命或子蜂數均與雌蜂貯存期呈顯著之直線迴歸關係；但子代雌性比卻與雌蜂在 15°C ($p = 0.1550$) 或 25°C ($p = 0.4408$) 下之貯存期無關（圖五）。各處理組雌蜂壽命雖均較對照組顯著延長；但子蜂數方面，僅雌蜂在 15°C 下貯存 10 日之處理組與對照組無顯著差異，至於各處理組之子代雌性比則不受雌蜂貯存之影響，均與對照組無顯著差異（表三）。

異角釉小蜂一生之致死寄主總數、或寄生致死寄主數、或寄生致死寄主與取食致死寄主之比例等均與雌蜂在 15°C 下之貯存期呈顯



圖三 供應蜂蜜時異角釉小蜂壽命與溫度之關係。

Fig. 3. Relationship between temperature and longevity of *Hemiptarsenus varicornis* fed with honey. Regression lines drawn for relationships where $p < 0.05$.



圖四 供應蜂蜜時異角釉小蜂成蜂日存活率與溫度之關係。

Fig. 4. Relationship between temperature and daily survival rates of adult *Hemiptarsenus varicornis* fed with honey.

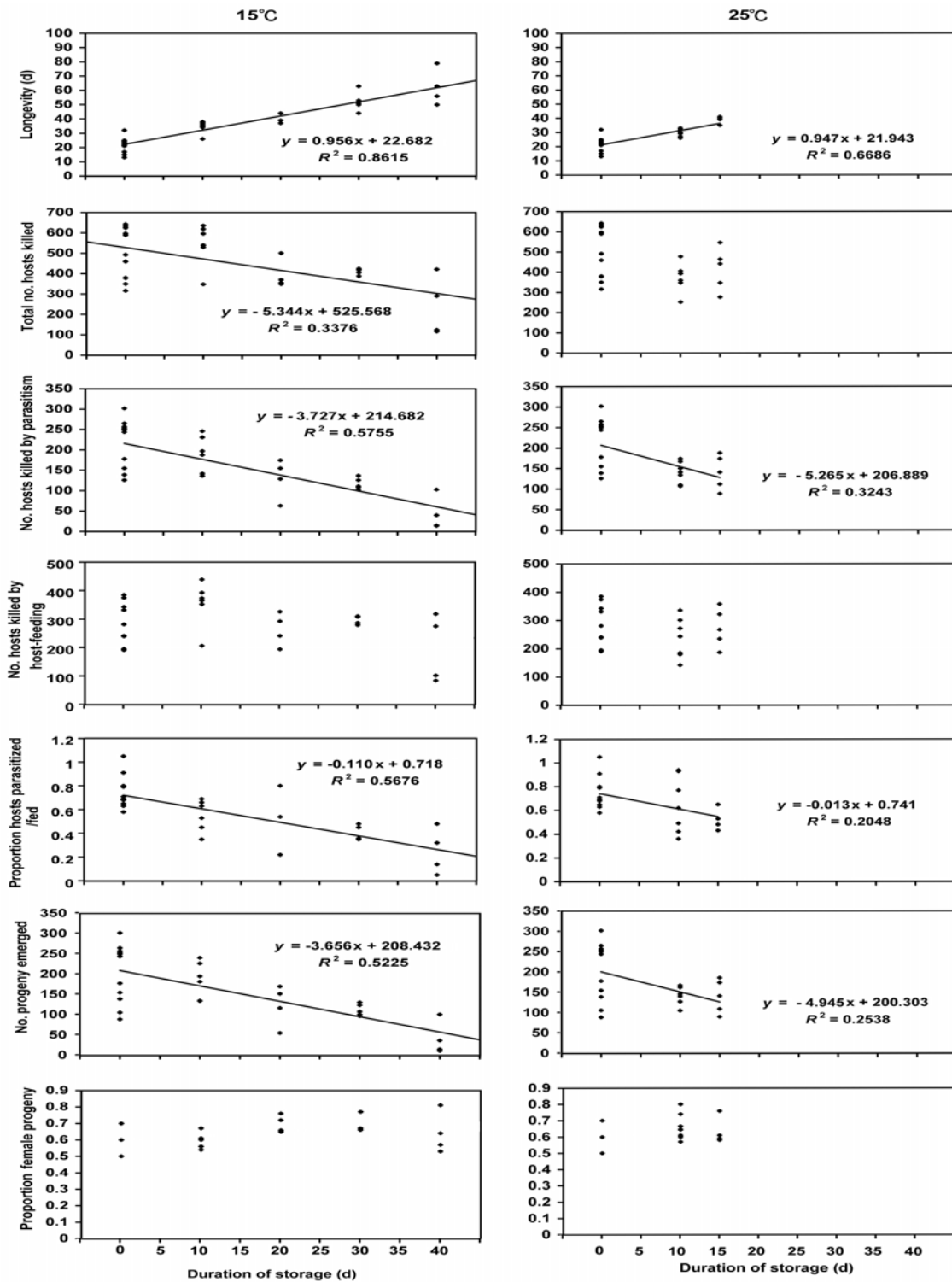
著之直線迴歸關係 (圖五); 但雌蜂在 25°C 下貯存時, 後兩項雖仍與貯存期各呈顯著之直線迴歸關係, 但前項卻與貯存期無關 ($p = 0.0559$) (圖五)。至於雌蜂一生取食致死寄主

數, 則均與該蜂在 15°C ($p = 0.1089$) 或 25°C ($p = 0.3976$) 下之貯存期無關 (圖五)。顯示異角釉小蜂雌蜂不論在 15°C 下貯存 10~30 日或在 25°C 下貯存 15 日, 其致死寄主總數不受雌蜂貯存之影響, 與對照組均無顯著差異; 寄生致死寄主數方面, 各處理組中僅在 15°C 下貯存 10 日者與對照組無顯著差異; 取食致死寄主數方面, 各處理組均不受雌蜂貯存之影響, 與對照組無顯著差異; 寄生致死寄主與取食致死寄主之比例方面, 各處理組中僅在 25°C 下貯存 10 日者與對照組無顯著差異 (表三)。

五、雌蜂之產卵與取食調節能力

由圖六所示, 異角釉小蜂雌蜂於供食純蜂蜜經不同隔離寄主時間與兩種溫度貯存後, 在 25°C 下之各日寄生型式中, 以 15°C 下隔離寄主 10 天者與 25°C 下未隔離寄主之對照組間最為近似, 前者供應寄主後當日可產下 1.2 粒卵, 且自第三日起每日產下 6.4~14.0 粒卵, 維持近 20 天之產卵高峰期; 後者初羽化後供應寄主當日可產下 3.5 粒卵, 且自第二日起每日產下 7.5~14.2 粒卵, 維持 18 天之產卵高峰期。至於其他處理組之開始產卵日期、產卵高峰期之發生與持續日期雖與對照組略同, 但彼等產卵高峰期之日產卵寄生數卻較對照組降低。顯示異角釉小蜂僅餵食純蜂蜜在 15°C 下與寄主隔離 10 天、或在 15 與 25°C 下與寄主各隔離 20~30 與 10~15 天後, 該蜂若遇寄主仍可發揮其全部或 56.4~68.6% 之寄生能力, 但若雌蜂在 15°C 下與寄主隔離長達 40 天者, 一旦遇寄主其寄生能力僅剩 26.0% (表三)。

異角釉小蜂雌蜂於供食純蜂蜜經不同隔離寄主時間與兩種溫度貯存後, 各處理組雌蜂對寄主之取食數不但與對照組無顯著差異 (表



圖五 異角袖小蜂雌蜂經不同隔離寄主時間與兩種溫度貯存後在 25°C 下之壽命、生育力及致死寄主能力。
 Fig. 5. Longevity, fertility, and host-killing capability of female *Hemiptarsenus varicornis* at 25°C after females had been stored and isolated from the hosts for various durations at 2 temperature regimes. Regression lines drawn for relationships where $p < 0.05$.

表三 異角釉小蜂雌蜂經不同隔離寄主時間與兩種溫度貯存後在 25°C 下之壽命、生育力及致死寄主能力
 Table 3. Longevity, fertility, and host-killing capability ($\bar{x} \pm SE$) of female *Hemiptarsenus varicornis* at 25°C after females had been stored and isolated from the hosts for various durations at 2 temperature regimes

Duration of storage (d)	n	Longevity (d)	No. progeny produced/♀		No. hosts killed/♀			
			No. of adult emerged	Proportion of female	Parasitized (A)	Feeding (B)	Total	A/B
15°C								
10	6	34 ± 2cd ¹⁾	186 ± 18ab	0.60 ± 0.02b	190 ± 18ab	355 ± 32a	545 ± 43a	0.55 ± 0.05bc
20	4	40 ± 2c	124 ± 25bc	0.70 ± 0.03a	131 ± 24bc	263 ± 29ab	394 ± 36bcd	0.53 ± 0.12bc
30	4	50 ± 2b	115 ± 8cd	0.70 ± 0.04ab	119 ± 8cd	290 ± 6ab	409 ± 8abcd	0.41 ± 0.03cd
40	5	62 ± 5a	53 ± 20d	0.64 ± 0.06ab	56 ± 21d	218 ± 52b	274 ± 67d	0.27 ± 0.08d
25°C								
10	7	29 ± 1d	136 ± 9bc	0.66 ± 0.03ab	140 ± 10bc	237 ± 27b	377 ± 26cd	0.65 ± 0.09ab
15	5	38 ± 1c	140 ± 18bc	0.63 ± 0.03ab	141 ± 19bc	274 ± 30ab	415 ± 17abc	0.51 ± 0.04bc
Control	11	22 ± 2e	204 ± 22a	0.62 ± 0.02ab	210 ± 19a	287 ± 21ab	497 ± 38ab	0.73 ± 0.04a

¹⁾ Means within each column followed by the same letter are not significantly different at $p \leq 0.05$ (LSD).

三), 且各處理組在 25°C 下之開始取食寄主日期、取食寄主高峰期之發生與持續日期及取食寄主高峰期間之日取食寄主數等皆與對照組相近 (圖六)。

討論與結論

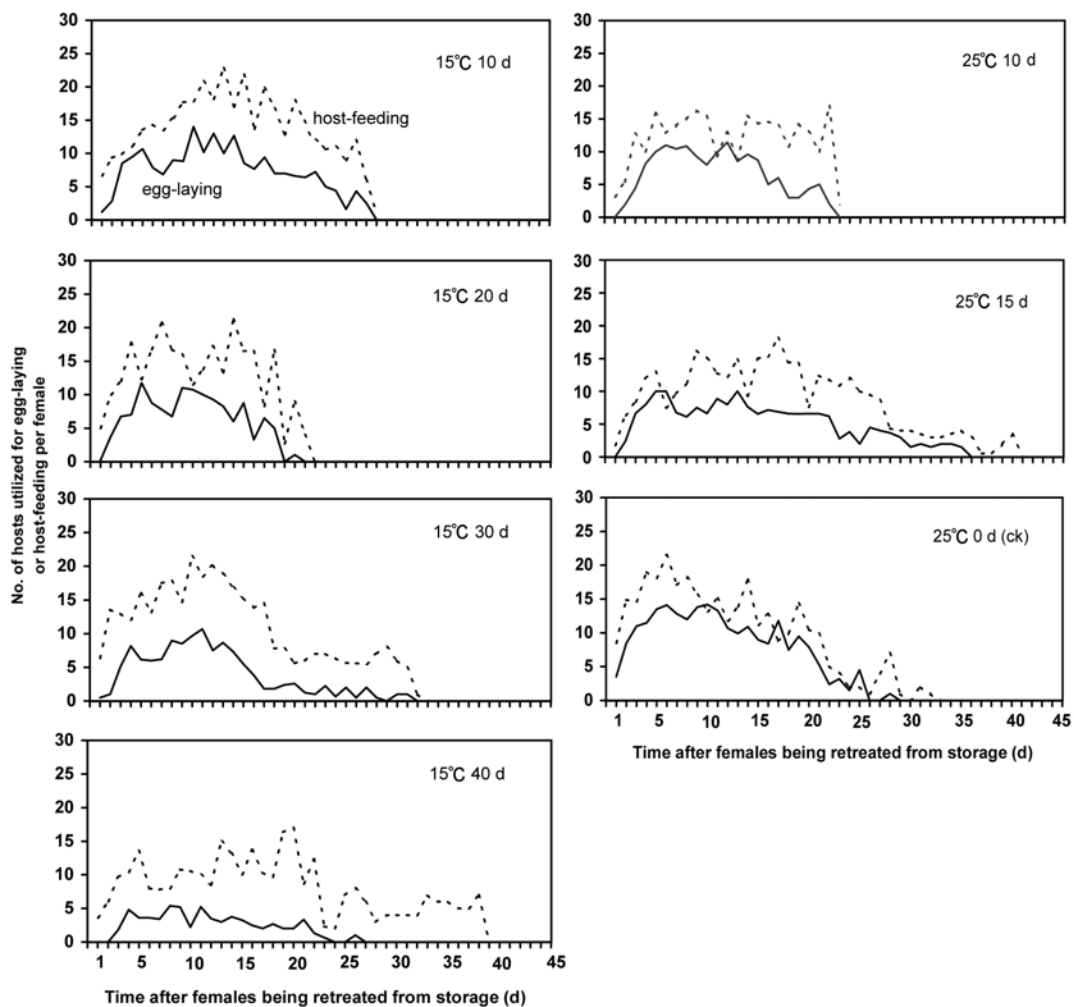
一、異角釉小蜂蜂蛹之貯存

寄生蜂蜂蛹貯存之條件需考量溫度、蛹齡、羽化率、發育日數及成蜂之生育力與致死寄主能力等。由本試驗結果得知, 單就羽化率而言, 異角釉小蜂第一日齡蜂蛹最適貯存之溫度與期限為 10°C 下貯存 1~5 週, 且在此貯存期中蛹停滯發育。至於羽化後成蜂之生育力與致死寄主能力, 則顯示雌、雄蜂壽命與子代雌性比雖不受蜂蛹低溫貯存 1~4 週之影響, 但其致死寄主總數與子蜂數卻受其影響, 較對照組各減少 44.3~54.7% 與 55.9~67.2%。因而就寄生蜂之繁殖而言, 異角釉小蜂第一日齡蜂蛹並不適宜貯存, 但以生物藥劑形態田間釋放應用時, 該蜂蛹之貯存條件尚可訂為在 10°C 下貯存 1~4 週, 但在 10°C 下

貯存 6~8 週時, 該蜂對寄主之致死力僅達 22.5~38.2%。

二、異角釉小蜂成蜂之貯存

寄生蜂成蜂貯存之條件需考量食物、溫度、空間及成蜂貯存後之生育力與致死寄主能力等。由本試驗結果得知, 單就壽命而言, 成蜂以純蜂蜜餵食時, 在 15°C 下壽命最長。但若考量成蜂貯存後之生育力與致死寄主能力時, 發現雌蜂在 15°C 下貯存 10 日後, 前述兩項特性完全不受低溫貯存影響; 而雌蜂在 15°C 下貯存 20~30 日或 25°C 下貯存 10~15 日後, 其壽命、子代雌性比及致死寄主總數雖不受貯存溫度與時間之影響, 但其子蜂數卻較對照組各減少 39.2~43.6% 與 31.4~33.3%。因而推論, 當繁殖異角釉小蜂時, 因顧及其子蜂之數量, 所以雌蜂最適之貯存條件為在供食純蜂蜜情況, 於 15°C 下貯存 10 日; 其次為在 15°C 下貯存 20~30 日或在 25°C 下貯存 10~15 日。但以生物藥劑 (bioinsecticide) 之形態釋放該蜂田間應用時, 因祇需考量寄生蜂對寄主之致死能力, 因



圖六 經不同隔離寄主時間與溫度處理後異角釉小蜂之日產卵與取食寄主型式。

Fig. 6. Daily oviposition and host-feeding patterns of female *Hemiptarsenus varicornis* after females had been stored and isolated from the hosts for various durations at 2 temperature regimes.

此雌蜂最適之貯存條件可放寬為在 15°C 下貯存 20~30 日或在 25°C 下貯存 10~15 日，甚至在 15°C 下貯存 40 日時，該蜂對寄主之致死能力仍達 55.1%。

三、異角釉小蜂貯存之適當蟲期與條件

進行害蟲生物防治時，為配合害蟲之發生，常需貯存天敵以備適時釋放，如此天敵之貯存蟲期與條件即為害蟲生物防治成敗的關

鍵之一。就本試驗結果得知，相較異角釉小蜂蜂蛹與成蜂貯存後對其生育力與致死寄主能力之影響，建議異角釉小蜂繁殖時，其貯存之最適蟲期與條件為成蜂在 15°C 下餵食純蜂蜜貯存 10 日，其次為成蜂在 15 或 25°C 下餵食純蜂蜜各貯存 20~30 或 10~15 日，再次為第一日齡蛹在 10°C 下貯存 1~4 週。異角釉小蜂以生物藥劑方式田間釋放時，其貯存之最適蟲期與條件為雌蜂在 15 或 25

℃ 下餵食純蜂蜜貯存 10~30 或 10~15 日，其次為雌蜂在 15℃ 下餵食純蜂蜜貯存 40 日或第一日齡蛹在 10℃ 下貯存 1~4 週。

四、異角釉小蜂之產卵調節與保育

寄生蜂卵之形成方式，Price (1974) 認為可分為原定式產卵 (proovigenic) 與應變式產卵 (synovigenic) 兩型。原定式產卵者雌蜂壽命短、產卵期短、日產卵數變化大、無取食寄主習性、排卵自發性、將卵貯存於貯卵腔內而調節產卵；應變式產卵者雌蜂壽命長、產卵期長、日產卵數依微卵管數而約為固定、雌蜂藉取食寄主之方式獲得營養並供成熟卵之持續形成、排卵受外界因子影響非自發性、以卵吸收 (oosorption) 方式調節產卵時機。Bell and Bohm (1975) 亦認為採取應變式產卵繁殖策略之寄生蜂，在不適繁衍環境下常以卵吸收之方式調節產卵時機，從而保存生殖資源並獲得與寄生用適齡寄主同時發生之同律性 (synchronism)。異角釉小蜂依生物性其卵形成之方式屬應變式產卵 (Chien and Ku, 2001b; Chien *et al.*, 2004)，本試驗雖未探究該蜂在隔離寄主後是否有卵吸收現象，但研究結果顯示雌蜂僅餵食純蜂蜜在 15℃ 定溫下隔離寄主 10 天仍可維持其原來未經貯存之生殖力，而在 15 與 25℃ 定溫下，其產卵調節期雖可各延長 20~30 與 10~15 天，但其寄生能力卻大幅降為 56.4~68.6%，甚至在 15℃ 下產卵調節期長達 40 天者，其寄生能力僅剩 26.0%。由此得知異角釉小蜂當棲所環境不穩定致使其與寄主同律性遭受破壞時，其適應性有限，為發揮異角釉小蜂對非洲菊斑潛蠅之抑制效果，建議田間防治非洲菊斑潛蠅時除慎選對寄生蜂無毒或低毒之選擇性藥劑外，尚應注意藥劑之殘效期避免超過寄生蜂之

產卵調節時限及在田間供應寄生蜂之蜜源以延長寄生蜂之壽命。

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Study of the Storage and Oviposition-Regulating Capability of *Hemiptarsenus varicornis* (Hymenoptera: Eulophidae)

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ABSTRACT

In this study, we investigated the suitable life stages and conditions for storage of the wasp, *Hemiptarsenus varicornis* (Girault). The wasp's oviposition-regulating capability after storage was also determined. Results showed that there was a significant difference in the percent emergence between 1-day-old pupae stored at 8°C for 1-2 weeks (% emergence = 71.2-73.4%) and the control (% emergence = 96%). However, the percent emergence did not decrease if the 1-day-old pupae were stored at 10°C for 1-5 weeks. Emerged from the pupae previously stored at 10°C for 1-4 weeks, and followed by rearing at 25°C with honey and host (*Liriomyza trifolii* (Burgess)), the wasps were not affected by the storage conditions in their adult longevity in both sexes and offspring sex ratio. However, the wasp's host-killing capability and offspring production decreased by 44.3-54.7% and 55.9-69.2%, respectively, compared to those of the control. Adults were fed only with honey at between 15 and 30°C for various time periods for the study of storage conditions. It was found that mean adult longevity was the highest under the 15°C storage conditions with the female and male longevity of 44.7 and 42.3 days, respectively. In addition, the survival rate still reached 80% after the female and male had been stored for 38 and 37 days, respectively. After the end of the storage periods, wasps were kept at 25°C with both honey and hosts to evaluate their capability of host-killing and offspring production. The results revealed that the host-killing capability and fertility of the wasps were not influenced after the adults had been stored at 15°C for 10 days. Although adult longevity, host-killing capability, and female progeny proportion were not affected, the total offspring production decreased significantly after adult wasps had been stored at 15°C for 20-30 days or 25°C for 10-15 days. Maintaining a high fertility of the wasp is essential to rearing *H. varicornis* for mass production. For this purpose, suitable conditions to store the colony according to priority are (1) female wasps at 15°C for 10 days, (2) female wasps at 15°C for 20-30 days or 25°C for 10-15 days and (3) 1-day-old pupae at 10°C for 1-4 weeks. With the field release of *H. varicornis* as a bioinsecticide, the primary concern is the host-killing capability of the wasp. As such, the storage conditions can be less restrictive as (1) female wasps at 15°C for 10-30 days or 25°C for 10-15 days, and (2) female wasps at 15°C for 40 days or 1-day-old pupae at 10°C for 1-4 weeks. Female wasp has an ability to self-regulate oviposition in response to different storage conditions. Under the storage conditions at 15°C for 10 days, female *H. varicornis* shows a comparable daily oviposition pattern to that of the control. Although the oviposition schedules and the occurrence and persistence of the peak oviposition period were similar to the control under other storage conditions, the number of daily eggs laid by the wasp at its peak oviposition period was lower than that of the control.

Key words: *Hemiptarsenus varicornis*, *Liriomyza trifolii*, storage, host-killing capability, oviposition-regulating capability