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Host Plants Dependent Prey Suitability of Predatory Lady Beetles

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ABSTRACT

Host plants play an important role in the suitability of preys for development of predatory insects. The suitability of *Aphis gossypii* (Glover) (Hemiptera: Aphididae) from different host plant species, *Solanum xanthocarpum* Schrad. and Wendl. (Solanaceae) and *Chromolaena odorata* (L.) (Asteraceae) as food sources for two lady beetle species, *Menochilus sexmaculatus* Fab. and *Micraspis discolor* (Fabricius) (Coleoptera: Coccinellidae) was evaluated by examining the effect of prey consumption on the performance of lady beetle larvae. Results demonstrated that *A. gossypii* from *S. xanthocarpum* was more suitably for larval growth than *A. gossypii* from *C. odorata*, with faster development time and higher larval survival of both lady beetle species. Consistent with the results of larval performance, larvae of *M. sexmaculatus* showed feeding preference on *A. gossypii* from *S. xanthocarpum* over *A. gossypii* from *C. odorata*. For *M. discolor*, however, longer development time of larvae when reared on *A. gossypii* from *C. odorata* result higher consumption on *A. gossypii* from *C. odorata*. Regardless of lady beetle species and aphid, 4th larval instar was the most voracious. *Menochilus sexmaculatus* was likely resistant to toxic of host plant of aphid, *C. odorata*, while *M. discolor* was susceptible to noxious allelochemicals of *C. odorata* distinctly. The different of essential prey and alternative prey of both lady beetle species was discussed in this study.

Key words: Allelochemicals; *Aphis gossypii*; *Chromolaena odorata*; *Menochilus sexmaculatus*; *Micraspis discolor*.

INTRODUCTION

Many species of predatory lady beetle are important as biological control agents in pest management. The adult and larva of lady beetle prey upon many hemipterans such as aphid (Giorgi *et al.,* 2009), plant hopper, mealy bug, whitefly (Heinz and Zalom, 1996; Liu *et al.,* 1997) and coccid (Gordon, 1985; Obrycki and Kring, 1998; Slipinski, 2007). Life history parameter and consumption rate of lady beetle were studied for application of field and greenhouse pest control (Liu *et al.,* 1997; Ren *et al.,* 2002). Prey species plays a major role in reproduction rate, egg maturation or larval development of lady beetle (Mari *et al.,* 2004; Solangi *et al.,* 2005; Roy *et al.,* 2010). Generally, preference of lady beetle is unequal among prey species. For example, prey species supported performance of larvae and adults (essential prey) were more preferred by lady beetle than poor prey species (alternative prey) (Omkar and Mishra, 2005; Cabral *et al.,* 2006; Giorgi *et al.,* 2009). Alternative prey may range from highly toxic to quite suitable, enabling survival in periods of scarcity of essential

prey (Evans *et al.,* 1999; Hodek and Honek, 1996). Allelochemical compounds of host plant are the one of explanation of unsuitability prey to predatory lady beetle. Some evidence that concentration of glucosinolates (GLS) in host plant influenced to lady beetle development (Francis *et al*., 2001; Pratt *et al*., 2008). *Aphis craccivora* Koch (Hemiptera: Aphididae) was toxic to many lady beetle species when feed on some host plants, i.e., *Vicia faba* L. (Fabaceae) (Okamoto, 1966), while they gave nutritionally adequate for development of lady beetle when feed on *Dolichos lablab* L. (Fabaceae) (Omkar and Mishra, 2005) and *Lablab purpureus* L. (Fabaceae) (Chowdhury *et al.,* 2008). *Brevicoryne brassicae* (L.) (Hemiptera: Aphididae) is unsuitable as prey of lady beetle because of *B. brassicae* is able to take up and sequester glucocinolates, defense secondary metabolic compound, from cruciferous host plants (Francis *et al*., 2001; Bridges *et al.*, 2002). In consistent, Tsaganou *et al.* (2004) presented that larvae of *Harmonia axyridis* (Pallas) (Coleoptera: Coccinellidae) only developed to the 2nd instar when fed exclusively on *B. brassicae* and just to the 3rd instar on *Megoura viciae* Buckton (Hemiptera: Aphididae). Jalali and Michaud (2012) indicated that *Myzus persicae* (Sulzer) (Hemiptera: Aphididae) reared on sweet pepper was the most suitable prey and that the same species reared on tobacco was the least suitable for growth of *Adalia bipunctata* (L.) (Coleoptera: Coccinellidae). In other cases, some allelochemicals such as linamarin acted as defensive compounds to reduce ability of herbivore to utilize plant protein. As a result, prey quality is reduced and development of predator that feed on these prey is decreased (Riddick *et al*., 2011).

Cotton aphid, *Aphis gossypii* (Glover) (Hemiptera: Aphididae) is one of the well known pests of agricultural system, causing significant damage to horticultural plants, either in the fields or in greenhouses. *Aphis gossypii* attacks many host plant species involve economic crop and weed species (Hill, 1983). *Aphis gossypii* has commonly infested Siam weed, *Chromolaena odorata* (L.) (Asteraceae) in the fields (Author's per obs.). Some species of predatory lady beetles such as *Menochilus sexmaculatus* Fab. (Coleoptera: Coccinellidae) and *Micraspis discolor* (Fabricius) (Coleoptera: Coccinellidae) used *A. gossypii* fed on *C. odorata* as the one of their food sources (Author's per obs.). *Chromolaena odorata*, a perennial shrub native to the South Americas, has been introduced into the tropical regions of Asia, Africa and the Pacific, where it has become a major invasive weed in many countries (Orapa, 2004). In favour of its traits, *C. odorata* has been applied for pest management. *Chromolaena odorata* contains noxious secondary compounds act as insecticidal, insect repellent and antibacterial activities (Bouda *et al.,* 2001; Cui *et al.,* 2009; Owolabi *et al.,* 2010). Here, tritrophic interaction between host plant (*C. odorata*), prey (*A. gossypii*) and coccinellid predators (*M. sexmaculatus* and *M. discolor*) may occur in the field. *Menochilus sexmaculatus* has been known as an important predator of aphids (Begum *et al.,* 2002; Mari *et al.,* 2004; Solangi *et al.,* 2005) as well as *M. discolor* fed on aphid (Omkar and Pervez, 2002; Chowdhury *et al.,* 2008) and brown planthopper (Begum *et al.,* 2002). These two lady beetle species were major coccinellid predators for aphid control in Phatthalung agroecosystem. An understanding of factor effect to prey suitability of *M. sexmaculatus* and *M. discolor* will be beneficial for development

of suitable management tactic to conserve these two natural enemies in the field. Likewise, the role of host plant in the tritrophic interactions involving the predator, prey and host plant need to drive step of evaluated the efficacy of biological control agent.

MATERIALS AND METHODS

Insects

Colonies of *A. gossypii* infested egg plant *Solanum xanthocarpum* Schrad. and Wendl. (Solanaceae) were collected from field by cutting infested branches of egg plant. After that, infested branches were put on the *C. odorata* and *S. xanthocarpum* plants grown in the 25 × 25 × 25 cm flowerpots and kept in 90 × 90 × 120 cm Perspex cage covered mesh all four sides at 25 ± 2 ºC, 75 ± 2 % relative humidity (RH) and 12L:12D h. Adults of *M. sexmaculatus* and *M. discolor* were collected from vegetable plots and rice paddy fields at Thaksin University, Phatthalung, Thailand. Lady beetles were provided all stages of *A. gossypii* infested *C. odorata* and *S. xanthocarpum*. F2 offsprings were used to conduct the experiment for reduced losses of fitness of further generation from simultaneously change from field prey to laboratory prey (Rana *et al.,* 2002). Lady beetle cultures were reared under the laboratory condition similar to that of aphid cultures.

Experiments

The eggs laid by females of each lady beetle species on aphid-host leaves were transferred to 9 cm petri-dishes having a circular paper sheets spread over the bottom for egg hatched. Newly hatched 1st instar larvae were placed individually in cylindrical plastic cup (diameter: 4.5 cm, height: 5 cm) contained small moisture cotton and covered with perforated lid. Larvae of each lady beetle species were provided 3nd instar of *A. gossypii* from infested plants (*C. odorata* or *S. xanthocarpum*) twice a day (07.00 and 17:00). The number of aphids supplied in each developmental stage of lady beetles was determined from preliminary observations. The number of aphid consumed by larvae was estimated daily until emergence of the adults. Meanwhile, the development time were estimated by observing the individuals twice a day. For *M. sexmaculatus*, 10 replicates were conducted for *A. gossypii* from both host plant species. For *M. discolor*, 10 and 26 replicates were conducted for *A. gossypii* from *S. xanthocarpum* and *C. odorata*, respectively.

Statistical Analysis

Independent-samples t-test was conducted to evaluate effects of host plants of aphids on prey consumption and larval performance of two lady beetle species. Response variables analysed were the duration of larval growth and the number of consumed prey. Data were transformed using log (x + 1), if required, to meet the assumptions of statistical analysis and then back-transformed for presentation in tables and graph.

RESULTS

Larval development

Effects of host plant species on larval development were evaluated for each instar. For *M. sexmaculatus*, with the exception of last instar larvae, the development times of larvae reared on *A. gossypii* from *C. odorata* were longer than those reared on the same aphid species from *S. xanthocarpum* (Table 1). Then, the total development time of larvae reared on *A. gossypii* from *C. odorata* was higher significantly than larvae reared on *A. gossypii* from *S. xanthocarpum* (Table 1). Likewise, *M. discolor* larvae represented the difference of larval growth and survival when fed on *A. gossypii* from different host plant species. The duration of all larval stages of *M. discolor* reared on *A. gossypii* from *C. odorata* was longer than larvae reared on *A. gossypii* from *S. xanthocarpum* (Table 1). All *M. discolor* larvae survived and managed to complete their life cycles when fed on *A. gossypii* from *S. xanthocarpum*. In contrast, there was only one larva fed on *A. gossypii* from *C. odorata* completed life cycle. Almost of *M. discolor* larvae died when reach to 3rd instar (Table 1).

Table 1. Mean duration (± SE) in days for each instars of *M. sexmaculatus* and *M. discolor* when consumed *A. gossypii* from different host plant species.

Species/ Instar	Duration of days (Mean ± SE)		t-test
	A. gossypii from S. *xanthocarpum*	*A. gossypii* from *C. odorata*	
M. sexmaculatus			
1st	1.10 ± 0.10b	1.55 ± 0.14a	t = -2.535, d.f. = 18, *P* = 0.021
2nd	0.80 ± 0.03b	1.10 ± 0.10a	t = -3.328, d.f. = 18, *P* = 0.004
3rd	1.00 ± 0.00b	1.45 ± 0.18a	t = -2.646, d.f. = 18, *P* = 0.016
4th	2.48 ± 0.16a	2.00 ± 0.21a	t = 1.821, d.f. = 18, *P* = 0.085
Pupa	2.98 ± 0.14a	3.13 ± 0.15a	t = -0.746, d.f. = 18, *P* = 0.465
Larval duration	5.38 ± 0.15b	6.10 ± 0.10a	t = -3.897, d.f. = 18, *P* = 0.001
Total	8.35 ± 0.17b	9.23 ± 0.17a	t = -3.625, d.f. = 18, *P* = 0.002
	n = 10	n = 10	
M. discolor			
1st	2.00 ± 0.24b	3.99 ± 0.46a (18)	t = 3.114, d.f. = 26, *P* = 0.004
2nd	1.90 ± 0.08b	3.28 ± 0.18a (10)	t = 7.232, d.f. = 18, *P* ≤ 0.0001
3rd	2.00 ± 0.13b	3.29 ± 0.24a (6)	t = 5.105, d.f. = 14, *P* ≤ 0.0001
4th	4.00 ± 0.32	7.25 ± 0.00 (2)	
Pupa	4.85 ± 0.10	5.00 ± 0.00 (1)	
Larval duration	9.90 ± 0.50	17.75 ± 1.50	
Total	14.75 ± 0.58	21.25 ± 0.00 (1)	
	n = 10	n = 26	

Values (mean ± SE) in the same row not followed by the same letter are statistically different based on Independent-samples t-test at P < 0.05. Significance is based on log (x + 1)-transformed data, non-transformed data are presented]

Larval consumption

Host plant species also influenced to aphid consumption of larvae. *Menochilus sexmaculatus* larvae of all stages consumed more *A. gossypii* from *S. xanthocarpum*

than those from *C. odorata* significantly (t-test: 1st instar, t = 2.682, d.f. = 18, *P* = 0.015; 2nd instar, t = 4.538, d.f. = 18, *P* ≤ 0.0001; 3rd instar, t = 2.665, d.f. = 18, *P* = 0.016; 4th instar, t = 2.207, d.f. = 18, *P* = 0.041) (Fig. 1). Hence, total number of *A. gossypii* from *S. xanthocarpum* consumed by larvae from 1st instar to 4th instar (253.30 ± 6.01) was higher significantly than total number of *A. gossypii* from *C. odorata* (189.70 ± 3.72) (t-test: t = 9.329, d.f. = 18, *P* ≤ 0.0001).

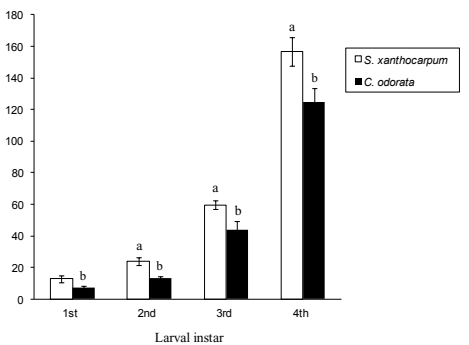

Fig. 1. Mean (± SE) number of *A. gossypii* from different host plant species that consumed by each instars of *M. sexmaculatus*. Columns capped with different letters are statistically different (t- test: P < 0.05; n = 10) Significance is based on log (x + 1)-transformed data, non-transformed data are plotted.

In contrast to results of *M. sexmaculatus*, with the exception of 1st instar larvae, the number of *A. gossypii* consumed by 2nd and 3rd instar larvae of *M. discolor* did not differ significantly among two host plant species (t-test: 2nd instar, t = 0.877, d.f. = 18, *P* = 0.392; 3rd instar, t = -1.302, d.f. = 14, *P* = 0.214) (Fig. 2). For 1st instar, however, longer development time of larvae when reared on *A. gossypii* from *C. odorata* resulting higher consumption on *A. gossypii* from *C. odorata* (t-test: 1st instar, t = 3.075, d.f. = 26, *P* = 0.005) (Fig. 2).

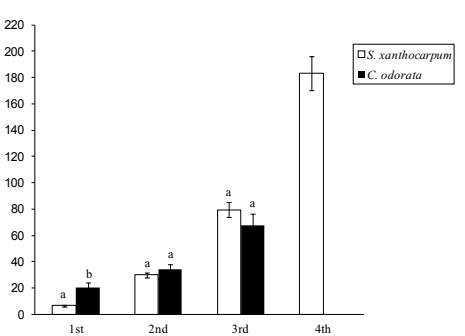

Fig. 2. Mean (± SE) number of *A. gossypii* from different host plant species that consumed by each instars of *M. discolor*. Columns capped with different letters are statistically different [t- test: P < 0.05; *S. xanthocarpum*, n = 10; *C. odorata* , 1st instar, n = 18, 2nd instar, n = 10, 3rd instar, n = 6, 4th instar, n = 2). Significance is based on log (x + 1)-transformed data, non-transformed data are plotted.

Large consumption of two survived larvae of 4th instar that reared on *A. gossypii* from *C. odorata* causing the total number of aphid that consumed by larvae from 1st instar to 4th instar (477.00 ± 32.00) was higher than those of larvae that reared on *A. gossypii* from *S. xanthocarpum* (299.60 ± 10.42). Fourth larval instar of both lady beetle species was the most voracious, regardless of host plant species.

DISCUSSION

The consensus results indicated strongly that host plant of aphid influence to larval development and larval consumption of both *M. sexmaculatus* and *M. discolor*. Larvae of two lady beetle species consumed *A. gossypii* from *S. xanthocarpum* developed faster than those consumed aphids from *C. odorata*. Moreover, larvae of *M. discolor* which reared on aphids from *C. odorata* had high mortality. These results may be partially explained by allelochemical compounds of host plant. *Chromolaena odorata* contains noxious secondary compounds (Bouda *et al.,* 2001; Cui *et al.,* 2009; Owolabi *et al.,* 2010), has been reported as being toxic to adult of *S. zeamais* (Bouda *et al.,* 2001), and this may be the causes of slow development for *M. sexmaculatus* larvae and death to larvae of *M. discolor*. Chemical constitutions of host plant are the one of explanation of unsuitability or suitable prey to predatory lady beetle (Omkar and Mishra, 2005; Chowdhury *et al.,* 2008). The better development and survival of both lady beetle species when reared on aphid from *S. xanthocarpum* can probably be assumed that chemical composition of *S. xanthocarpum* was likely favourable for the suitability of *A. gossypii* to larval growth of *M. sexmaculatus* and *M. discolor* than chemical composition of *C. odorata.* Generally, lady beetle more preferred prey species supported performance of their larvae and adults (essential prey) than poor prey species (alternative prey) (Omkar and Mishra, 2005; Cabral *et al.,* 2006; Giorgi *et al.,* 2009). Hence, higher number of *A. gossypii* from *S. xanthocarpum* consumed by *M. sexmaculatus* may partially represent the preference of *M. sexmaculatus* on aphids from this plant. For *M. discolor*, with the exception of first instar larval stage, there was no significant difference in the number of consumed aphid between two host plant species. Longer duration of 1st instars that reared on aphid from *C. odorata* resulting number of consumed aphid was higher than larvae that reared on *S. xanthocarpum*.

Menochilus sexmaculatus larvae were higher resistant to detrimental effects of *A. gossypii* from *C. odorata* than *M. discolor* larvae with better larval development and survival. Predatory lady beetle resistance to plant toxicity has been reported in some studies. Hukusima and Kamei (1970) reported the resistance of adults and larvae of *Propylea japonica* (Thunberg) to toxicity of *Robinia pseudoaccacia* L. (Fabaceae) that passed through their prey consumptions. In consistent, *Coccinella septempunctata* (L.) (Coleoptera: Coccinellidae) had higher resistance to glucosinolates that accumulated in host plant of their prey than *A. bipunctata* (Pratt *et al*., 2008). For *M. sexmaculatus*, however, I could not assumed that *A. gossypii* from *C. odorata* was unsuitable host for *M. sexmaculatus* larvae. Many studies reported different larval durations of *M. sexmaculatus* when reared on different aphid species. Larval periods of *M.*

sexmaculatus reared on mustard aphid, *Lipaphis erysimi* Kalt (Hemiptera: Aphididae) (Solangi *et al.,* 2005) and alfalfa aphid, *Therioaphis trifolii* Monell (Hemiptera: Aphididae) (Mari *et al.,* 2004) were 12.3 ± 2.41 and 22.1 ± 2.9 days, respectively. Thus, larval duration of *M. sexmaculatus* larvae reared on *A. gossypii* from *C. odorata* was shorter than these aphid species (6.10 ± 0.10 days). In consistent with the result of previous field observation, I often found *M. sexmaculatus* fed on *A. gossypii* from *C. odorata*. Then, it is possibly that *A. gossypii* from *C. odorata* may be the importance food source of *M. sexmaculatus* in the field. In contrast, by relied on essential prey and poor prey (Omkar and Mishra, 2005; Cabral *et al.,* 2006; Giorgi *et al.,* 2009), *A. gossypii* from *C. odorata* may act as the alternative preys (poor preys) for sustaining *M. discolor* populations when essential preys are scarce. This study indicated the tritrophic effects on suitability of prey for performance of lady beetle as many previous studies presented (Bridges *et al.*, 2002; Tsaganou *et al.*, 2004; Chowdhury *et al.,* 2008, Jalali and Michaud, 2012).

Thus, further study should be focus on host preference of lady beetle for deeper understanding of host utilization by lady beetle in cropping systems. Generally, crude extracts of many plants have been used for pest control in Thailand for many years. The effects of these plant crude extracts include Siam weed to lady beetles have not been studied. This knowledge is needed for supporting the potential of biological control method in the field.

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