Suitability of Five Prey Aphid Species for Development, Fecundity and Survival of the Predators *Coccinella septempunctata* (L.) and *Harmonia axyridis* (Pallas) Under Laboratory Conditions

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Abstract

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The developmental time, larval survival and fecundity of *Harmonia axyridis* Pallas and *Coccinella septempunctata* (L.) reared on *Acyrthosiphon pisum* Harris, *Aphis fabae* Scopoli, *A. craccivora* Koch, *Schizaphis graminum* Rondani, *Rhopalosiphum padi* (L.) were studied under laboratory conditions (22±1°C, 70±5% r.h. and 16:8 hours dark:light photoperiod). *C. septempunctata* and *H. axyridis* larvae took shorter time to develop to pupal stage when they fed on *S. graminum* and *A. craccivora* than when fed on the other three species. There was no significant effect of aphid species on the sex ratio. Adult *C. septempunctata* and *H. axyridis* from larvae reared on *A. pisum* and *S. graminum* weighed more than adults reared on the other aphid species. Fecundity of *H. axyridis* and *C. septempunctata* was significantly higher when reared on *A. pisum* (1461±115.04 and 1992±124.80 eggs/ female, respectively) than on the other aphid species. There was no significant effect of aphid species on the longevity of *C. septempunctata* and *H. axyridis adults. A. pisum* and *S. graminum* seem to be the most suitable hosts for *C. septempunctata* and *H. axyridis*, and should be used in rearing these two predators.

Keywords: Aphids, *Harmonia axyridis, Coccinella septempunctata*, development, fecundity

Introduction

Coccinellids are important natural enemies regulating aphid populations (8). *Coccinella septempunctata* is widely distributed in the Palearctic and Oriental Regions (21). It preys on several aphid species in a variety of agroecosystems (8). It has been released and successfully established in several regions of the United States (1, 22). Studies in Eurasia indicate that *C. septempunctata* prefers herbaceous plants in sunny habitats (9).

Harmonia axyridis is a Palearctic species originating from the Far East (10). It was introduced from China into France in 1982 and it is used as a biological control agent in orchards (19), and into North America from Japan (10). It was introduced from France into Syria in 1996 (2).

H. axyridis is an arboreal species, but is also found in gardens and annual crops (8, 10). It is principally aphidophagous (8), but also feeds on scale insects (15), on psyllids (10), mites (14), lepidopteran and coleopteran eggs (8, 23). However, *H. axyridis* has become an important contaminant of wine grapes (6) and pest of other fruits (12). Because *H. axyridis* was recently introduced to Syria, and to evaluate its potential as a biological agent, a series of studies were needed.

The objective of this study was to evaluate the effects of five aphid species as the food source on the developmental time, larval survival, adult weight, fecundity and longevity of *C. septempunctata* and *H. axyridis.*

Materials and Methods

In 2001, adult *C. septempunctata* were collected from faba bean (*Vicia faba* L.) fields in Aleppo, Syria and adult *H. axyridis* were obtained from the Biological Control Laboratory at the University of Aleppo where they were reared on *Ephestia kuehniella* Zeller eggs.

Both predators were reared separately on pea aphid, *A. pisum*, black bean aphid, *A. fabae*, cowpea aphid, *A. craccivora*, greenbug aphid, *S. graminum*, and the bird-cherry oat aphid *R. padi*. The pea aphid, black bean aphid and the cowpea aphid were reared on young faba bean plants and the greenbug and bird-cherry oat aphid were reared on wheat seedlings.

The cultures were maintained in a rearing room set at 22±1°C, 70±5% r.h. and L16:D8 photoperiod at the International Center for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria. Each predator was reared on each aphid species separately, by placing 20 pairs into a plastic container (12x12x8 cm) with a screened cover and supplied daily with fresh plant sections containing aphids. Each predator was reared for two generations, and the offspring of the second generation was used in the experiments. The egg clusters were transferred to separate petri dishes (5 cm diam and 1 cm high) until eggs hatched, then each larva was placed in a petri dish; a total of 30 larvae (replicates) from each predator was used for each aphid species. They were supplied with an abundunce of aphids and checked daily for ecdysis until they reached the pupal stage. Twelve hours after emergence and prior to

feeding, live weights of the beetles were taken and their sex was determined. Days from egg hatch to pupation, survival to pupal stage and adult eclosion were recorded.

Ten pairs (replicates) from each predator were randomly selected and placed in a plastic container and supplied daily with fresh plant sections containing aphids. The number of eggs laid by each female was recorded until the death of the female, oviposition periods (preoviposition, oviposition and postoviposition) and longevity of both males and females were recorded.

We used a completely randomized design for the two experiments. Data were analysed using analysis of variance (ANOVA). Means were compared using Fisher's least significant different (LSD). The computation were carried out using GenStat Ed:10 (20).

Results

The mean developmental time to adult eclosion, sex ratio and survival for the two predators fed on the five species of aphids are given in Table 1. *C. septempunctata and H. axyridis* larvae took a significantly shorter time to develop from egg to the pupal stage when fed on *S. graminum* and *A. craccivora* (F= 134.54, P< 0.001). Also the preimaginal developmental time of *H. axyridis* and *C. septempunctata* was significantly shorter when fed on *S. graminum* and *A. craccivora* than on the other three species.

There was no significant effect of aphid species on the sex ratio. Weight of *H. axyridis* males reared on *A. pisum* was significantly higher than those reared on the other aphid species. Weight of *H. axyridis* females reared on *A. pisum* and *S. graminum* were significantly higher than those reared on the other aphid species. Weight of *C. septempunctata* males reared on *A. pisum* and *S. graminum* was significantly higher than those reared on the other aphid species, while weight of females reared on *A. pisum* was significantly higher than that of those reared on the other aphid species, except for females reared on *S. graminum* (Table 2).

Preoviposition periods of *H. axyridis* and *C. septempunctata* were significantly shorter when reared on *A. pisum* and *S. graminum* than on the other aphid species (*F*= 17.59, *P*< 0.001), where the preoviposition period of *H. axyridis* was 8.90±0.37 and 9.90±0.38 days when reared on *A. pisum* and *S. graminum*, respectively (Table 3). The preoviposition period of *C. septempunctata* was 9±0.67 and 9.40±0.69 days when reared on *A. pisum* and *S. graminum*, respectively. The longest oviposition period of *H. axyridis* was when they were reared on *S. graminum* and *A. pisum* (56.80±3.39 and 54.30±3.92 days, respectively). This period was significantly longer when *C. septempunctata* were reared on *A. pisum* and *S. graminum* (63.40±3.55 and 62.4±3.61 days, respectively). The shortest oviposition period for *H. axyridis* was when reared on *R. padi* and *A. craccivora* (44.50±3.28 and 46.10±3.02 days, respectively) and for *C. septempunctata* when reared on *R. padi* and *A. fabae* (48.00±2.83 and 50.20±3.32 days, respectively).

There was a significant effect of aphid species on the fecundity for the two predators (F= 40.78, P< 0.001). Fecundity of *H. axyridis* was significantly higher when reared on *A. pisum* (1461±115.04 eggs/ female), with a daily fecundity of 27.74±2.42. The fecundity of *C. septempunctata* was significantly higher when reared on *A. pisum* and *S. graminum* (1992±24.80 and 1720±120.86 eggs/ female, respectively), with a daily fecundity of 31.88±1.91 and 28.54±2.82, respectively. The lowest fecundity of *H. axyridis* and *C. septempunctata* females was when reared on *R. padi* (791±60.46 and 1018±52.34 eggs/ female, respectively), with a daily fecundity of 18.30±1.78 and 21.08±1.63, respectively (Table 3). There was no significant effect of aphid species on the longevity of males and females of the two predators (F= 1.6, P= 0.18).

Table 1. Preimaginal developmental time, percentage of females and survival of *H. axyridis* and *C. septempunctata* reared on five aphid species under laboratory conditions, ICARDA, 2001.

Predator species/Aphid species	Developmental time (days±SE)								
	Instar						Total		
	First	Second	Third	Fourth	Total larval	Pupal	preimaginal	Females	Survival
H. axyridis									
A. pisum	3.03±0.11a	1.80±0.07 a	1.50±0.10 a	4.77±0.11 c	11.10±0.20 c	4.80±0.10 a	15.90±0.27 b	50.00 a	96.67
A. craccivora	2.13±0.07 b	1.36±0.09 b	2.57±0.09 c	4.39±0.09 b	10.45±0.06 b	5.15±0.13 b	15.60±0.52 ab	51.72 a	96.67
A. fabae	2.07±0.05 b	1.79±0.12 a	1.99±0.04 b	5.82±0.09 e	11.68±0.11 c	4.68±0.08 a	16.36±0.58 b	57.14 a	93.34
R. padi	2.10±0.05 b	1.37±0.09 b	2.50±0.09 c	5.23±0.01d	11.20±0.21 c	5.30±0.13 b	16.50±0.20 b	52.17 a	90.00
S. graminum	2.17±0.07 b	1.77±0.08 a	1.73±0.09 a	3.87±0.11 a	9.53±0.16 a	4.90±0.18 a	14.43±0.53 a	50.00 a	100.00
C. septempunctata									
A. pisum	2.20±0.09 a	2.07±0.06 b	3.01±0.12 d	4.15±0.06 a	11.28±0.16 b	4.36±0.09 a	15.78±0.21 b	55.55 a	93.34
A. craccivora	2.03±0.03 a	1.59±0.09 a	2.67±0.09 c	3.93±0.08 a	10.09±0.12 a	5.09±0.10 c	15.31±0.13 ab	51.86 a	90.00
A. fabae	2.32±0.08 a	1.95±0.06 ab	2.14±0.08 b	5.31±0.15 c	11.72±0.14 b	4.65±0.10 b	16.36±0.18 c	55.17 a	96.67
R. padi	2.95±0.04 b	2.42±0.11 b	1.69±0.09 a	6.19±0.12 d	12.80±0.17 c	8.28±0.15 d	21.53±0.23 d	48.14 a	86.70
S. graminum	2.20±0.07 a	1.77±0.08 ab	1.73±0.09 a	4.50±0.09 b	10.20±0.15 a	4.27±0.08 a	14.47±0.16 a	53.61 a	96.67

Means within the same column followed by the same letter are not significantly different among aphid species within a predator species; LSD test, P= 0.05.
SE: Standard Error.

Table 2. Weight of adults *H. axyridis* and *C. septempunctata* reared on five aphid species under laboratory conditions, ICARDA, 2001.

Predator species/ Aphid species	Adults weight (mg±SE)	
	Male	Female
H. axyridis		
A. pisum	28.83±0.74 a	32.32±1.05 a
A. craccivora	22.45±0.59 bc	28.63±0.69 b
A. fabae	23.55±0.48 b	29.29±0.86 b
R. padi	21.23±1.20 c	23.93±1.12 c
S. graminum	21.17±0.69 c	31.58±0.68 a
C .septempunctata		
A. pisum	33.74±2.87 a	38.83±4.40 a
A. craccivora	26.61±2.41 ab	32.77±2.61 b
A. fabae	24.95±1.84 b	34.41±2.85 b
R. padi	27.60±3.02 ab	34.74±3.27 b
S. graminum	31.49±2.24 a	36.54±3.42 ab

Means within the same column followed by the same letter are not significantly different among aphid species within a predator species; LSD test, P= 0.05.
SE: Standard Error.

The longevity of *H. axyridis* males ranged from 62.6 to 71.32 days, and for females from 66.2 to 74.2 days when reared on the five aphid species. The longevity of *C. septempunctata* males ranged from 64 to 72.3 days, and for females from 68.2 to 79.1 days when reared on the five aphid species (Table 4).

Discussion

A. pisum and *S. graminum* were the most suitable preys for *C. septempunctata* and *H. axyridis*. In previous studies, It was found that *A. pisum* was highly suitable for *C. septempunctata*, based on mean larval developmental time, larval survival and adult weight at eclosion, among the six aphid species tested (3). It was also found that 80% of *C. septempunctata* survived to the adult stage (mean weight 40.5 mg) when reared on *A. pisum* at 20° C (17). *A. pisum* was also a more suitable prey than *R. maidis* Fitch for *C. septempunctata*, with shorter larval developmental time and higher adult weight (16). When adults *H. axyridis* were reared on *A. pisum* at 22° C, larval survival was 90%, larval developmental time was 14.8 days and the fecundity was 718.7 eggs/ female (15).

S. graminum was found to be a highly suitable prey for *C. septempunctata* (5), where the larval survival was 97% and adult weights were 37.1 and 32.4 mg for females and males, respectively. In our study, the highest larval mortality and the lowest fecundity for the two predators were found when reared on *R. padi*. It was reported that *R. padi* was a lower quality prey than *Sitobion avenae* (Fabricius) and *Metopolophum dirhodum* Walker for *C. septempunctata* (7). Based on fecundity, it was concluded that *R. padi* was a lower quality prey for *C. septempunctata* (13).

When *Semiadalia undecimnotata* (Schneider) were reared on *A. craccivora*, the larvae did not complete their development (8). In our study, *A. craccivora* was found to be a relatively poor food source; the larvae completed their development, but fecundity was significantly lower than those reared on *A. pisum* and *S. graminum*. It was found that female fecundity of *C. septempunctata* was 1060 eggs/female when it was reared on *A. craccivora* (18).

Table 3. Oviposition periods and fecundity of females *H. axyridis* and *C. septempunctata* reared on five aphid species under laboratory conditions, ICARDA, 2001.

Predator species/ Aphid species	Oviposition periods (days±SE)			No. of eggs laid/ female	No. of eggs laid/ female/ day
	Preoviposition	Oviposition	Postoviposition		
H. axyridis					
A. pisum	8.90±0.37 a	54.30±3.92 a	4.80±0.85 a	1461±115.04 a	27.74±2.42 a
A. craccivora	11.80±0.86 b	46.10±3.02 c	8.20±0.91 b	923±60.01 c	20.5±1.41 cd
A. fabae	12.19±0.82 b	50.7±3.36 b	8.84±0.95 b	1084±60.46 b	21.74±1.36 c
R. padi	13.20±0.79 b	44.50±3.28 c	9.70±1.59 b	791±60.46 d	18.30±1.78 d
S. graminum	9.90±0.38 a	56.80±3.39 a	6.20±0.91a	1368±85.38 a	24.57±1.63 b
C. septempunctata					
A. pisum	9.00±0.67 a	63.40±3.55 a	6.70±0.79 a	1992±124.80 a	31.88±1.91 a
A. craccivora	12.80±0.79 c	55.60±2.46 b	6.90±1.00 a	1177±93.63 bc	20.98±0.91 b
A. fabae	10.40±0.71 b	50.20±3.32 c	7.90±0.82 a	1415±112.75 b	29.85±3.73 a
R. padi	14.00±0.85 d	48.00±2.83 c	7.40±0.83 a	1018±52.34 c	21.08±1.63 b
S. graminum	9.40±0.69 a	62.40±3.61 a	5.40±0.60 b	1720±120.86 a	28.54±2.82 a

Means within the same column followed by the same letter are not significantly different among aphid species within a predator species ; LSD test, P= 0.05.
SE: Standard Error.

When *H. axyridis* and *C. septempunctata* were reared on *A. fabae*, the larvae completed their development, but the fecundity was significantly lower than those reared on *A. pisum* and *S. graminum*. In a previous study, El-Hariri (4) found that *A. fabae* was a low suitable prey for *Adalia bipunctata* (Linnaeus), with longer developmental time, lower adult weights and fecundities compared to *A. pisum*. Kalushkov and Hodek (11) found that *A. pisum*, *A. fabae* and *A. craccivora* were suitable food for *C. septempunctata* according to the rate of larval development, larval mortality and adult fresh weight, but females of *C. septempunctata* fed with *A. pisum* laid twice as many eggs as those fed with *A. fabae* and *A. craccivora*.

A. pisum and *S. graminum* are the most suitable hosts for *C. septempunctata* and *H. axyridis*, and should be used in rearing these two predators.

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Table 4. Longevity of males and females *H. axyridis* and *C. septempunctata* reread on five aphid species under laboratory conditions, ICARDA, 2001.

Predator species/ Aphid species	Adults longevity (days±SE)	
	Male	Female
H. axyridis		
A. pisum	66.70±2.44 a	67.00±3.76 a
A. craccivora	62.60±2.82 a	64.10±3.48 a
A. fabae	71.32±2.37 a	73.20±3.13 a
R. padi	65.20±3.08 a	66.20±3.42 a
S. graminum	71.10±2.61 a	74.20±3.61 a
C.septempunctata		
A. pisum	71.30±3.24 a	79.10±3.86 a
A. craccivora	64.00±3.28 a	75.30±2.97 a
A. fabae	70.50±3.08 a	71.60±3.61 a
R. padi	64.80±3.37 a	68.20±3.35 a
S. graminum	72.30±4.22 a	76.10±3.73 a

Means within the same column followed by the same letter are not significantly different among aphid species within a predator species ; LSD test, P= 0.05.
SE: Standard Error.

الملخص

شحادة، فاطمة، مصطفى البوحسيني، محمد عبد الحي وبروس باركر. 2012. ملاءمة خمسة أنواع من المنّ لتطور وخصوبة وبقاء المفترسين *Coccinella septempunctata* (L.) و *Harmonia axyridis* (Pallas)، على قيد الحياة، تحت الظروف المختبرية. مجلة وقاية النبات العربية، 30: 261-265.

درس زمن تطور وبقاء اليرقات على قيد الحياة، والخصوبة عند المفترسين *Harmonia axyridis* Pallas و *Coccinella septempunctata* (L.)، عند تربيتهما على خمسة أنواع من الفرائس هي: *Acyrthosiphon pisum* Harris، *Aphis fabae* Scopoli، *A. craccivora* Koch، *Schizaphis graminum* Rondani و *Rhopalosiphum padi* (L.)، وذلك تحت الظروف المختبرية (درجة حرارة 22±1 °س، رطوبة نسبية 70±5% و فترة ضوئية 16: 8 ساعة ضوء: ظلام). عندما تمت تغذية يرقات المفترسين *C. septempunctata* و *H. axyridis* على نوعي الفريسة *S. graminum* و *A. craccivora*، فإنها استغرقت وقتاً أقصر للتطور إلى طور العذراء منها عندما تمت تغذيتهما على أنواع الفرائس الأخرى المدروسة. ولم يوجد تأثير معنوي لأنواع المنّ في النسبة الجنسية. كان وزن بالغات المفترسين *C. septempunctata* و *H. axyridis* التي غذيت في طورها اليرقي على *A. pisum* و *S. graminum* أعلى منه عند البالغات التي غذيت في طورها اليرقي على الأنواع الأخرى من المنّ. كما كانت خصوبة المفترسين *C. septempunctata* و *H. axyridis* أعلى وبفروق معنوية عندما غذيا على *A. pisum* (1461±115.04 و 1992±124.80 بيضة/أنثى، على التوالي) منها عندما غذيا على أنواع المنّ الأخرى. لم يوجد تأثير معنوي لأنواع المنّ في طول فترة حياة بالغات المفترسين *C. septempunctata* و *H. axyridis*. يبدو أن النوعين *A. pisum* و *S. graminum* هما النوعان الأكثر ملاءمة للمفترسين *C. septempunctata* و *H. axyridis*، ويتعيّن أن يستخدما لتربية هذين المفترسين.

كلمات مفتاحية: المنّ، *Harmonia axyridis*، *Coccinella septempunctata*، تطور، خصوبة.

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