Entomologia Experimentalis et Applicata **102:** 93–97, 2002.

Short communication

Effects of various aphid foods on *Cycloneda sanguinea*

A. A. Işıkber* & M. J. W. Copland
*Department of Agricultural Sciences, Imperial College at Wye, University of London, Wye, Ashford, Kent, TN25 5AH, UK; *Current address: Sutcu Imam University, Agriculture Faculty, Plant Protection Department, 46060, Kahramanmaraş, Turkey*

Accepted: January 8, 2002

Key words: Coleoptera, Coccinellidae, *Cycloneda sanguinea*, *Aphis gossypii*, *Aphis fabae*, *Myzus persicae*, *Megoura viciae*, development, toxicity, nutritional requirement

Introduction

Cycloneda sanguinea (L.) (Coleoptera: Coccinellidae) is primarily an aphidophagous coccinellid species occurring in temperate areas of Central and South America (Vandenberg & Gordon, 1988). It has been reported as an efficient predator of aphids on cucumbers and chrysanthemums grown in glasshouses (Gurney & Hussey, 1970). Işıkber (1999) also reported that *C. sanguinea* would be a possible candidate for biological control of cotton aphid, *Aphis gossypii* Glover (Homoptera: Aphididae), in temperate glasshouses and would play an important role in reducing the populations of cotton aphid attacking field crops.

Studies examining prey suitability for predators provide basic knowledge about which prey species supplies the necessary nutritional requisites for the predator, and also offer an explanation for success or failure of predators in biological control systems (Thompson, 1951). Several authors have examined the suitability of some aphid species for *C. sanguinea*. The brown citrus aphid, *Toxoptera citricida* (Kirkaldy) (Homoptera: Aphididae), was found to be an inadequate prey for the larvae of *C. sanguinea* as it prevented complete larval development, although it has been found feeding naturally on the brown citrus aphid (Morales & Burandt, 1985). On the other hand, Michaud (2000) recorded that *C. sanguinea* completed development and reproduced successfully on both *T. citricida* and *Aphis spiraecola* Patch (Homoptera: Aphididae), with shorter developmental times and heavier adult weights resulting from the *T. citricida* diet.

The cotton aphid, *A. gossypii*, the black bean aphid, *Aphis fabae* Scop. (Homoptera: Aphididae), the peach-potato aphid, *Myzus persicae* (Sulzer) (Homoptera: Aphididae), and the vetch aphid, *Megoura viciae* Buckton (Homoptera: Aphididae) are important insect pests on many field crops, as well as some glasshouse crops and ornamental plants in temperate areas (Blackman & Eastop, 1984; van Schelt et al., 1990). As the ability of *C. sanguinea* to complete development and reproduce when feeding on these aphid species has not been examined before, this study was carried out to compare their suitability as food for *C. sanguinea*.

Materials and methods

The species of aphids used were the cotton aphid, *A. gossypii*, the black bean aphid, *A. fabae*, the peach-potato aphid, *M. persicae*, and the vetch aphid, *M. viciae*. *Aphis fabae* and *M. viciae* were cultured on the broad bean, *Vicia faba* L., whilst *A. gossypii* and *M. persicae* were cultured on cotton, *Gossypium hirsutum* L., and turnip, *Brassica rapa* L., respectively. All the aphid cultures were reared on plants in cages kept in a growth room at 26 ± 2–3 °C and a L16:D8 photoperiod and the studies were conducted in incubator cabinets at 22.5 ± 1 °C constant temperature with a L16:D8 photoperiod and 60 ± 5% r.h. which was provided using a saturated salt solution of Magnesium Nitrate ($MgNO_3$).

The newly-hatched *C. sanguinea* larvae were weighed using a micro-balance (accurate to 0.001 mg) to record their initial weights and thereafter transferred

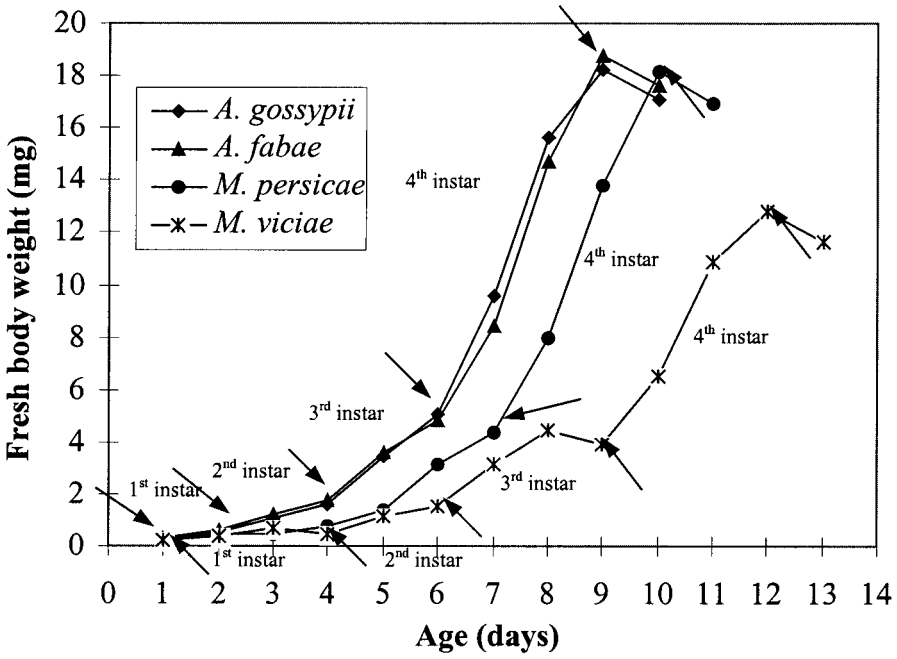

Figure 1. Fresh body weight increase during the development of larval instars of *C. sanguinea* when fed on four aphid prey species during their development (arrows indicate the start and the end of each instar).

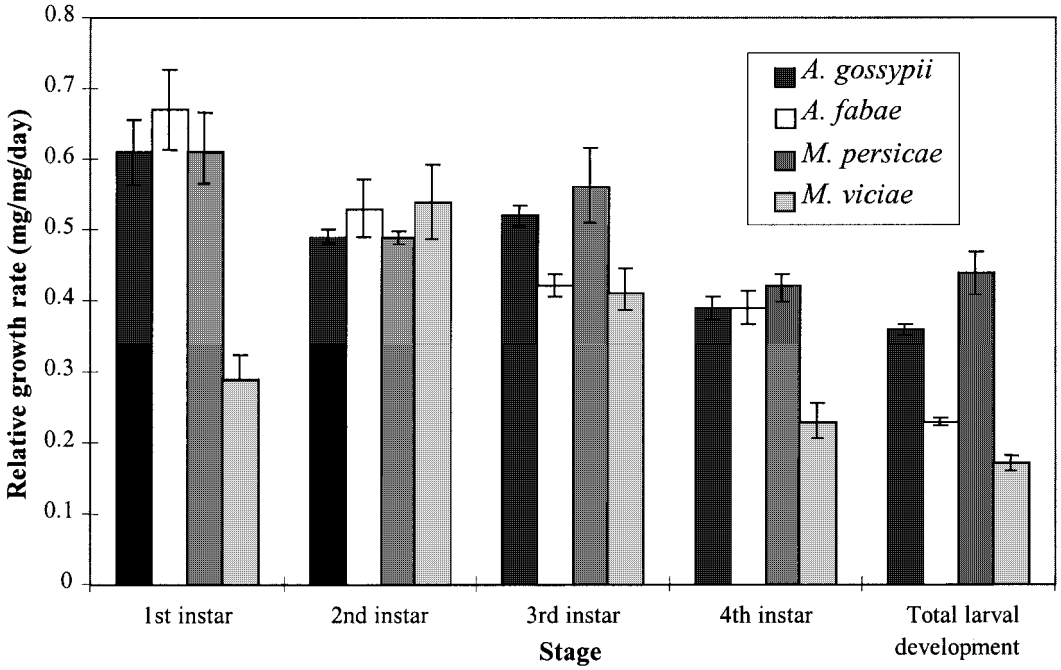

Figure 2. Relative growth rate (mg/mg/day) during the development of larval instars of *C. sanguinea* on four aphid preys. Bar = Standard error of relative growth rate. Seven to fifteen individuals were used as replicates.

Table 1. Developmental times of various stages of *C. sanguinea* on four aphid species (figures in brackets show the number of individuals as replicates)

STAGE	*A. gossypii*	*A. fabae*	*M. persicae*	*M. viciae*	F and P value	LSD value
Total larval development[a]	8.2±0.1 b (13)	8.3±0.2 b (15)	8.1±0.2 b (10)	11.2±0.9 a (7)	F = 15.1, d.f = 3, 41 P<0.01	0.9341
Prepupa	1.0±0.0 a (12)	1.3±0.1 b (15)	1.0±0.0 a (10)	1.0±0.0 a (7)	F = 3.2, d.f. = 3, 40 P<0.05	0.2426
Pupa	5.4±0.2 a (12)	5.8±0.1 a (13)	5.4±0.3 a (10)	4.4±0.2 b (7)	F= 7.9, d.f.= 3, 38 P<0.01	0.5385
Overall development[b]	14.6±0.2 b (12)	15.2±0.2 b (13)	14.5±0.3 b (10)	16.7±0.8 a (7)	F = 7.8, d.f. = 3, 38 P<0.01	0.9387

Means within rows with the same letter are not significantly different (LSD at 1% level). One way ANOVA was applied for data analysis.
[a]Total larval development (1st, 2nd, 3rd and 4th instar stage).
[b]Overall development (Total Larva + Prepupa + Pupa stage).

Table 2. Survival rate of various stages of *C. sanguinea* on four different aphid foods (first and second values in brackets show the numbers of surviving individuals at the start of each stage and numbers at the end of each stage, respectively)

Stage	Aphid species				Chi-squared test
	A. gossypii	*A. fabae*	*M. persicae*	*M. viciae*	
Total larval survival[a]	0.93 a (14/13)	0.94 a (16/15)	0.77 a (13/10)	0.39 b (18/7)	$\chi^2 = 17.3$, d.f = 3 P = 0.001
Prepupa	0.92 (13/12)	1 (15/15)	1 (10/10)	1 (7/7)	–
Pupa	1 (12/12)	0.87 (15/13)	1 (10/10)	1 (7/7)	–
Overall survival[b]	0.86 a (14/12)	0.81 a (16/13)	0.77 a (13/10)	0.39 b (18/7)	$\chi^2 = 10.9$, d.f = 3 P = 0.012

Survival rate followed by different letters in the same row are significantly different.
[a]Total larval survival (1st, 2nd, 3rd and 4th instar stage). [b]Overall survival (Total Larva + Prepupa + Pupa stage).

to individual Petri-dishes (1.5 × 6 cm) containing a sufficient number of medium-size aphids (third instar) on excised leaves stuck onto the surface of agar medium. Excised leaves of cotton for *A. gossypii*, turnip for *M. persicae* and broad bean plants for *A. fabae* and *M. viciae* were used. *Aphis gossypii*, *A. fabae*, *M. persicae*, and *M. viciae* were replicated 14, 16, 13, and 18 times, respectively. Each of three Petri-dishes were placed in large transparent boxes (27 × 16 × 10 cm) with a saturated salt solution of $MgNO_3$ in a small cup and observed once a day. After each observation the aphids were replenished as needed and the weights of the larvae were recorded using a microbalance to determine their fresh weight gain. Larval and pupal development were also checked for ecdysis and mortality. Moulted skins and dead larvae were removed at each observation.

The following parameters were estimated for each aphid food:

Development time calculated as the time from egg hatch to adult emergence in days.

Survival rate calculated as the numbers of surviving individuals at the end of each stage divided by the numbers of individuals at the start of each stage.

Fresh weight gain during an instar calculated as the final fresh body weight of the instar (Fwt) less initial fresh body weight of the instar (Iwt) in mg.

Relative growth rate (RGR) (mg fresh body weight increase per mg fresh body weight per day; mg/mg/day) calculated as the fresh weight gain of the instar divided by the mean fresh weight of the instar

times duration of the instar (Mean fresh weight was calculated as final fresh weight of the instar plus initial fresh weight of the instar divided by two in mg).

$$\mathrm{RGR} = \frac{(\mathrm{Fwt} - \mathrm{Iwt})}{\frac{(\mathrm{Fwt} + \mathrm{Iwt})}{2} \times \mathrm{D}}. \quad (1)$$

Developmental time of immature stages and overall development of *C. sanguinea* were analysed using one-way analysis of variance (ANOVA) and the means were separated by LSD at 1% level (SAS Institute, 1985). Survival data were presented as a proportion but were analysed by the Chi-squared test (Minitab Inc., 1995) using their original (count) data.

Results and discussion

There were no significant differences in times of total larval and overall development on *A. gossypii*, *A. fabae,* and *M. persicae* whereas the times of total larval and overall development on *M. vicia* were significantly longer than those on *A. gossypii*, *A. fabae*, and *M. persicae* (Table 1). The fastest total development of *C. sanguinea* was found to be on *M. persicae*, *A. gossypii*, and *A. fabae*, respectively. Total survival rate of larvae and overall development of *C. sanguinea* were significantly lower on *M. viciae* than those on *A. gossypii*, *A. fabae,* and *M. persicae* whilst there were no significant differences in total survival rates of larvae and overall development on *A. gossypii*, *A. fabae* and *M. persicae* (Table 2). The highest survival rate was found to be on *A. gossypii*, *A. fabae*, and *M. persicae*, respectively.

The fresh weight increase of the larvae of *C. sanguinea* on *A. gossypii* had a similar trend to that on *A. fabae* but they were both different from that on *M. persicae* and *M. viciae* (Figure 1). The larvae fed on *A. gossypii* and *A. fabae* developed more quickly than on *M. persicae*, whilst the larvae fed on *M. viciae* developed more slowly than on the other aphids. Relative growth rates of larval instars fed on *M. viciae* were also found to be lower than on *A. gossypii*, *A. fabae*, and *M. persicae* (except second instars) whilst first, second, and fourth instars fed on *A. gossypii*, *A. fabae*, and *M. persicae* had almost the same relative growth rate (Figure 2). *Myzus persicae* gave the highest relative growth rate of larval instars (except first and second instars).

In this study, *A. gossypii*, *A. fabae,* and *M. viciae* were found to be suitable food for *C. sanguinea*. This result is similar to that recorded by Blackman (1965, 1967) for *C. septempunctata* when fed on *A. fabae*, but contrasts to that for *Adalia bipunctata* (L.) (Blackman, 1965). Blackman (1965), Dixon (1958), and Radwan & Lovei (1983) found that *M. viciae* was toxic to *A. bipunctata*, *Adalia decempunctata* (L.), and *Exochomus quadripustulatus* (L.), respectively. However, Blackman (1967) reported that *M. viciae* was only slightly less suitable for *C. septempunctata* than other aphids. Similarly, this study found that *M. viciae* is unsuitable food for *C. sanguinea*.

There are several factors that determine prey suitability for insect predators, which can be divided into nutritional and non-nutritional factors. Therefore, reasons for the unsuitability of certain aphid species are not easy to determine. In this case, four factors might be implicated for *M. viciae*: difficulty in capturing the prey, difficulty in ingesting food once the prey is captured, toxicity (Dixon, 1958), and low nutritive value of the aphid food. The aphid host plant may also affect the value of the aphid as food. The mortality of the larvae of *C. sanguinea* fed on *M. viciae* could also be caused by some specific substance that may be contained in the prey's body, probably derived from the plant and toxic for the coccinellid. However, the exact reasons why *M. viciae* caused high mortality, and slow growth and development of the larvae of *C. sanguinea* cannot be established without further investigation.

In conclusion, there was a considerable variation in the suitability of aphid species as food for *C. sanguinea*. *Aphis gossypii*, *A. fabae,* and *M. persicae* seem to satisfy all the nutritional requirements for larval development of *C. sanguinea*. However, *M. viciae* is not a suitable prey for larval development of *C. sanguinea*. The ability of *C. sanguinea* to complete development on *A. gossypii*, *A. fabae*, and *M. persicae* suggests the potential for the coccinellid to establish its population on these aphid species.

Acknowledgement

I would like to express my sincere thanks to the Higher Educational Council of the Republic of Turkey and Kahramanmaraş Sutcu Imam University for financial support of this study.

References

Blackman, R. L., 1965. Studies on specificity in Coccinellidae. Annals of Applied Biology 56: 336–338.

Blackman, R. L., 1967. The effect of different aphid foods on *Adalia bipunctata* L. and *Coccinella septempunctata* L. Annals of Applied Biology 59: 207–219.

Blackman, R. L. & V. F. Eastop (eds.), 1984. Aphids on the World's Crops: An Identification Guide, John Wiley and Sons, Chichester, 466 pp.

Dixon, A. F. G., 1958. The escape responses shown by certain aphids to the presence of the coccinellid *Adalia decempunctata* (L.). Transactions of the Royal Entomological Society of London 110: 319–334.

Gurney, B. & N. W. Hussey, 1970. Evaluation of some coccinellid species for the biological control of aphids in protected cropping. Annals of Applied Biology 65: 451–458.

Işıkber, A. A., 1999. Evaluation of two predatory coccinellid beetles, *Scymnus levaillanti* and *Cycloneda sanguinea* (Coleoptera: Coccinellidae) for the biocontrol of cotton aphid, *Aphis gossypii* (Homoptera: Aphididae). PhD. Thesis, Wye College, University of London. 244 pp.

Michaud, J. P., 2000. Development and reproduction of ladybeetles (Coleoptera: Coccinellidae) on the citrus aphids *Aphis spiraecola* Patch and *Toxoptera citricida* (Kirkaldy) (Homoptera: Aphididae). Biological Control 18: 287–297.

Minitab Inc., 1995. MINITAB Reference Manual, Release 10 for Windows, Minitab Statistical Software, Pennsylvania, USA.

Morales, J. & C. L. Burandt Jr., 1985. Interaction between *Cycloneda sanguinea* and the brown aphid: adult feeding and larval mortality. Environmental Entomology 14: 520–522.

Radwan, Z. & G. L. Lovei, 1983. Aphids as prey for the coccinellid *Exochomus quadripustulatus*. Entomologia Experimentalis et Applicata 34: 283–286.

SAS Institute, 1985. User's guide: Statistics. SAS Institute, Cary, N.C, 1985.

Schelt, J. van, J. B. Douma & W. J. Ravensberg, 1990. Recent developments in the control of aphids in sweet peppers and cucumbers. IOBC/WPRS Bulletin, 12/5: 190–193.

Tompson, W. R., 1951. The specificity of host relationships in predaceous insects. Canadian Entomology 83: 262–269.

Vandenberg, N. & R. D. Gordon, 1988. The Coccinellidae (Coleoptera) of South America, part I. A revision of the genus *Erythroneda* Timberlake, 1943. Revista Brasiliera de Entomologia 32: 31–43.