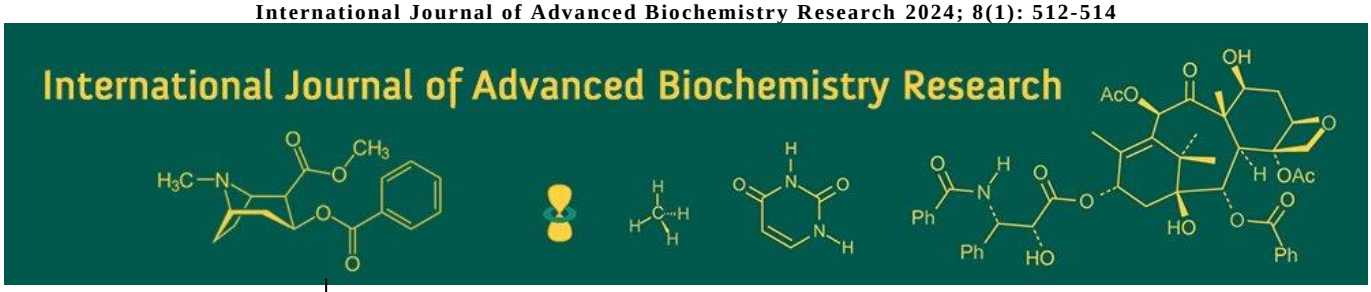

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Singh NA
Department of Entomology, N. M. College of Agriculture, Navsari Agricultural University, Navsari, Gujarat, India

Dabhi MR
Department of Entomology, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat, India

Rojasara YM
Department of Entomology, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat, India

Varma CB
Department of Entomology, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat, India

Corresponding Author:
Singh NA
Department of Entomology, N. M. College of Agriculture, Navsari Agricultural University, Navsari, Gujarat, India

Feeding potential of ladybird beetle, *Cheilomenes sexmaculata* (Fabricius) on different species of aphids

Singh NA, Dabhi MR, Rojasara YM and Varma CB

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Abstract
A study was carried out to explore the feeding capabilities of the zig-zag beetle, *Cheilomenes sexmaculata* (Fabricius), a commonly found species of ladybird beetle, at Department of Agricultural Entomology, B. A. College of Agriculture, Anand Agricultural University, Anand (Gujarat) during the year 2019-20. The feeding potential of the predator was calculated on four hosts *i.e.*, mustard aphid, *Lipaphis erysimi* (Kaltenbach), cotton aphid, *Aphis gossypii* (Glover), maize aphid, *Rhopalosiphum maidis* (Fitch) and cowpea aphid, *Aphis craccivora (*Koch). Results revealed that highest number of aphids consumed by first instar was *A. craccivora* (20.13 ± 0.61), second instar of ladybird beetle preferred *R. maidis* (35.27±0.49), while during the third and fourth instar stage larvae exhibited a higher preference for feeding on *A. gossypii*, consuming 57.87 ± 47 and 79.60 ± 1.99. The total consumption of grubs revealed that grubs of *C. sexmaculata* fed more on *A. gossypii* (191.20±4.17) closely followed by *A. craccivora* (177.10±5.48). The consumption capacity of *C. sexmaculata* adult indicated that *A. craccivora* (820.30±44.94) followed by *A. gossypii* (739.93±28.96). The least number of aphids eaten during grub and adult period was of *L. erysimi* (105.73±3.83 and 441.33±40.35). Throughout its entire lifespan, *C. sexmaculata* demonstrated a greater consumption rate on *A. craccivora* (997.40±45.60). Thus it was concluded that *C. sexmaculata* can control the *A. craccivora* and *A. gossypii*, effectively.

Keywords: Feeding potential, ladybird beetle, *Cheilomenes. sexmaculata,* aphid, predation

Introduction
Today, the world is bending towards the natural or organic agriculture *i.e.* limited or no use of chemical insecticides. This has caused the waves to turn toward the past, towards traditional techniques and natural means for crop protection. Around 6000 documented species of Coccinellidae have been identified (Vanderberg, 2000) [11]. Their notable dispersal capacity enables introduced coccinellids to swiftly and effortlessly broaden their range of influence, invading a majority of their prey sites in a brief period. Ladybirds are uniquely referred to as a component of ''*biological services*" (Landis *et al.*, 2008) [3]. The immature and adult stages of the ladybird beetle play important role in biological ecosystems by actively contributing to pest management, particularly in managing such as aphids, mealy bugs, thrips and mites (Tank *et al.*, 2010) [10]. *Cheilomenes sexmaculata* is found to be active throughout the year in many parts of India with many generations. The important features of *C. sexmaculata* includes its wide geographic distribution and host range, broad habitats, resistance/tolerance to certain pesticides, enhanced searching ability, voracious larval feeding capacity and easy rearing in laboratory (Venkatesan *et al.*, 2006) [13]. The quantity of prey consumed significantly influences the development, survival, and reproduction of predators. The findings of this biological study hold promise for the mass multiplication of the bio-agent, as indicated by Chakraborty (2012) [2]. Consequently, a research initiative was undertaken to assess the feeding potential of *C. sexmaculata.*

Materials and Methods
The experiment was carried out at Department of Entomology, Anand Agricultural University, Anand on four different species of aphids. A laboratory research was conducted involving the individual rearing of 15 grubs of *C. sexmaculata* on distinct species of aphids, namely mustard aphid (*L. erysimi*), cotton aphid (*A. gossypii*), maize aphid (*R. maidis*) and cowpea aphid (*A. craccivora*),in plastic vials (5.0×4.0 cm). This rearing process commenced on the first day of hatching from eggs and continued until the formation of pupae.

Initially counted numbers of 15 to 20 aphids were provided, but with the gradual larval development, the numbers of aphids were increased incrementally adjusted. Daily records were maintained for the number of aphids consumed by each individual larva, and the feeding potential was calculated for each instar as well as for the entire larval period. Newly emerged adults of *C. sexmaculata* were individually housed in plastic bottles (6.5×6.0 cm) and each adult was provided with 100 aphids daily during entire adult period and the feeding capacity of adult was worked out. The feeding capacity of the adult ladybird beetle was then determined by recording the daily consumption of aphids at various stages of both the larval and adult phases.

Results and Discussion

The data on the consumption capacity of *C. sexmaculata* reveals significant trends in the feeding preferences of different instar larvae on four distinct species of aphids as presented in Table 1. The results revealed that the first instar grubs of *C. sexmaculata* consumed significantly highest (20.13±0.605) numbers of *A. craccivora* individuals, closely followed by *A. gossypii* (20±0.67) showing a preference over *R. maidis* and *L. erysimi*. First instar grub consumed an average of 10.67 ± 0.53 and 9.6 ± 0.89 individuals of *R. maidis* and *L. erysimi* respectively. In case of second instar grub, a highest number of individuals consumed were of *R. maidis* (35.27±0.49), followed by *A. gossypii* (33.97±0.91) and *A. craccivora* (32.93±3.80), but significantly less consumption was found with *L. erysimi* (19.93±0.64). The third instar grub exhibited the highest consumption of *A. gossypii* (57.87±47) were consumed by the third instar grub of *C. sexmaculata* followed by *A. craccivora* (56.03±1.58). Significantly more numbers of *A. gossypii* individuals were predated by third instar grubs than *R. maidis* (52.40±1.34) and *L. erysimi* (31.37±1.81). The feeding preference observed in the fourth instar grub mirrored that of the third instar grubs in consumption of *A. gossypii* and *A. craccivora*. Maximum numbers of *A. gossypii* (79.60±1.99) were fed by fourth instar than rest of the three species of aphids. *Aphis craccivora* (68.00±2.83) stood next to *A. gossypii* in preference. The minimum feeding by fourth instar grubs was observed in *L. erysimi* (44.83±2.51). The total number of aphids consumed during entire grub period was varied from 105.73 to 191.20. Maximum (191.20±4.17) numbers of *A. gossypii* were fed by the grubs of *C. sexmaculata* followed by *A. craccivora* (177.10±5.48), *R. maidis* (161.83±4.26) and *L. erysimi* (105.73±3.83). The grubs consumed significantly more number of individuals of *A. gossypii* and *A. craccivora* over *R. maidis* and *L. erysimi*.

Data (Table 1) on biotic potential of *C. sexmaculata* adults revealed that by the individual beetle exhibited a significantly maximum consumption, with 820.30 ± 44.94 individuals of *A. craccivora*, surpassing the consumption of all other aphid species. The adult consumed an average of 739.93 ± 28.96, 576.23 ± 23.43 and 441.33 ± 40.35 individuals of *A. gossypii*, *R. maidis* and *L. erysimi*, respectively. The overall consumption of aphids by both the feeding stages (grub and adult) of *C. sexmaculata* varied from 547.07 to 997.40. Significantly highest (997.40±45.60) numbers of *A. craccivora* individuals were consumed by the predator than individuals of other species of aphids. *Aphis gossypii* (930.67±55.59) was also found to be a favored host for *C. sexmaculata*, next to *A. craccivora*. This said predator consumed 738.06 ± 22.87 individuals of *R. maidis* during its entire life. *Lipaphis erysimi* proved less preferred host for *C. sexmaculata* as 547.07 ± 42.91 individuals were eaten by the predator.

The data revealed that feeding efficacy of *C. sexmaculata* adults was higher than that of larvae. This is further confirmed by Priyadarshani *et al.* (2016) [6] as they also observed that larvae consumed more aphids than adults. The observations of present studies coincided with the results of the feeding potential of *C. sexmaculata* done by Zala (1995) [15] on *L. erysimi* and Patel (1998) [16] on *R. maidis*. Similarly, Solangi *et al.* (2007a) [8] documented that both *C. sexmaculata* grubs and adults exhibited voracious feeding behavior on the corn leaf aphid, *R. maidis*, cotton aphid, *A. gossypii* and alfalfa aphid, *T. trifolii*. The third and fourth instars grubs consumed more prey per day than first and second instars. Further, Pirsanna *et al.* (2012) [5] also recorded more or less similar results. They obseved that fourth instar grubs exhibited significantly higher aphid consumption compared to first, second, and third instars. Additionally, the per day predation rate by female ladybird beetles on *A. craccivora* was 37.2 ± 3.32, followed by *A. gossypii* (35.2±2.22) and *L. erysimi* (23±0.94). The male could feed only on *A. craccivora* (35.8±2.67) followed by *A. gossypii* (30.8±1.98), *R. maidis* (27.8±4.28) and *L. erysimi* (20.8±1.15).

Also, Vasista (2019) [12] revealed that beetle prefer *A. craccivora* the most followed by *A. gossypii*. From above results it is observed that among the four different species of aphids, *L. erysimi* was preferred least by *C. sexmaculata* which is in close conformity with the results of Tank (2006) [9] and Chakraborty (2012) [2]. Singh *et al.* (2012) [7] also reported that mustard aphid, *L. erysimi* found least preferred host for *C. septempunctata* in laboratory.

Table 1: Feeding potential of *C. sexmaculata* on different species of aphids

Aphid species	Mean no. of aphids consumed at different feeding stages						Mean no. of aphids consumed / individual
	Grub					Adult	
	1st instar	2nd instar	3rd instar	4th instar	Total		
A. cracivvora	20.13 ± 0.61 (16-24)*	32.93 ± 3.80 (23-41)	56.03 ± 1.58 (52-62)	68.00 ± 2.83 (61-79)	177.10 ± 5.48 (167-188)	820.30 ± 44.94 (610-918)	997.40 ± 45.60 (792-1102)
A. gossypii	20 ± 0.67 (17-24)	33.97 ± 0.91 (29-40)	57.87 ± 2.81 (51-63)	79.60 ± 1.99 (72-90)	191.20 ± 4.17 (177-209)	739.93 ± 28.96 (523-888)	930.67 ± 55.59 (711-1085)
R. maidis	10.67 ± 0.53 (52-62)	35.27 ± 0.49 (32-39)	52.40 ± 1.34 (49-60)	63.50 ± 2.76 (51-69)	161.83 ± 4.26 (146-171)	576.23 ± 23.43 (472-643)	738.06 ± 22.87 (636-807)
L. erysimi	9.6 ± 0.89 (8-13)	19.93 ± 0.64 (12-24)	31.37 ± 1.81 (26-36)	44.83 ± 2.51 (40-56)	105.73 ± 3.83 (96-119)	441.33 ± 40.35 (251-579)	547.07 ± 42.91 (347-689)
S. Em. ±	0.49	1.41	1.24	1.80	2.95	26.01	26.64
C. V. (%)	4.55	6.54	3.56	3.98	2.63	5.71	4.67

* Figures in bracket indicate range values

Conclusion

Thus, from the above results it can be concluded that *C. sexmaculata* can be used successfully to control the aphid population in the field. The consumption ability of *C. sexmaculata* on aforesaid four species of aphids can be arranged in descending sequence as: *A. craccivora* > *A. gossypii* > *R. maidis* > *L. erysimi.*

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