

Journal of Biological Control, 39(1): 39-46, 2025, DOI: 10.18311/jbc/2025/49238

Research Article

Biology, morphometrics and predation potential of *Coccinella septempunctata* Linn. (Coleoptera: Coccinellidae) on corn leaf aphid, *Rhopalosiphum maidis* (Fitch) infesting wheat

ANUJ KALARAMNA[1], POONAM JASROTIA[2*], MAHA SINGH JAGLAN[1] , SUNNY MAANJU[3] and PRITAM KUMARI[3]

[1]CCS Haryana Agricultural University, Regional Research Station, Karnal – 132001, Haryana, India
[2]ICAR-Indian Institute of Wheat and Barley Research (IIWBR), Karnal – 132001, Haryana, India
[3]CCS Haryana Agricultural University, Hisar – 125004, Haryana, India
**Corresponding author Email:* poonamjasrotia@gmail.com

ABSTRACT: The study explored the biological parameters of the aphid-feeding ladybird beetle, *Coccinella septempunctata* L., focusing on its development, body measurements, cannibalistic behaviour, and predation efficiency against corn leaf aphid (*Rhopalosiphum maidis* F.) at two temperatures: 25±1°C and 18±1°C. The duration of life stages, including egg, larval, pre-pupal, pupal, and pre-imaginal phases, was shorter at 25±1°C, with egg period 3.30±0.10 days and the entire pre-imaginal stage lasting 17.84±0.23 days. These stages required slightly more time to complete at 18±1°C. The sex ratio at both temperatures favoured females, recorded as 1.2:1 (F:M) at 25±1°C and 1.5:1 (F:M) at 18±1°C. Females underwent pre-oviposition, oviposition, and post-oviposition periods, while males experienced a sexual maturity phase, with temperature affecting their lifespan and reproductive performance. On average, females laid 372 eggs at 25±1°C and 339 eggs at 18±1°C. The study found that cannibalistic behaviour increased with larval age and food scarcity. Both larvae and adults exhibited significant predatory activity against *R. maidis*. The feeding capacity per larval stage rose progressively from the first to the fourth instar, with fourth instar larvae consuming an average of 168.04±31.27 aphids per stage. Among adults, females consumed 112.20±14.80 aphids per day, while males consumed 84.20±9.04 aphids.

KEYWORDS: Aphids, biological control, cereals, life cycle, predators

(Article chronicle: Received: 02-04-2025; Received: 02-02-2025; Revised: 28-03-2025; Accepted: 30-03-2025)

INTRODUCTION

Wheat (*Triticum aestivum*), which provides approximately 20% of the world's dietary calories and protein, is essential for global food security (Dadrasi *et al.,* 2023). However, wheat production faces numerous challenges, particularly from biotic and abiotic stresses, which cause significant economic losses. Among biotic stresses, insect pests are the major constraint of wheat production. Cereal aphids are especially problematic, with four species—*Rhopalosiphum maidis*, *Sitobion avenae*, *Sitobion miscanthi*, and *Rhopalosiphum padi*—forming a dominant pest complex that severely reduces yield potential (Jasrotia *et al.*, 2022a). Of these, the corn leaf aphid (*R. maidis*), primarily a pest of corn, has emerged as the most prevalent species affecting wheat in India's North-Western Plains Zone (NWPZ). Both nymphs and adults damage plants by sucking sap from tender parts, while the honeydew they excrete fosters black sooty mold, which impairs photosynthesis and reduces plant vigour and yield(Yadav *et al.*, 2024).

Corn leaf aphids directly cause yield losses of 20–30% by sap-feeding and indirectly contribute to losses ranging from 5–80% through the transmission of viral and fungal diseases. Chemical control methods are widely used for aphid management in wheat, but these approaches have led to challenges such as pesticide resistance and the disruption of natural biological control mechanisms. Consequently, alternative management strategies are necessary. Approaches such as cultural, physical, mechanical, biological control, and host plant resistance have been explored under the umbrella of Integrated Pest Management (IPM) (Jasrotia *et al.,* 2022b).

Biological control, in particular, focuses on utilising predators, parasitoids, and pathogens to regulate pest populations. Predators like coccinellids (ladybird beetles) are key biological control agents in natural ecosystems. Among these, *Coccinella septempunctata* (Coleoptera: Coccinellidae) is recognised as a highly effective predator with significant feeding potential (Kundoo & Khan, 2017). This species has been extensively studied for its role in

managing aphid populations worldwide (Michaud, 2012). The predatory efficiency of *C. septempunctata* increases with age, peaking in the adult stage (Mishra *et al.,* 2012). Despite its established predatory role, limited information exists on the biology, morphology, and feeding potential of *C. septempunctata* on the corn leaf aphid (*R. maidis*). Therefore, this study aims to enhance the understanding of its potential for inundative biological control of *R. maidis* in wheat crops.

MATERIALS AND METHODS

Insect rearing

Adults of *C. septempunctata* (n=100) were collected from a research farm, CCS HAU Regional Research Station, Karnal and farmer's fields in Karnal district. To ensure uniformity and reduce experimental variability caused by field conditions (*e.g.*, feeding on diverse prey, parasitism, improper mating, or pathogen presence), these adults were reared for two generations (F1 and F2) with an ample supply of *Rhopalosiphum maidis*. Adults from the F2 generation were sexed by examining the fifth sternite, which has a curved distal edge in males and is absent in females (Stellwag & Losey, 2014). Mated pairs were kept in separate glass jars (15 cm × 10 cm) lined with moist blotter paper to provide an optimal surface for activity and egg-laying. Eggs laid on the blotter paper were collected using a moist camel hair brush, while those deposited on plant material were removed along with the leaf or twig segment.

Pre-imaginal development

Egg incubation and hatching periods were studied by placing freshly laid eggs (n = 300, from 10 F2 females) in 5 cm Petri dishes. Hatching was monitored daily, and newly hatched larvae were transferred to individual petri dishes lined with moist blotting paper. Observations were recorded for 30 larvae to document the duration of larval instars, the pre-pupal period, pupation rates, and mortality. Fresh *R. maidis* aphids along with wheat leaves and twigs were provided daily. Larval molting was tracked hourly by checking for exuviae. The pre-pupal phase was the period before the fourth instar larvae became immobile and turned pale yellow, while still responding to gentle prodding. Data on all larval stages were recorded until pupation. Observations of 30 pupae included the duration of the pupal stage, sex ratios, and emergence rates. Pupae were kept in individual petri dishes with fresh plant material to maintain a suitable environment.

Reproductive and longevity parameters

Newly emerged adults were paired with sexually mature (15-day-old) counterparts and kept in 9 cm petri dishes containing aphids and wheat twigs until maturity. Pairs were observed daily from 10:00 a.m. to 5:00 p.m. to confirm mating. Pairs were separated after each observation and re-paired until successful genital contact was established. The pre-mating period was defined as the time required for sexual maturity. Ten replicates were used to record pre-oviposition, oviposition, post-oviposition periods, and adult longevity.

The experiments were conducted under two environmental conditions: a controlled regime at 25±1°C, 65±5% Relative Humidity (RH), and a 16:8 light-dark cycle in a B.O.D. incubator, and a natural-like condition at 18±1°C.

Morphometric studies

Developmental stages of *C. septempunctata* were preserved by freezing and analyzed under a dissecting microscope at 7.5x magnification. Morphological features, patterns, and body sizes were measured for ten individuals per stage using a micrometre.

Larval cannibalism

Cannibalistic behaviour was studied at 25±1°C, 65±5% RH, and a 16:8 light-dark cycle. Fourth, third, and second instar larvae were isolated in 5 cm Petri dishes and starved for 12 hours to standardise hunger levels. Younger instars (1^{st}, 2^{nd}, and 3^{rd}) were introduced in known numbers to the isolated larvae (n=10 per stage). Cannibalism was assessed over 24 hours, and observations included larval consumption and predation tendencies. All larvae used in the experiment were from the F2 generation.

Predation potential

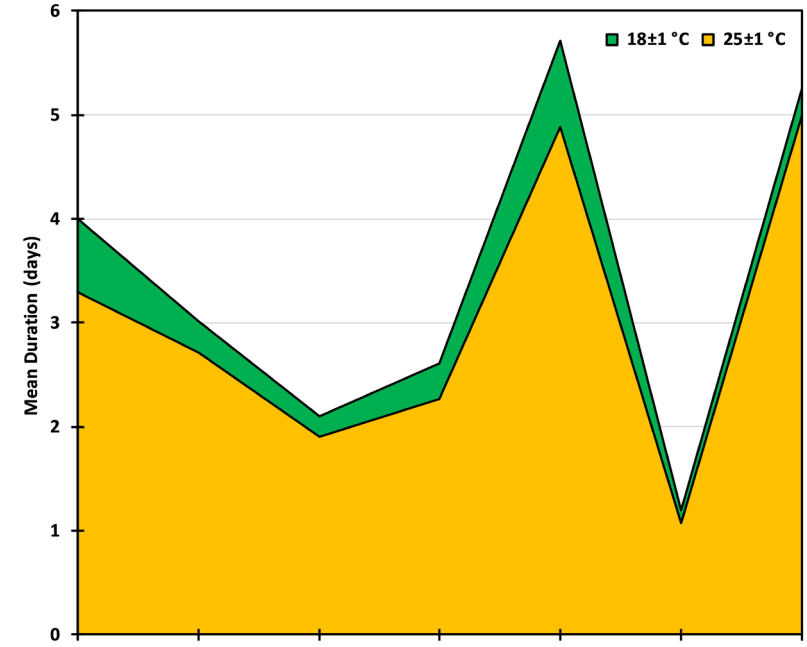
The predation capacity of *C. septempunctata* grubs and adults on *R. maidis* was tested at 25±1 °C, 65±5% RH, and a 16:8 light-dark cycle. Immature and adult predators were placed individually in Petri dishes with varying numbers of aphids along with fresh wheat twigs and leaves. Predation was assessed by counting surviving aphids after 24 h. Grubs were provided prey densities ranging from 25 to 300 aphids based on their developmental stage, while adults were given an ad libitum supply. Ten replicates were used for each predator stage, and predation efficiency was calculated.

Data analysis

Biology and predation data collected under the two temperature regimes were statistically analyzed. Mean values, standard deviations, and t-tests were applied to biological parameters. Analysis Of Variance (ANOVA) was used to analyze predation data, following the procedure outlined by Mari *et al.* (2005). Significant differences among means were determined using the Least Significant Difference (LSD) test at a 5% significance level.

RESULTS

Observations on the biology of *C. septempunctata* on corn leaf aphid, *R. maidis* at 25±1 °C and 18±1°C temperature are presented in Figures 1-3.



n	300	30	30	30	30	30	30
t	21.00*	9.56*	8.69*	15.53*	31.29*	3.46*	1.35^{ns}

*Significant at p<0.05; ^{ns}Non significant; n=Number observed; t='t' test value

Figure 1. Duration of different immature stages of *C. septempunctata* feeding on *R. maidis* at 25±1°C, 65±5% RH, 16:8 L:D and room temperature (18±1°C).

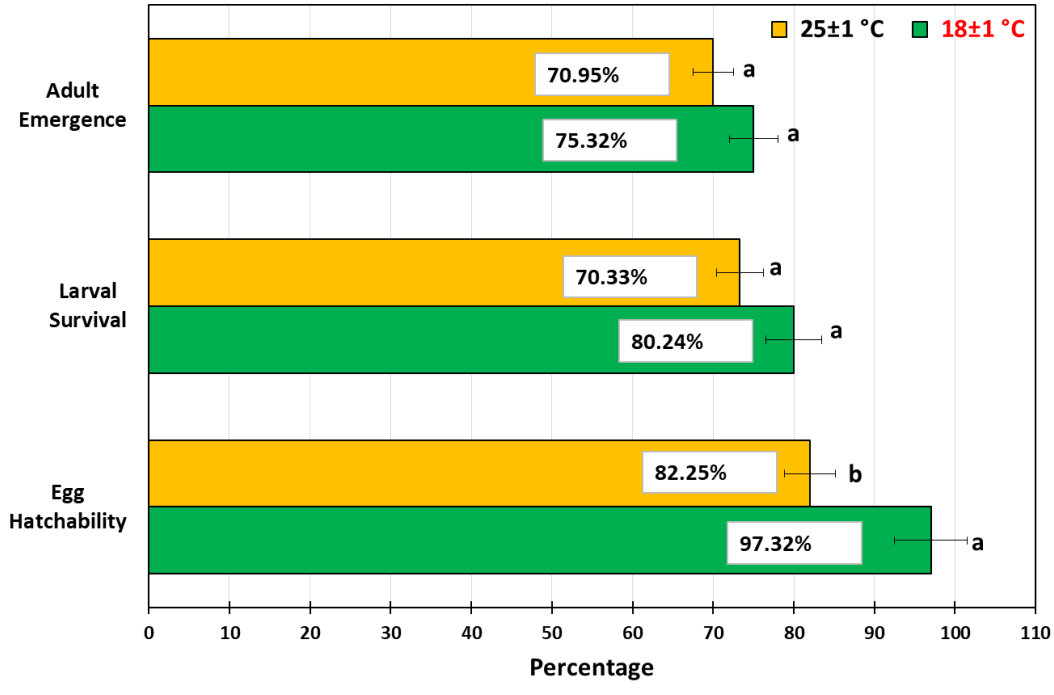
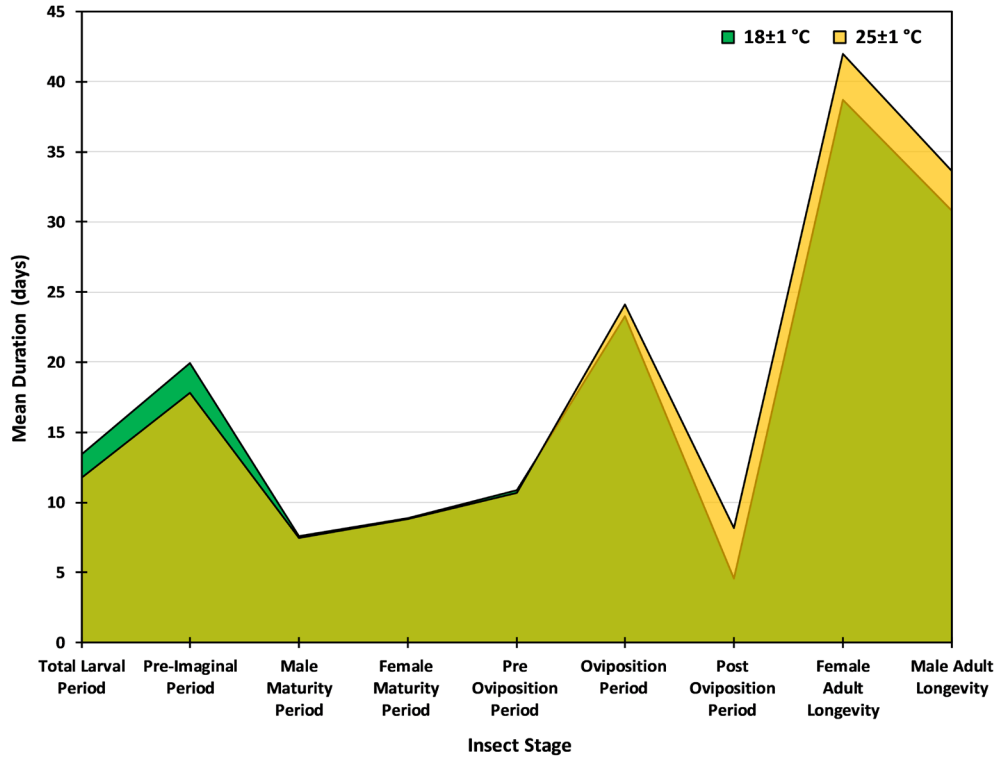


Figure 2. Egg hatchability, larval survival and adult emergence of *C. septempunctata* feeding on *R. maidis* at two different temperatures (25±1°C and 18±1°C).



n	30	30	10	10	10	10	10	10	10
t	31.65*	20.23*	1.33^{ns}	0.50^{ns}	1.11^{ns}	0.44^{ns}	4.83*	1.90*	1.67^{ns}

*Significant at p<0.05; ^{ns}Non significant; n=Number observed; t='t' test value

Figure 3. Duration of total larval period and different adult stages of *C. septempunctata* feeding on *R. maidis* at 25±1° C, 65±5% RH, 16:8 L:D and room temperatures (18±1°C).

Pre-imaginal period

The developmental stages of *Coccinella septempunctata* feeding on the corn leaf aphid (*Rhopalosiphum maidis*) at temperatures of 25±1°C and 18±1°C are summarised in Figures 1 and 2. Females laid bright yellow, elongated, cylindrical eggs resembling small rice grains, clustered together. The incubation period averaged 3.30±0.10 days at 25±1°C, with a hatching rate of 82%, whereas at 18±1°C, the incubation period increased to 4.00±0.21 days with a higher hatching rate of 97%.

The larvae underwent four instars before transitioning to the pre-pupal and pupal stages. Newly hatched larvae were light brownish, while later instars developed distinctive pigmentation, including bright yellow thoracic and abdominal markings. The mean duration of the larval instars at 25±1°C were as follows: 1st instar, 2.71±0.12 days; 2nd instar, 1.90±0.08 days; 3rd instar, 2.27±0.96 days; and 4th instar, 4.88±0.11 days, totalling 11.75±0.19 days with a larval survival rate of 73.33%. At 18±1°C, the corresponding durations were 3.01±0.12, 2.10±0.09, 2.61±0.07, and 5.71±0.10 days, respectively, with a total larval period of 13.43±0.21 days and an 80% survival rate. Mortality rates were higher in the earlier instars.

The pre-pupal period was marked by the cessation of feeding and colour changes to dull greyish. Pupae initially appeared light yellow but darkened over time. At 25±1°C, the pre-pupal and pupal stages averaged 1.07±0.09 and 5.00±0.53 days, respectively, while at 18±1°C, they lasted 1.20±0.047 and 5.26±0.31 days. The entire pre-imaginal stage spanned 17.84±0.23 days at 25±1°C and 19.91±0.29 days at 18±1°C.

Adult stage

The emergence and duration of the adult stages are depicted in Figures 2 and 3. Adult emergence rates were 70% and 75% at 25±1°C and 18±1°C, respectively, with sex ratios (F:M) of 1.2:1 and 1.5:1. Newly emerged adults were bright yellow with no spots, and pigmentation developed over time, culminating in the characteristic seven spots of the species. Females were larger than males, and ventral differences included curved, hair-like structures in males versus flat, grooved features in females.

Female longevity averaged 42.00±3.97 days at 25±1°C and 38.7±3.80 days at 18±1°C, while males lived for 33.60±3.72 and 30.81±3.80 days, respectively. Females reached sexual maturity in 8.83±0.36 days at 25±1°C and 8.90±0.29 days at 18±1°C. Oviposition periods averaged

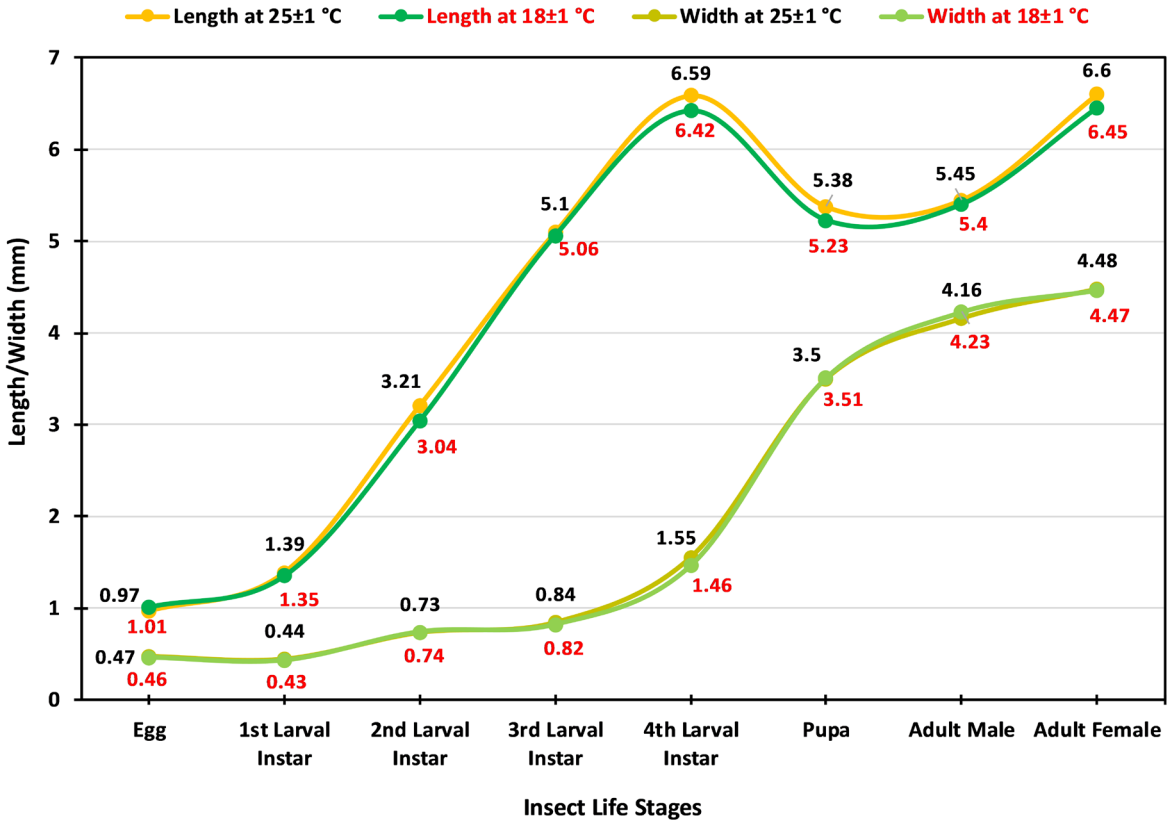


Figure 4. Morphometrics (length and width) of various life stages of *C. septempunctata* reared on *R. maidis* at two different temperatures (25±1°C and 18±1°C).

Table 1. Intra-specific larval cannibalism in *C. septempunctata*

Predator larval instar	Host larval instar	No. of host larvae served	Mean No. of host cannibalized	Per cent cannibalism	Mean ± SD	Range
4th	1st	50	48.10	96.20	48.10±2.80[a]	42-50
4th	2nd	35	26.90	76.80	26.90±1.72[b]	24-30
4th	3rd	15	4.60	30.66	4.60±2.06[d]	0-6
3rd	1st	30	25.10	83.66	25.10±1.44[b]	22-26
3rd	2nd	20	11.60	58.00	11.60±3.13[c]	4-14
2nd	1st	20	6.00	30.00	6.00±3.16[d]	0-11

SD – Standard deviation. Figures followed by different letters are statistically significant.

24.10±4.61 days at 25±1°C and 23.30±3.40 days at 18±1°C, with females laying an average of 372 and 339 eggs, respectively.

Morphometry

Morphometric analyses (Figure 4) revealed that the length of various stages at 25±1°C ranged from 0.97±0.07 mm (eggs) to 6.60±0.24 mm (adult females), with corresponding widths ranging from 0.47±0.02 mm to 4.48±0.30 mm. At 18±1°C, stage length and width were slightly reduced and consistent with the cooler temperature.

Larval cannibalism

High cannibalism rates were observed in the absence of prey (Table 1). Fourth instar larvae displayed the highest cannibalistic behaviour, consuming up to 96.20% of provided first instar larvae. Cannibalism rates decreased with older larval stages or smaller prey availability.

Predation potential

Both larval and adult stages of *C. septempunctata* demonstrated significant predatory capacities on *R. maidis* (Tables 2 and 3). The predation rate increased with larval

Table 2. Predation potential of different larval instar of *C. septempunctata* at different prey densities of *R. maidis*

1st Instar			2nd Instar			3rd Instar			4th Instar		
PD	**Mean ± SD**	**Range**	**PD**	**Mean ± SD**	**Range**	**PD**	**Mean ± SD**	**Range**	**PD**	**Mean ± SD**	**Range**
25	12.40±3.94^{b}	4-18	**25**	21.50±3.77^{d}	12-24	**75**	63.70±8.89^{ac}	44-72	**150**	121.50±27.99^{bd}	62-145
50	23.90±5.42^{a}	12-29	**50**	32.00±5.72^{c}	22-40	**100**	74.10±13.60^{ab}	52-89	**200**	163.50±30.91^{bc}	97-196
75	24.20±4.12^{a}	14-29	**75**	36.80±9.45^{b}	22-52	**150**	106.6±29.60^{aa}	57-142	**250**	189.30±46.19^{bb}	139-248
Mean	20.16±3.22		**100**	37.10±4.8a^{9}	26-57	**200**	110.10±31.20^{aa}	52-159	**300**	197.87±51.20^{bb}	149-268
			Mean	31.85±5.53		**Mean**	88.63±11.14		**Mean**	168.04±31.27	

PD - Prey density; SD – Standard deviation. Figures followed by different letters are statistically significant.

Table 3. Comparison of *C. septempunctata* grub and adult predation potential feeding on *R. maidis.*

Stage	Category	Mean	Range
Larval period (1st – 4th instar)	Lowest prey density	219.10±36.05^{c}	139-248
Larval period (1st – 4th instar)	Highest prey density	356.60±59.60^{b}	225-424
Adult Male	In 25 days	1684±180.81^{a}	1440-1960
Adult Female	In 25 days	2244±295.86^{a}	1840-2680
Adult Male	Per day	84.20±9.04^{e}	72-98
Adult Female	Per day	112.20±14.80^{d}	92-134

*Significant at p<0.01; a - t-test comparing means of larval predation potential at lowest and highest prey densities; b - t-test comparing means of adult predation potential of male and female in 25 days; c - t- test comparing means of daily adult predation potential of male and female per day.

instar and prey density. Fourth-instar larvae consumed up to 197.87 aphids at a density of 300 aphids, while adult females and males averaged daily consumptions of 112.20 and 84.20 aphids, respectively.

This comprehensive study highlights the biological and ecological roles of *C. septempunctata* as an effective predator of *R. maidis*.

DISCUSSION

The biology, morphometry, and predation potential of *Coccinella septempunctata* on the corn leaf aphid (*Rhopalosiphum maidis*) were investigated. Notable variations were observed in the development of immature stages when feeding on *R. maidis*. The incubation period of *C. septempunctata* ranged from 3.20–3.50 days at 25±1°C and 3.60–4.20 days at 18±1°C, consistent with findings by Kakkar (1998) and Rauf *et al.* (2013), who reported an incubation period of 3.6–4.0 days at temperatures between 23–26°C. The developmental duration for larval instars varied from 2.54–5.21 days at 25±1°C and 2.67–5.92 days at 18±1°C, while the total larval period lasted 11.36–12.27 days and 13.18–14.01 days, respectively. Similar observations were made by Obrycki and Orr (1990), who documented durations of 3.1, 2.2, 2.6, and 8.0 days for the 1st to 4th larval instars and a total larval period of 16.0 days at 23±2°C.

The duration of the pupal stage did not vary significantly between the two temperature settings, lasting 4.50–6.00 days at 25±1°C and 5.00–6.00 days at 18±1°C. These results are consistent with the observations of Özder and Sağlam (2003), who reported pupal development times ranging from 4.00 to 5.33 days across various aphid hosts. Similar findings were also noted by Kumar *et al.* (2019), who recorded pupal durations of 4.66 and 5.67 days under comparable environmental conditions.

The highest survival rates were observed during the egg stage (82–97%), while the lowest occurred in the adult stage (70–75%). These findings are in line with those of Rajput *et al.* (2017), who recorded an egg survival rate of 89% and 4.64% for pupae. Female adults took slightly longer to reach sexual maturity than males, requiring 8–11 days compared to 6–9 days for males, consistent with Srivastava (2013). Females also lived longer than males, a trend supported by Kumar *et al.* (2019), who reported average lifespans of 36.67 days for females and 30.67 days for males. The female-to-male sex ratio was 1.2:1 at 25±1°C and 1.5:1 at 18±1°C, aligning with the results of Kakkar (1998), Sattar *et al.* (2008), and Sarwar *et al.* (2010).

Morphometric measurements showed significant differences in larval, pupal, and adult stages based on temperature. Egg lengths ranged from 0.97–1.01 mm, while adult females measured 6.45–6.60 mm at different temperatures. Widths ranged from 0.46–4.48 mm, similar to results by Bukero *et al.* (2015) on *C. septempunctata* reared on angoumois grain moth eggs.

Cannibalistic behaviour was observed, with higher predation rates on 1st instar larvae by 2nd, 3rd, and 4th instars. These findings align with Yasuda and Ohnuma (1999) and Pervez *et al.* (2006), who reported significant cannibalism among *C. septempunctata* instars, with older instars preying on younger ones.

The predation potential increased with larval instar progression. First to fourth instars consumed 14–29, 26–57, 52–159, and 149–268 aphids, respectively, at varying prey densities. The fourth instar was the most voracious, consuming the highest number of aphids. This trend aligns with findings by Khinchi *et al.* (2015), Chaudhary *et al.* (2015) and Unal *et al.,* (2017). Adults demonstrated a higher predation rate than larvae, with females consuming more aphids than males. Female predation rates averaged 117 aphids per day compared to 96 for males, corroborating studies by Chaudhary *et al.* (2015) and Khinchi *et al.* (2015).

Differences in results across studies may be attributed to variations in host aphid species, temperature, and laboratory conditions. These findings confirm that *C. septempunctata* is a highly effective predator capable of significantly reducing aphid populations.

CONCLUSION

The present study revealed that the corn leaf aphid, *R. maidis* is a suitable host for the rearing of *C. septempunctata.* Both the grubs and adults of *C. septempunctata* are potential predators of *R. maidis* and are highly effective in controlling the corn leaf aphid. Thus it can be concluded that *C. septempunctata* can be used as a potential biocontrol agent in biological control of corn leaf aphid.

ACKNOWLEDGEMENTS

The authors thank the Director of ICAR-Indian Institute of Wheat and Barley Research (IIWBR), Karnal, India for providing the research facilities for conducting the study. The authors also acknowledge the support provided by the technical staff of the institute.

REFERENCES

Bukero, A. B. A., Nizamani, M. A., Nizamani, I. A., Ali, S. S., Khaskheli, M. I., Lanjar, A. G., …, Nahiyoon, S. A. 2015. Effect of different diets on the development and morphometric of *Coccinella septempunctata* (*Linnaeus*). *J Basic Appl Sci,* **11**: 484-486. https://doi.org/10.6000/1927-5129.2015.11.63

Chaudhary, D. D., Kumar, B., and Mishra, G. 2015. Resource partitioning in a ladybird, *Menochilus sexmaculatus*: Function of body size and prey density. *Bull of Entomol Res,* **105**(1): 121-128. https://doi.org/10.1017/S0007485314000874 PMid:25467186

Dadrasi, A., Chaichi, M., Nehbandani, A., Soltani, E., Nemati, A., Salmani, F., …, Yousefi, A. R. 2023. Global insight into understanding wheat yield and production through Agro-Ecological Zoning. *Sci Rep*, **13**(1): Article 15898. https://doi.org/10.1038/s41598-023-43191-x PMid:37741907 PMCid:PMC10517951

Decourtye, A., Henry, M., and Desneux, N. 2013. Overhaul pesticide testing on bees. *Nature,* **497**(7448): Article 188. https://doi.org/10.1038/497188a PMid:23657341

Gilkeson, L., and Kelin, M. 2001. Natural enemies of insect pests. Cooperative Extension, Cornell University, Ithaca, NY.

Jasrotia, P., Yadav, J., Singh, B., Patil, S. D., Kumar, S., and Singh, G. P. 2022a. Efficiency of sticky traps for monitoring aphids in wheat under North-Western Plains and Peninsular zones of India. *J Environ Bio*, **43**(6): 794-800. https://doi.org/10.22438/jeb/43/6/MRN-1952

Jasrotia, P., Singh, B., and Nagpal, M. 2022b. Biology and management strategies of major insect-pests of wheat. In New horizons in wheat and barley research: crop protection and resource management (pp. 283-307). Springer Nature, Singapore. https://doi.org/10.1007/978-981-16-4134-3_9

Kakkar, J. 1998. Studies on biology, feeding potential and population dynamics of ladybird beetle, *Coccinella septempunctata* Linn. on cereal aphid, *Sitobion avenae* (F.). [Master's thesis, CCS Haryana Agricultural University, Hisar].

Khinchi, S. K., Yadav, R. C., and Kumawat, K. C. 2015. Mass rearing, feeding and biotic potential of ladybird beetle, *Coccinella septempunctata* (Linn.) on aphid, *Rhopalosiphum maidis* (Fitch). Proceedings of the International Conference on Emerging Trends in Biotechnology and Sciences with Especial Reference to Climate Change, 52-58.

Kumar, S., Singh, R., Kumar, A., Krishna, H., and Kumar, V. 2019. Biology of *Coccinella septempunctata* (Linnaeus) on mustard aphid, *Liphaphis erysimi* (Kalt.). *J Entomol Zool Stud,* **7**(2): 1239-1241.

Kundoo, A. A., and Khan, A. A. 2017. Coccinellids as biological control agents of soft bodied insects: A review. *J Entomol Zool Stud*, **5**(5): 1362-1373.

Mari, J. M., Rizvi, N. H., Nizamani, S. M., Qureshi, K. H., and Lohar, M. K. 2005. Predatory efficiency of *Menochilus*

sexmaculatus Fab. and *Coccinella undecimpunctata* Lin., (Coccinellidae: Coleoptera) on alfalfa aphid *Therioaphis trifolii* (Monell). *Asian J Plant Sci,* **4**(4): 365-368. https://doi.org/10.3923/ajps.2005.365.369

Michaud, J. P. 2012. Coccinellids in biological control. In Ecology and behaviour of the ladybird beetles (Coccinellidae) (pp. 488-519). https://doi.org/10.1002/9781118223208.ch11

Mishra, G., Omkar, Kumar, B., and Pandey, G. 2012. Stage and age-specific predation in four aphidophagous ladybird beetles. *Biocont Sci Technol*, **22**(4): 463-476. https://doi.org/10.1080/09583157.2012.664617

Obrycki, J. J., and Orr, C. J. 1990. Suitability of three prey species for Nearctic populations of *Coccinella septempunctata*, *Hippodamia variegata*, and *Propylea quatuordecimpunctata* (Coleoptera: Coccinellidae). *J Economic Entomol,* **83**(4): 1292-1297. https://doi.org/10.1093/jee/83.4.1292

Özder, N., and Sağlam, Ö. 2003. Effects of aphid prey on larval development and mortality of *Adalia bipunctata* and *Coccinella septempunctata* (Coleoptera: Coccinellidae). *Biocont Sci Technol,* **13**(4), 449-453. https://doi.org/10.1080/0958315031000124477

Pervez, A., and Gupta, A. K. 2006. Larval cannibalism in aphidophagous ladybirds: Influencing factors, benefits and costs. *Biol Cont,* **38**(3): 307-313. https://doi.org/10.1016/j.biocontrol.2006.03.004

Rajput, A., A., Memon, S. A., Mastoi, A. H., Narejo, M.-U.-N., Afzal, M., …, Ullah, A. 2017. Biology and feeding potential of ladybird beetle (*Coccinella septempunctata*) against different species of aphids. *Sci Int,* **29**(6): 1261-1263.

Rauf, M., Khan, J., Rehman, A., Gillani, W. A., and Ali, A. 2013. Biology and predatory potential of *Coccinella septempunctata* Linn. on *Schizaphis graminum* aphid under controlled conditions. *J Agricult Res,* **26**(2): 124-129.

Sarwar, M., and Saqib, S. M. 2010. Rearing of predatory seven-spotted ladybird beetle *Coccinella septempunctata* L. (Coleoptera: Coccinellidae) on natural and artificial diets under laboratory conditions. *Pak J Zool,* **42**(1): 47-51.

Sattar, M., Hamed, M., and Nadeem, S. 2008. Biology of *Coccinella septempunctata* Linn. (Coleoptera: Coccinellidae) and its predatory potential on cotton aphids, *Aphis gossypii* Glover (Hemiptera: Aphididae. *Pak J Zool,* **40**(4): 239-242.

Srivastava, S. 2013. The reproductive behaviour of an aphidophagous ladybeetle, *Coccinella septempunctata* (Coleoptera: Coccinellidae). *Europ J Entomol,* **99**(4): 465-470. https://doi.org/10.14411/eje.2002.060

Stellwag, L., and Losey, J. E. 2014. Sexual dimorphism in North American coccinellids: Sexing methods for species of *Coccinella* L. (Coleoptera: Coccinellidae) and implications for conservation research. *Coleopt Bull,* **68**(2): 271-281. https://doi.org/10.1649/0010-065X-68.2.271

Unal, S., Er, A., Akkuzu, E., and Salek, L. 2017. Predation efficacy of the predator *Coccinella septempunctata* L. on the aphid species *Macrosiphum rosae* (L.) in Kastamonu Province, Turkey. *Pak J Zool,* **36**(4): Article 285. https://doi.org/10.17582/journal.pjz/2017.49.1.327.330

Yadav, J., Jasrotia, P., Jaglan, M. S., Sareen, S., Kashyap, P. L., Kumar, S., …, Singh, G. P. 2024. Unravelling the novel genetic diversity and marker-trait associations of corn leaf aphid resistance in wheat using microsatellite markers. *Plos One*, **19**(2): Article p.e0289527. https://doi.org/10.1371/journal.pone.0289527 PMid:38386640 PMCid:PMC10883527

Yasuda, H., and Ohnuma, N. 1999. Effect of cannibalism and predation on the larval performance of two ladybird beetles. *Entomol Exp Appl,* **93**(1): 63-67. https://doi.org/10.1046/j.1570-7458.1999.00565.x