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Feeding potential of the predatory ladybird beetle *Coccinella septempunctata* (Coleoptera; Coccinellidae) as affected by the hunger levels on natural host species

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Abstract

Ladybird beetles/Ladybugs, both adults and larvae, are well-known primarily as predators of aphids (plant lice); however, they also prey upon many other soft bodied insects and eggs of different borers. Laboratory rearing of predatory ladybirds often need a live host particularly aphids. Studies were conducted to check the suitability of live and frozen rose and mustard aphids to rear seven spotted ladybird beetle under two feeding conditions i.e., fed normally (unstarved beetles) or hungry (starved) for 16 hours. Results showed that hungriness may affect the food consumption efficiency. When the beetles were not starved, they showed preference for eating live mustard aphids as compared to frozen (Mean ± SE = 6.24 ± 0.37 live aphids, 4.43 ± 0.40frozen aphids). Similar trend was observed on rose aphids (6.51 ± 0.5 (live aphids) and 4.86 ± 0.49 (frozen aphids)). But the adults in starved condition consumed equal number of live and frozen aphids. During the 1st hour, starved beetles consumed more aphids of both species as compared to unstarved beetles. Also, more number of mealybugs was consumed in starved condition. This study highlights that feeding potential of predatory seven spotted ladybird is not only affected by the type of host but also the condition of host (live vs frozen). Moreover, starvation level of the predator can also be an important factor in determining its devouring capacity.

Key words: Coccinella, live and frozen aphids, predation, starvation.

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Introduction

Ladybirds (Coccinellidae) contain a large number of formally described species, and a global distribution (Hodek, 1967). They are considered to be beneficial insects, feeding on pest species such as psyllids, aphids, scale insects, whitefly, mealybugs, mites, small Lepidoptera and Coleoptera larvae (Obrycki & Kring 1998; Hodek 1967; Hagen 1962). They are also recorded feeding on nectar and pollen (Hodek 1967; Hagen 1962).The majority of coccinellid beetles are useful because of their predaceous nature upon a variety of pests viz., aphids, leaf-hoppers, scale insects, mealybugs, mites and other soft bodied insects (Sharma & Joshi 2010; Joshi & Sharma 2008; Omkar & Bind 1996). Predaceous coccinellids have a wide range of accepted food. The larvae prey on the same prey as the adults. Hence, it is the adults, which select a certain type of food for the larvae, while laying their eggs. The natural enemies once established in the ecosystem are self-powered, self-sufficient and self-regulating, requiring no further investments in control (Pimental, 1991). Coccinellid beetles have been utilized as biological control agents for over a century (Obrycki & Kring, 1998). There have been some significant successes using ladybirds as biological control agents, but methods to enhance their efficacy are under continuous development (Obrycki & Kring, 1998).In fact, coccinellids could be considered crucial in developing an integrated approach to pest control (Obrycki & Kring, 1998).*Coccinella septempunctata* Linnaeus (Coleoptera: Coccinellidae) has been extensively used in the past as a biological control agent due to its voracity and polyphagy, being recorded to feed on up to 97 different prey species (Lucas et al. 2002; Hoy & Nguyen, 2000) and is a dominant species in almost all ecosystems. Aphids are very serious insect pests in agriculture everywhere in the world (Minks & Harrewijn, 1987). Most aphids are extremely host specific, feeding on one or a few plant species that are usually closely related. The mustard aphid, *Lipaphis erysimi* Kaltenbach (Hemiptera; Aphididae) is a major pest of *Brassica compestris* and *Brassica juncea* (Ghosh, 1975). The rose aphid *Macrosiphum rosae* Linnaeus (Hemiptera; Aphididae) infests rosebushes, especially around new buds. Mealybug *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae), is also a serious pest on a wide range of host plants (Arif et al., 2002). It has been found infesting 154 plant species including field crops, vegetables, ornamentals, weeds, bushes and trees. The economical losses had been recorded on cotton, brinjal, okra, tomato, sesame, sunflower and China rose. Coccinellid beetles, (Coleoptera: Coccinellidae) are very effective predator of mealybugs (Osborne et al. 2004; Mani & Krishnamoorthy 2008; Hameed et al. 2013). Adults and larvae of predatory beetle feed on immature as well as adult stages of mealybugs (Khuhroo et al, 2012). Lohar (2001) reported *Brumus sutuaralis* (Coleoptera: Coccinellidae) as a voracious feeder of mature and immature stages of mealybug on different field and vegetable crops. Moore (1988) also stated that despite the frequent use of predators, only the coccinellids can be considered successful. In order to have field application of coccinellid beetles for the integrated pest management (IPM) of various crops or vegetables, a year round availability of beetles is required. Field populations of natural prey can be relied on only at intervals during the year. For continuous laboratory rearing of ladybird beetles, a constant availability of prey is indispensable. Freezing and storing the host could be an approach in such circumstances (Khan & Khan, 2002). Use of frozen mustard aphid *Lypaphis erysimi* has been reported as a good host for rearing of *Hippodamia convergens* Guer under laboratory conditions (Bukero et al., 2015). Mealybugs as prey are efficient food source and have positive effects on the biological traits of ladybeetles (Hameed et al., 2013). The present experiments were therefore designed with the objective to test the feeding behaviour of seven spotted ladybeetle, *C. septempunctata* adults on two aphid species; mustard and rose aphids under laboratory conditions. The offered aphids were alive or frozen by keeping the adult beetles either hungry (starved) or normally fed (unstarved). The feeding potential of adult *C. septempunctata* on different stages of cotton Mealybug under starved and unstarved conditions was also tested.

Materials and methods

***C. septempunctata* feeding on Aphid species:** Studies were conducted to check the feeding potential of *C. septempunctata* on two species of aphids viz.; rose aphid *Macrosiphum rosae* (Linnaeus.) and mustard aphids *Lipaphis erysimi* (Kalt.) to rear seven spotted ladybird beetle *C. septempunctata.* There were two groups of beetles, one kept starved for 12 hrs and the other unstarved. The aphids offered to beetles as food were live and frozen for both species. Twenty beetles were used in each group (ten per treatment replicated twice) for live aphid and twenty for frozen aphids (N = 40). Twenty five aphids of each aphid species were provided to individual adult beetle in a petri dish (3.5 inches) and observations were recorded for the feeding response of adult beetles. For hourly consumption of *C. septempunctata,* observations were recorded for three consecutive hours on two aphid species viz., *L. erysimi* and *M. rosae*. For this purpose beetles were grouped as 12h starved and unstarved ones. For each group, twenty five aphids of each species were released in individual petri dishes for twenty beetles in each group (ten per treatment replicated twice, N = 40). Observations were recorded after 1st, 2nd and 3rd hour.

***C. septempunctata* feeding on cotton mealybug:** For the experiment regarding suitability of mealybug *Phenacoccus solenopsis* Tinsley as a host, three different instars of mealybug i-e 1st instar, 2ndinstar and 3rdinstar were offered to individual adult *C. septempunctata* beetles under starved conditions of 12 hours and unstarved conditions. The test was performed with three replicates and ten adult beetles per replicate (N = 30), following complete randomized design. Fifty mealybug of each 1st instar (crawlers) 2nd and 3rd instars were placed in separate petri dishes (3.5 inches) and offered to individual adult beetles. Observations were recorded for the feeding response of adult beetles. For hourly consumption of *C. septempunctata,* observations were recorded for three consecutive hours on three nymphal instars of mealybugs. For this purpose beetles were grouped as 12hr starved and unstarved ones. Each group of beetles was provided with fifty mealybugs of each instar released in individual petri dishes for twenty beetles in each group (ten per treatment replicated twice, N = 40). Observations were recorded after 1st, 2nd and 3rdfeeding hour.

Statistical Analysis: Statistical programme SPSS ver. 16.0 was used for all analysis. Normality of the data was checked by One-sample Kolmogorov-Smirnov test. Normal data were subjected to parametric variance tests, T test for two variables and one or two way analysis of variance ANOVA for more than two variables. LSD test was applied for differences between variables. Percent and ratio data were arcsine transformed.

Results

Feeding performance on live and frozen Aphids: *C. septempunctata* in both, starved and unstarved conditions consumed more aphids (rose and mustard) during 1st hour and feeding rate reduced during second and third hour of continuous feeding (Fig. 1, Table 1). Also, during 1st hour, starved beetles consumed more aphids of both species as compared to unstarved beetles (Fig. 1, Table 1). Overall, more rose aphids were consumed as compared to mustard aphids (Fig. 1, Table 1). There were no significant differences found in number of live and frozen mustard aphids consumed by *C. septempunctata* when they were starved. But, when the beetles were not starved, they showed preference for eating live aphids as compared to frozen (Mean ± SE = 6.24 ± 0.37 (live aphids), 4.43 ± 0.40 (frozen aphids, Fig. 2, Table 2).Similarly for rose aphids, unstarved beetles consumed more live aphids as compared to frozen (6.51 ± 0.5 (live aphids) and 4.86 ± 0.49 (frozen aphids)). On the contrary, starved beetles consumed the same number of live and frozen aphids (Mean ± SE= 6.64 ± 0.44 (frozen), 6.23 ± 0.45 (live)) (Fig. 2). Overall, for both aphid species, significantly higher number of frozen aphids was consumed by starved beetles as compared to unstarved beetles (Fig. 2, Table 2).

Table 1: A Comparison of hourly predation by *Coccinella septempunctata* adults on rose and mustard aphid species (Two-way ANOVA has been used for analysis).

Source	df	F	Sig.
Hourly predation	2	103.52	<0.001
Rose vs mustard aphids	1	5.147	0.024
Hours * rose/ mustard	2	5.669	0.004
Hours * starved/ unstarved	2	4.657	0.010

Table 2: A Comparison of predation by starved and unstarved *Coccinella septempunctata* adults on live and frozen rose and mustard aphid species (Two-way ANOVA has been used for analysis).

Source	df	F	Sig.
Starved vs unstarved	1	4.363	0.037
Live vs frozen aphids	1	1.839	0.176
Live/frozen * starved / unstarved	1	26.980	<0.001
Live/ frozen * rose/ mustard	1	12.734	<0.001

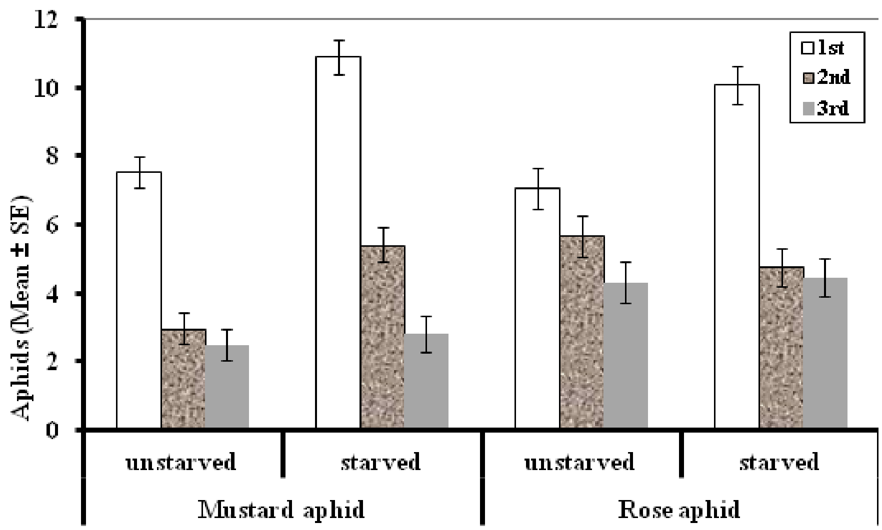

Figure 1: Hourly feeding preference of seven spotted ladybird beetle upon two aphid species under starved and unstarved conditions (N = 40).

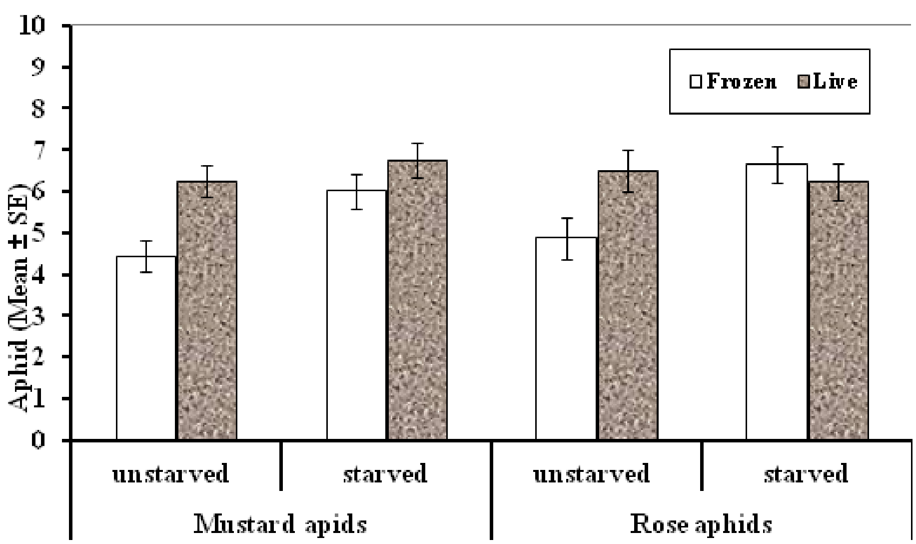

Figure 2: Feeding of seven spotted ladybird beetle upon live and frozen mustard vs rose aphid species (N = 40).

Predatory response on cotton mealybug: Results for rearing *C. septempunctata* beetle upon different developmental stages of mealybug with beetles either kept starved or unstarved showed significant differences in hourly feeding, and rate of feeding was the highest during the 1st hour (Fig. 3, Table 3). Also, during the first hour of feeding crawlers (1st instar) were preferred over 2nd and third instar mealybug, third being the least preferred (Fig. 3). Beetles consumed more number of mealybugs when kept starved(Means ± SE = 25.60 ± 0.39 (starved beetles) as compared to unstarved beetles (16.82 ± 0.37, Fig. 3). Unstarved beetles consumed equal number of crawlers and 2nd instar mealybug but 3rd instar was least preferred (Fig. 3).

Table 3: A Comparison of hourly predation by starved and unstarved *Coccinella septempunctata* adults on different life stages of mealybug, *Phenacoccus solenopsis* (Two-way ANOVA has been used for analysis).

Source	df	F	Sig.
Hours	2	1.997	<0.001
Starved/ unstarved	1	64.125	<0.001
Life stage	2	986.172	<0.001
hours * starved/ unstarved	2	16.433	<0.001
hours * life stage	4	402.795	<0.001
Starved/ unstarved * life stage	2	67.623	<0.001
hours * starved/ unstarved * life	4	83.767	<0.001

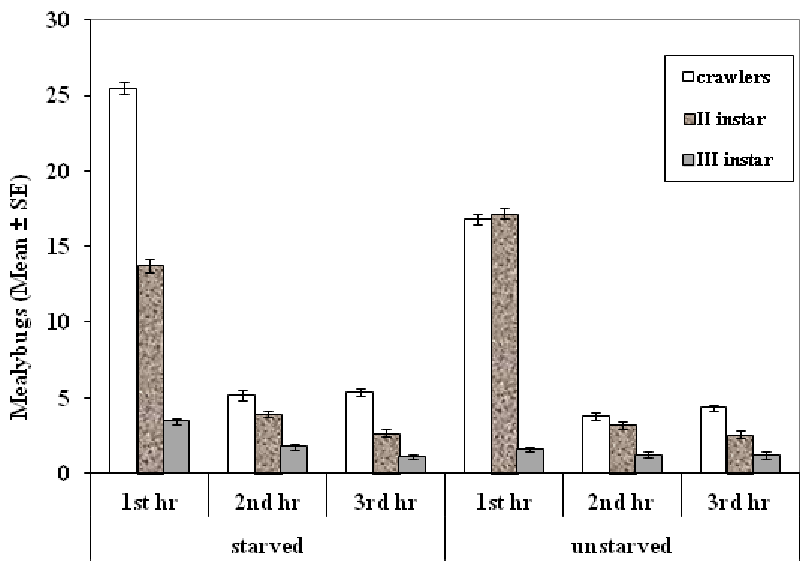

Figure 3: Hourly feeding by seven spotted ladybird beetle upon different life stages of mealybugs (N = 30).

Discussion

Starvation of adults or grub of ladybird beetles can enhance their feeding potential. The results of present study showed that the adults of *C. septempunctata* when kept starved consumed equal number of live and frozen aphids. Whereas, when the beetles were not starved they showed preference for live aphids only. The present findings are in accordance with the Yen (1983) who reported that starved adults of the predators are more efficient than fed ones. Similarly, more number of mealybugs was consumed by starved beetles. This kind of eating behaviour shows that starvation levels may increase the willingness of predators towards their hosts or they start feeding what they normally may not like. The results of another study also indicate that the starved adult beetles consumed more number of aphids than unstarved or well-fed adults (Sharma & Joshi, 2010). The starvation of *C. septempunctata* increased the feeding potential of grubs and adults on *L. erysimi* (Pandey 2002). Karnatak and Thorat (2006) also reported that starved adult of *C. septempunctata* consumed more aphids than unstarved or well fed ones. Further, the predators starved for 2 h before release could be effective in increasing feeding potential of all the stages of ladybird under field conditions (Sharma & Joshi, 2010). Sarmad et al. (2015) reported that rose aphid consumption rate of 12 hours starved adult *C. septempunctata* was a bit lower than 16 hours starved adult beetles. Their results are similar to present findings i-e starvation duration affects the predation rate of the predators, longer the starved adult coccinellid beetle higher will be the predation rate. The hourly consumption of adults of *C. septumpunctata* for *L. eryisimi* was 9.20±0.78, 8.50±0.97 and 8.22±1.22 for first, second and third hours, respectively (Sharma & Joshi 2010). Starvation induces varied degree of hungriness towards prey and the prey choice, on the other hand is affected by many factors including prey type, size, morphological and physiological characteristics of the prey (Omkar et al. 2004; Dixon 2000).A study reported that coccinellid beetles feeding on mealybugresulted into higher rate of adult emergence withhigher female sex ratio when *Brumus suturalis* Fabricius reared on cotton mealybug (Khuhro et al., 2008). *C. septempunctata* adults when kept starved consumed more *P. solenopsis* as compare to normal feed adults. Normally feed beetles showed no differences for acceptance of crawlers and second instar*P. solenopsis*. Ourthese findings are in contrary to those reported by Hameed et al. (2013) where *Coccinella undecimpunctata* L. adult beetles consumed more number of the first instar (crawlers) as compared to second and third instar *P. solenopsis* under normal feeding regimes. Present findings are similar to those reported by Arif et al. (2011), as the *Coccinella septempunctata* showed significant high predation (96.7 percent consumption) on *P. solenopsis*. Overall first instar nymphs of mealybug were the most preferred food of adult *C. septempunctata* as reported by Rashid et al. (2012) for *C. montrouzieri*. Coccinellids prefer to feed on crawlers of mealy bug (Saikia & Balasubramanian, 2002). Consumer resource relationship plays an important role in the predator ecology and influencing both dynamics of populations and the flow of energy through different food levels. The predatory beetles usually acquire significantly higher survival and faster development when fed on live aphids (Khan & Khan, 2002). When continuous rearing in laboratory is considered for ladybird beetles, provision of ample number of live aphids is crucial to trigger oviposition. Due to unavailability of aphids at times when not present in field, their rearing in the laboratory could mean extra labor and work. Therefore drying or freezing live aphids is an approach to save time and labor in continuous mass rearing environments. Although the reproductive potential decreases on dried and frozen aphids (Khan& Khan, 2002), the tradeoff for saving labor and time balances out.

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References

Arif MI, Rafiq M, Ghaffar A, 2002. Host Plants of cotton Mealybug (*Phenacoccus solenopsis*) A new Menace to cotton Agro-eco-system of Punjab, Pakistan. International Journal of Agriculture and Biology **11**: 163–167.

Arif MJ, Gogi MD, Abid AM, Imran M, Shahid MR, Husain S, Arshad M, 2011. Predatory potential of some native coccinellid predators against *Phenacoccus solenopsis*, Tinsely (Pseudococcidae: Hemiptera). Pakistan Entomologist **33**: 97–103.

Bukero A, Rustamani MA, Lanjar AG, Khan I, Solangi AW, Nahyoon SA, Mastoi GQ, 2015. Influence of *Lipaphis erysimi* (kalt.) on life stages of *Hippodamia convergens* Guer under laboratory conditions. Sci. Int. (Lahore) **27:** 2267–2270.

Dixon AFG, 2000. Insect predator prey dynamics, lady bird beetles and biological control. Cambridge University Press.

Ghosh AK, 1975. Aphids (Homoptera: Insecta) of economic importance in India. The Agricultural Society of India, Calcutta. Standard Printing Press, 134p.

Hagen KS, 1962.Biology and ecology of predaceous Coccinellidae. Annual Review of Entomology **7:** 289–326.

Hameed A, Saleem MH, Karar H, Ahmad S, Hussain M, Nazir W, Akram M, Hussain H, Freed S,2013. Life history and predatory potential of eleven spotted beetle (*Coccinella undecimpunctata* Linnaeus) on cotton mealybug (*Phenacoccus solenopsis* Tinsley). African Journal of Agricultural Research **8**: 6142–6148.

Hameed A, Saleem MH, Ahmad S, Iqbal J, Karar H, Amin A, 2013. Predatory Potential and Life History Characteristics of Eleven Spotted Beetle, *Coccinella undecimpunctata* L. Reared on Cotton Mealybug, *Phenacoccus solenopsis* Tinsley. Pakistan Journal of Zoology **45,** 1555–1562.

Hodek I, 1967. Bionomics and ecology of predaceous Coccinellidae. Annual Review of Entomology **12**: 79–104.

Hoy MA, Nguyen R, 2000. Classical biological control of brown citrus aphid: Release of *Lipolexis scutellaris*. Cit 2nd **81**; 24–26.

Joshi PC, Sharma P K, 2008.Feeding performance of *Cheilomenes sexmaculata* (F.) on mustard aphid, *Lipaphis erysimi* (Kalt.) and cotton aphid, *Aphis gossypii* (Glover). Proceeding on Emerging Trends of Researches in Insect Pest Management and Environment Safety, Uttar Pradesh Zoological Society, 118–121.

Karnatak AK, Thorat PV, 2006. Feeding potential of two ladybird beetle *Coccinella septempunctata* and *Coccinella transversalis* on mustard aphid *Lipaphis erysimi* (Kalt.). Journal of Applied Bioscience **32**: 123–125.

Khan MR,Khan MR, 2002. Mass rearing of *Menochilus sexmaculatus* Fabricius (Coleoptera: Coccinellidae) on natural and artificial diets. International Journal of Agriculture and Biology **4**: 107–109.

Khuhro SN, Lohar MK, Nizamani SM, Abro GH , Khuhro RD, 2008. Biology of lady bird beetle, *Brumus suturalis* Fabricius (Coleoptera:Coccinellidae) on cotton mealy bug, *Phenacoccus* sp. Pakistan Journal of Agriculture Engineering and Veterinary Sciences **24**: 53–58.

Khuhro SN, Lohar MK, Abro GH, Talpur MA, and Khuhro R, 2012. Feeding potential of ladybird beetle, *Brumus suturalis* Fabricius (Coleoptera: Coccinellidae) on cotton mealybug *Phenacoccus solenopsis* (Tinsley) in laboratory and field. Sarhad Journal of Agriculture **28**: 259-265.

Lohar, MK, 2001. Applied Entomology. 2nd Ed. Kashif Public, Hyderabad. 96-97pp.

Lucas É, Gagne I, Coderre D, 2002.Impact of the arrival of *Harmonia axyridis* on adults of *Coccinella septempunctata* and *Coleomegilla maculata* (Coleoptera: Coccniellidae). European Journal of Entomology **99**: 457–463.

Mani M, Krishnamoorthy A, 2008. Biological suppression of the mealybugs *Planococcus citri* (Risso), *Ferrisia virgata* (Cockerell) and *Nipaecoccus viridis* (Newstead) on pummelo with *Cryptolaemus montrouzieri* Mulsant in India. Journal of Biological Control **22**: 169–172.

Minks AK, Harrewijn P, 1987. In: Aphids, their control: biology, natural enemies and control. Elsevier, Amsterdam, Oxford, New York, Tokyo, Vol. B, 171–310.

Moore D, 1988. Agents used for biological control of mealybugs (Pseudococcidae). Biocontrol News and Information **9**: 209–225.

Obrycki JJ, Kring TJ, 1998. Predaceous Coccinellidae in biological control. Annual Review of Entomology **43**: 295–321.

Omkar, Bind RB, 1996. Record of aphids-natural enemies complex of Uttar Pradesh. V. The Coccinellids. Journal of Advances in Zoology **17**: 44–48.

Omkar, Singh SK, Pervez A, Mishra G, 2004. Age specific fecundity and natality lifetable of an aphidophagous ladybird, *Cheilomenes sexmaculata*. Biological Memoirs **30**: 20-25.

Osborne LS, Bolckmans K, Lando Z, Pena J, 2004.Kinds of natural enemies. In: Heinz M, van Driesche RG, Parrella MP, editors. BioControl in protected culture. Batavia, IL: Ball Publishing, 95–128 pp.

Pandey AK, 2002.Feeding potential of *C. septempunctata* L. on mustard aphid, *L. erysimi* Kalt. In: National Symposium on Biological Control of Insect Pest, held on Feb. 7-8, 2002 at Chennai, 36p.

Pimental D, 1991. Diversification of Biological control strategies in agriculture. Crop Protection **10**: 243–253.

Rashid MMU , Khattak MK, Abdullah K, Amir M, Tariq M, Nawaz S, 2012. Feeding potential of *Chrysoperla carnea* and *Cryptolaemus montrouzieri* on cotton mealybug, *Phenacoccus solenopsis*. The Journal of Animal & Plant Sciences **22**: 639–643.

Sarmad AS, Afzal M, Raza MA, Khalil SM, Khalil H, Aqueel AM, Mansoor MM, 2015. Feeding efficacy of *Coccinella septempunctata* and *Propyleaquatuor decimpunctata* against *Macrosiphum rosae*. Scientia Agriculturae **12**: 105–108.

Saikia P,Balasubramanian A, 2002. Feeding potential and larval development of *Cryptolaemus montrouzieri* Muls on aphids and mealybug.Journal of Agricultural SciencesSociety of North-East India.**13**: 8–11.

Sharma PK, Joshi PC, 2010. Feeding Potential of Seven Spotted Ladybeetle, *Coccinella septempunctata* (Linnaeus) on Mustard Aphid, *Lipaphis erysimi* (Kaltenbach) and Cotton Aphid, *Aphis gossypii*(Glover). Nature and Science **8**: 198–202.

Sharma PK, Joshi PC, 2010. New Records of Coccinellid Beetles (Coccinellidae: Coleoptera) from District Dehradun, (Uttarakhand), India. New York Science.

Yen J, 1983. Effects of prey concentration, prey size, predator life stage, predator starvation, and season on predation rates of the carnivorous copepod *Euchaeta elongata*. Marine Biology **75**: 69-77.