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Parasitism potential of *Campoletis chlorideae* Uchida (Hymenoptera : Ichneumonidae) against *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae)

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ABSTRACT: Studies were conducted on nutritional requirement and host age, specificity and density that play a vital role in mass rearing of the parasitoid *Campoletis chlorideae* Uchida a solitary larval parasitoid of *Helicoverpa armigera* (Hubner), a notorious and polyphagus pest of pulses and vegetables in India. Results indicated that *C. chlorideae* fed with 50% honey solution was best suited for maximum longevity of adults. *H. armigera* was the most suitable host and exposure of 3-6 day old caterpillars at a density of 20 gave maximum progeny production that can be effectively utilized in mass rearing programmes for field release.

KEY WORDS: *Campoletis chlorideae*, mass rearing, biocontrol, *Helicoverpa armigera*

INTRODUCTION

Helicoverpa armigera (Hubner) (Noctuidae: Lepidoptera) is a polyphagus and notorious pest of pulse crops in India (Bhosale, 2014). Among the biocontrol agents recorded on the pest *Campoletis chlorideae* Uchida (Hymenoptera : Ichneumonidae) is the most common and potent solitary larval parasitoid that can control the pest population effectively (Pawar *et al.*, 1989; Romeis and Shanower, 1996). Host searching and host density and high rate of parasitism are important factors for the success of biocontrol programme of any pest species (Sathe and Bhosale, 2012). In mass production of parasitoids nutritional suitability and age of host play an important role (Vinson, 1976; Vinson and Iwantsch, 1980).

Leong and Oatman (1968), Lingren and Nobel (1972), Eliopoulos (2007), Sathe and Bhosale (2011) and Khatri *et al.* (2012) made investigations on optimum age, density and specificity of hosts and nutritional requirement of ichneumon parasitoids. Several workers contributed on parasitism potential of *C. chlorideae* (Gupta *et al.,* 2004; Dhillon and Sharma, 2011; Ballal *et al.,* 2015 and Dubey *et al.,* 2017). The present study was carried out with *C. chlorideae*, a larval parasitoid of *H. armigera* to find out the optimum age of host, specificity and density for obtaining maximum progeny of parasitoids, which will help in mass rearing and field release for an effective biocontrol program against the pest.

MATERIALS AND METHODS

H. armigera were reared individually in small perforated plastic containers (7x8 cm, D x H). After adult emergence they were transferred to oviposition cages (25x25x25 cm, LxWxH). First

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instar caterpillars that usually hatch two days after oviposition. They were collected and used for further experiments. During the course of study, the host caterpillars were fed with gram leaves initially and pods later. Similarly, the hosts used to conduct the host specificity experiment were reared on their natural food like, *Spodoptera litura* (Fabricius) and *Achaea janata* (Linnaeus) on leaves of castor *Ricinus communis* L. and *Mythimna separata* Walker on leaves of maize *Zea mays* L.

Adults of *C. chlorideae* were reared in ventilated wooden cages (30x30x30 cm, LxWxH) with glass walls on three sides and top while one wall was made up of very fine mesh cloth for handling of parasitoids. The adults were fed with 50% honey solution. Adults of parasitoids that were released for oviposition in the rearing cages with different age and densities of *H. armigera* caterpillars. After 24 h, adults were removed and the cocoons of parasitoids then transferred into separate containers and adults of *C. chlorideae* that emerged out were used for experimental purpose. Emerged adults of *C. chlorideae* were fed with different food materials like 100% honey, 50% honey, 10% honey, 50% sucrose, 50% glucose, apple fruit juice, citrus fruit juice and water solution to analyze the ideal feed for getting highest longevity and nutritional requirements.

Host age related parasitism:

To determine the effect of host age on parasitism, 20 larvae of *H. armigera* of known age (ranging from less than 1 day to 13 days old) were exposed to single mated female of *C. chlorideae* in a glass cage for 24 hrs. The larvae were removed and placed in separate containers for further observations. Daily records of cocoon construction and parasitoid emergence from each container were observed.

Host density for optimum parasitization:

H. armigera caterpillars (4-5 day old) were exposed in densities of 10, 20, 30, and 40 towards mated females of *C. chlorideae* for 24 hrs in oviposition cage. Each experiment was replicated five times to confirming results. The host larvae were reared into plastic containers to record further development or parasitoid emergence.

Host specificity for optimum parasitization:

Host specificity was conducted by exposing the mated females of parasitoid towards caterpillars of different host species like *H. armigera*, *S. litura*, *M. separata* and *A. janata*. The hosts were placed in the oviposition cage for 24 h. Hosts were released in 20 densities for each replicate with multiple choice test experiment to record optimum parasitism. Afterwards the hosts were reared on the natural diet and observe the emergence of parasitoid or further lifecycle of host species.

The field experiments were carried out for western Maharashtra region and the *in-vitro* condition of 25±2°C, 60±5% RH and 12hr. photoperiod. During the course of the experiment (2015-16, 2016-17), gram pods were provided as a food to the caterpillars of *H. armigera* and other appropriate food for other experimented host species, while the parasitoids were fed with 50% honey solution. Each experiment was repeated five times for confirming the result. The statistical analysis was made by one way ANOVA Tukey's standardized range (HSD) test using the statistical software package SAS 9.3(32) English.

RESULTS AND DISCUSSION

Host specificity experiment revealed that the parasitoid preferred *H. armigera* as the primary host with 40% parasitism. Among tested hosts, the parasitoid showed 19 per cent parasitism for *S. litura*, 15 per cent parasitism for *M. separata* and 6 percent parasitism for *A. janata* (Fig.1). Adult longevity of *C. chlorideae* with different food materials indicated that the parasitoid survived longer with 50% honey solution with maximum male: female longevity ratio (1: 1.39) (Fig. 2). The maximum longevity of male and female when fed with 50% honey solution was 8.2 and 11.4 days respectively. Hence, it could be best suited for mass rearing of parasitoid in the laboratory. The

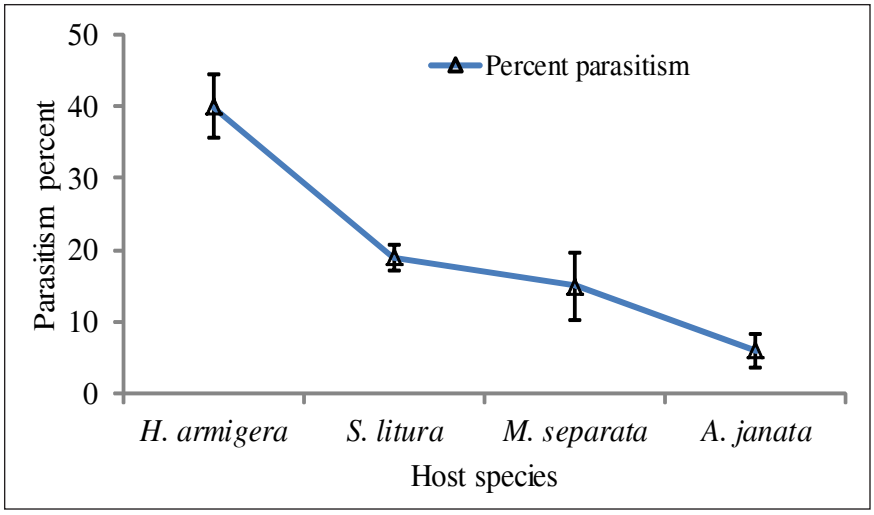

Fig. 1 Host specificity of *C. chlorideae*

*Each value is the mean of five replicates with error bars indicating standard error of mean

parasitoid caused maximum mortality in second instar caterpillars (Table 1). The caterpillars of 3-6 days old were preferred for parasitism whereas, beyond 11 days old were not attacked by the parasitoid. Four day old caterpillars were attacked most with high percent parasitism (42%) which was on par with five day old caterpillars with 26 per cent parasitism.

The results of optimum host density for maximum progeny production of parasitoid showed that the number of parasitoids obtained from host density 20 was highest with 40.00 per cent parasitism, compared to those produced from other host densities 10, 30, 40 and 50 with 16.00, 32.67, 30.00 and 24.80 mean percentage parasitism, respectively. Pawar *et al.* (1989) studied the parasitism of *C. chlorideae* on *H. armigera*, and found that first to third instar larvae, are only parasitised; the percentage parasitism on other crops was 44·2 on sorghum, 33·1 on chickpea, 32·6 on pearl millet, 7·1 on groundnut and 4·2 on pigeon pea. Lingren *et al.* (1970) reported the host age preference of *C. chlorideae* towards four lepidopterous host species *Prodenia ridinia* (Craner), *P. praefica* Grote, *Trichopulsia ni* (Hubner) and *Pseudoletia unipuncta* (Hawarth). They reported that 1-8 day old caterpillars of all hosts were susceptible for parasitism, and 2-6 day old caterpillars were most acceptable. In present findings 2-9 day old caterpillars of *H. armigera* were susceptible, and 3-6 day old being most suitable for parasitism.

Nikam and Basarkar (1981) studied the reproductive potential of *C. chlorideae* and reported maximum parasitization at host density 40. Sathe and Bhosale (2011) reported a host density 100 for obtaining maximum progeny production (38.50%) of the ichneumonid parasitoid *Diadegma insulare* (Cameron). In *Campoplex haywardi* Blanchard, an ichneumonid parasitoid of *Pthorimoea operculella* Zeller, the optimum host density was 75 larvae per tuber for maximum progeny production (Leong and Oatman, 1968). In present findings a host density of 20 showed maximum parasitism (40%).

Han *et al.* (2013) studied the host preference and suitability in *C. chlorideae* and recorded the parasitism against hosts *H. armigera*, *M. separata* and *Spodoptera exigua* (Hubner). They found that the parasitoid showed maximum parasitism on *H. armigera* followed by *M. separata* and *S. exigua*. Dhillon and Sharma (2007), recorded survival and development of *C. chlorideae* on various insect and crop hosts and found maximum cocoon formation (82.4%) and

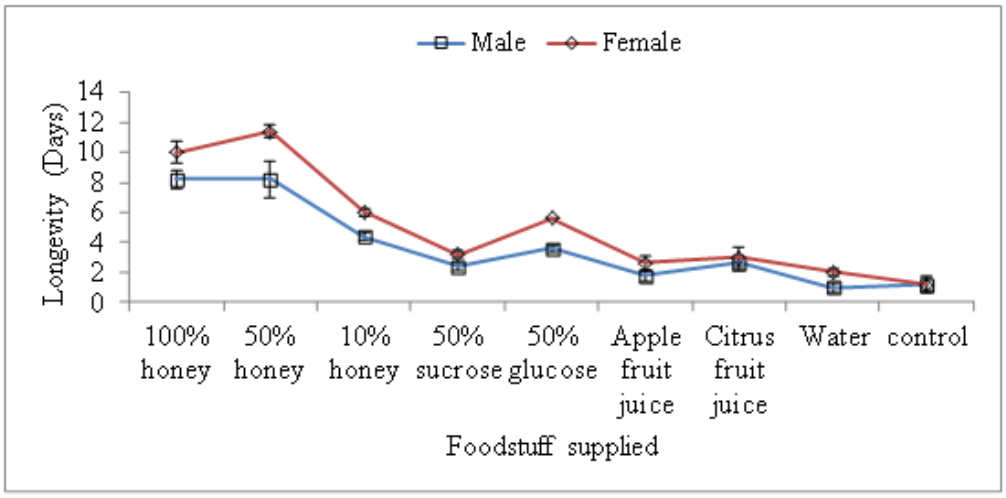

Fig. 2 Adult longevity of *C. chlorideae* with different food materials

*Each value is the mean of five replicates with error bars indicating standard error of mean

Table 1 Host age related parasitism by *C. chlorideae*

Host age (days)	% Parasitism	% Mortality	% Moth emergence
1	5.00 (±2.20)^{ef}	7.00 (±3.70)^{a}	88.00 (±2.50)^{ab}
2	9.00 (±3.70)^{de}	8.00 (±1.20)^{a}	83.00 (±3.70)^{abcd}
3	23.00 (±3.70)^{abc}	9.00 (±1.00)^{a}	68.00 (±3.00)^{de}
4	42.00 (±2.50)^{a}	9.00 (±2.90)^{a}	49.00 (±1.90)^{e}
5	26.00 (±3.70)^{ab}	7.00 (±2.50)^{a}	67.00 (±4.60)^{de}
6	22.00 (±3.40)^{abcd}	8.00 (±1.20)^{a}	70.00 (±2.70)^{cde}
7	15.00 (±0.00)^{bcd}	13.00 (±5.10)^{a}	72.00 (±5.10)^{bcd}
8	9.00 (±1.90)^{cde}	7.00 (±3.40)^{a}	84.00 (±1.90)^{abcd}
9	9.00 (±1.90)^{cde}	9.00 (±3.30)^{a}	82.00 (±4.60)^{abcd}
10	2.00 (±1.20)^{ef}	9.00 (±3.30)^{a}	89.00 (±2.40)^{a}
11	3.00 (±2.00)^{ef}	10.00 (±2.70)^{a}	87.00 (±2.50)^{abc}
12	0.00 (±0.00)^{f}	9.00 (±4.00)^{a}	91.00 (±4.00)^{a}
13	0.00 (±0.00)^{f}	12.00 (±3.40)^{a}	88.00 (±3.40)^{ab}
CD (P=0.05)	12.88	18.12	12.75

*The data presented are the mean of five replicates. Different letters indicate the significant difference (One way ANOVA) P<0.05 Tukey's standardized range (HSD) test. Figures in parentheses are standard error of mean (SEM).

adult emergence (70.5%) on *H. armigera* followed by *M. separata*, *S. exigua* and *A. janata*. In present findings the preference of the parasitoid to various hosts was in the order *H. armigera* >*S. litura*>*M. separata*>*A. janata*. To conclude the parasitoid *C. chlorideae* can be mass reared in the laboratory by using 50% honey solution as adult food and for getting maximum progeny of the parasitoid 3-6 day old *H. armigera* caterpillars may be exposed with a host density of 20 caterpillars.

Table 2 Host density dependent parasitism by *C. chlorideae*

Host density	% Parasitism	% Mortality	% Moth emergence
10	16.00 (±1.61)[b]	20.00 (±0.24)[a]	64.00 (±1.61)[a]
20	40.00 (±1.12)[a]	17.00 (±1.47)[a]	43.00 (±2.38)[b]
30	32.67 (±0.84)[a]	16.33 (±0.61)[a]	51.00 (±1.14)[ab]
40	30.00 (±0.87)[ab]	15.50 (±0.30)[a]	54.50 (±1.16)[ab]
50	24.80 (±0.43)[ab]	15.60 (±0.37)[a]	59.60 (±0.64)[ab]
CD (P=0.05)	12.58	8.08	11.99

*The data presented are the mean of five replicates. Different letters indicate the significant difference (One way ANOVA) P<0.05 Tukey's standardized range (HSD) test. Figures in parentheses are standard error of mean (SEM).

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REFERENCES

Ballal C.R., Joshi S., Bhaskaran T.V. and Lakshmi L. (2015) Feasibility of continuous rearing of a potential ichneumonid parasitoid *Campoletis chlorideae* Uchida Journal of Biological Control 29(2): 75-84.

Dubey R.J., Mishra B.B. and Tripathi C.P.M. (2017) Effect of food plants on the functional response of the parasitoids. International Journal of Entomology Research 2(4): 69-74.

Dhillon M.K. and Sharma H.C. (2007) Survival and development of *Campoletis chlorideae* on various insect and crop hosts: implications for Bt-transgenic crops. Journal of Applied Entomology 131(3): 179-185.

Dhillon M.K. and Sharma H.C. (2007) Effect of mating and parasitism regimes on progeny production and sex-ratio of Campoletis chlorideae Uchida. Indian journal of experimental biology 49(10): 786-790.

Eliopoulos P.A. (2007) The importance of food supplements for parasitoids of stored product pests: the case of *Venturia canescens* (Hymenoptera: Ichneumonidae). Integrated Protection of Stored Products 30(2): 37-41.

Gupta R.K., Raj D. and Devi N. (2004) Biological and Impact Assessment Studies on *Campoletis chlorideae* Uchida: A Promising Solitary Larval Endoparasitiod of *Helicoverpa armigera* (Hübner). Journal of Asia-Pacific Entomology 7(2): 239-247.

Han L.B., Huang L.Q. and Wang C.Z. (2013) Host preference and suitability in the endoparasitoid *Campoletis chlorideae* is associated with its ability to suppress host immune responses. Ecological Entomology 38: 173–82.

Khatri D., He X.Z. and Wang Q. (2012) Reproductive fitness of *Diadegma semiclausum* Hellen (Hymenoptera: Ichneumonidae) in response to host density. New Zealand Plant Protection 65: 142-147.

Leong G.K.L. and Oatman E.R. (1968) The biology of *Campoplex haywardi* (Hymenoptera : Ichneumonidae), a primary parasite of the potato tuber worm. Annals of Entomological Society of America 61: 26-36.

Lingren P.D., Guerra R.J., Nickelsen J.W. and White, C. (1970) Hosts and host-age Preference of *Campoletis perdistinctus*. Journal of Economic Entomology 63(2): 518-22.

Lingren P.D. and Nobel L.W. (1972) Preference of *Campoletis perdistinctus* for certain noctuid larvae. Journal of Economic Entomology 65: 104-107.

Nikam P.K. and Basarkar C.D. (1981) Influence of host density on reproductive potential of *Campoletis*

chlorideae (Uchida) (Hymenoptera : Ichneumonidae), an internal parasite of *Heliothis armigera* (Hubn.). Bioresearch 5: 101-4.

Pawar C.S., Bhatnagar V.S. and Jadhav D.R. (1989). *Campoletis chlorideae* Uchida (Hymenoptera: Ichneumonidae) as a parasite of *Helicoverpa armigera* (Hub.) (Lepidoptera: Noctuidae) in southwest India. Proceedings of Animal Sciences 98(4): 259-65.

Romeis J. and Shanower T.G. (1996) Arthropod natural enemies of *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae) in India. Biocontrol Sciences Technology. 6: 481.

Sathe T.V. and Bhosale A.M. (2011) *Plutella xylostella* (L.) density requirement for maximum progeny production of *Diadegma insulare* (Cameron). Asian Journal of Animal Sciences 6(2): 212-214.

Vinson S.B. (1976) Host selection by insect parasitoids. Annual Review of Entomology 21: 109–33.

Vinson S.B. and Iwantsch G.B. (1980). Host suitability for insect parasitoids. Annual Review of Entomology 25: 397-419.

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