https://doi.org/10.33307/entomon.v45i2.520
ENTOMON 45(2): 123-128 (2020)
Article No. ent. 45205

Parasitism potential of *Diadegma argenteopilosa* (Cameron) (Hymenoptera : Ichneumonidae), an internal larval parasitoid of *Spodoptera litura* (Fab.) (Lepidoptera: Noctuidae)

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ABSTRACT: *Diadegma argenteopilosa* (Cameron) (Ichneumonidae: Hymenoptera) is an internal larval parasitoid of *Spodoptera litura* (Fab.) (Noctuidae: Lepidoptera), a notorious and polyphagus pest of pulses and vegetables in India. Attempt has been made to initiate their mass multiplication for successful biocontrol programme. Behavioral studies, food stuffs, host selection aspects plays a crucial role in mass multiplication of biocontrol agents. Therefore, present work was conducted to study the optimum host age, specificity and host density for maximum progeny production of the parasitoid under laboratory conditions and later their release in the field for the management of pest species. The parasitoid caused highest mortality in the pest larvae of second instars, 4 day old larvae were attacked most with high percent parasitism, 39.00%. Optimum density for maximum progeny production of *D. argenteopilosa* was 20, which generate maximum parasitism (43.00%). Host specificity by exposing the parasitoids towards different host species and analyse parasitoid preference by *S. litura* > *Helicoverpa armigera* (Hubner) > *Mythimna separata* Walker > *Achaea janata* (Linnaeus). Nutritional requirement of parasitoid was tested with different foodstuffs and found 50% honey best suited for maximum longevity 8.2 and 11.4 days for males and females respectively. The longevity ratio also female biased, 1: 1.39 (Male: Female). From the results it concludes that *D. argenteopilosa* fed with 50% honey solution, exposed to 3-5 day old caterpillars of *S. litura* at density of 20 gave maximum progeny production and effectively utilized in the biocontrol programme.

KEY WORDS: Parasitoid, potential, biocontrol, pest management.

INTRODUCTION

Biological pest management is a complementary approach in devising a robust pest management strategy. Development in pest management strategies improves the status of farmer community. Farmers are facing problem of pests and diseases of crop plants. Long ago the pests and diseases could be controlled with environmental factors but then it shifted to era of chemical control. Due to pesticidal residue, pest resistance, pest resurgence, cost of sprays, lack of labor, secondary pest outbreak and phytotoxicity of pesticides the farmers now deliberately moved towards biological control of agricultural pests. Biological control of different pests with biocontrol agents enhance the crop yield and also improve the quality of produce. The above fact clearly indicates that there is extreme need of

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minimizing pesticidal use. Therefore, attempts have been made with the use of biocontrol agents for effective control of agricultural pests as ecofriendly control measure.

Armyworm *Spodoptera litura* (Fab.) (Noctuidae: Lepidoptera) is a polyphagous pest of agricultural crops in India. Several management practices were implemented to achieve the control of the pest, *viz.* biological, chemical, mechanical, cultural etc. Among biocontrol agents *Diadegma argenteopilosa* (Cameron) (Ichneumonidae: Hymenoptera) is most common and potent internal larval parasitoid. Host searching and selection of host density by parasitoid counts the success of biocontrol programme for any pest species (Bhosale, 2018). The high percent of parasitism is desirable character of an ideal parasitoid. In mass production and colonization of parasitoids in biocontrol strategies *viz.* shape, size, nutritional suitability and host age plays very important role (Vinson, 1976; Vinson and Iwantsch, 1980).

Leong and Oatman (1968), Lewis and Vinson (1971), Lingren and Nobel (1972), Romeis and Shanower (1996), King (1998), Wackers (2001), Eliopoulos (2007), Dhillon and Sharma (2007), Sathe and Bhosale (2011), Khatri *et al.* (2012), Sathe *et al.* (2012), Han *et al.* (2013), Bhosale and Bhosale (2019) made investigations on optimum age, density and specificity of hosts and nutritional requirement of ichneumon parasitoids. The present study was carried with *D. argenteopilosa*, an internal larval parasitoid of *S. litura* to find out the optimum age of host for obtaining maximum progeny of parasitoids, which will help in mass rearing and field release for effective biocontrol program.

MATERIALS AND METHODS

Rearing of host species

S. litura larvae were reared in small perforated plastic container (7x8 cm, Diameter x Height). After adult emergence they may transferred in oviposition cage 25x25x25 cm (LxWxH). First instar caterpillars usually hatch after 2 days from oviposition. These larvae were collected and further used for experiment. During the course of study, the host caterpillars were fed with castor (*Ricinus communis* L.) leaves. Similarly, the other host species used to conduct the host specificity experiment were reared their natural food like, *Helicoverpa armigera* (Hubner) on gram and *Achaea janata* (Linn.) on castor leaves and *Mythimna separata* Walker on leaves of maize *Zea mays* L.

Rearing of parasitoid

Adults of *D. argenteopilosa* were reared in ventilated wooden cage (30x30x30 cm, LxWxH). *D. argenteopilosa* are very minute and are negatively geotropic, hence cages must be made with glass walls on three sides and top of the cage while one wall was made up of very fine mesh cloth for proper handling of parasitoids. The adults of *D. argenteopilosa* were fed with 50% honey solution. Adults of parasitoids released for oviposition in the rearing cages for 24 h with different age and densities of *S. litura* caterpillars. After 24 h, adults were removed and hosts reared for further analysis. The cocoons of parasitoids then transfer into separate container and adults of *D. argenteopilosa* emerges out that can be used for experimental purpose.

Nutritional requirements and adult longevity of parasitoid on different foodstuffs

Emerged adults of *D. argenteopilosa* are fed with different foodstuffs to analyze the ideal feed for getting highest longevity. Honey acts as natural food for any parasitoid, hence three concentrations of 100, 50 and 10 percent were made to analyze the longevity of parasitoid. However, 50 percent glucose and sucrose; and juice of citrus and apple can also provide as a food for study.

Effect of host age on parasitism

To determine the effect of host age on parasitism, 20 larvae of *S. litura* of known age (ranging from less than 1 day to 13 days old) were exposed to single mated female of *D. argenteopilosa* 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.

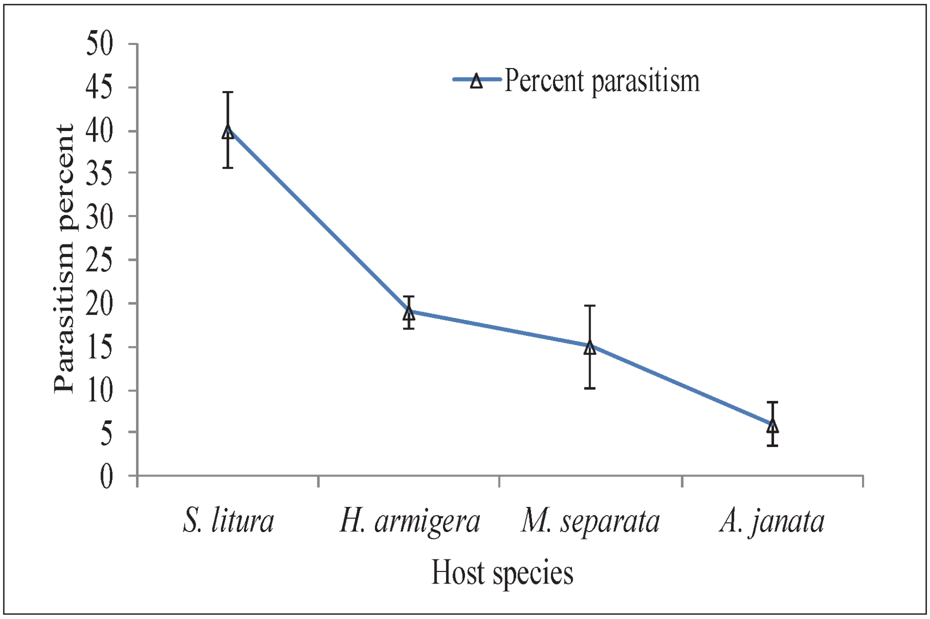

Fig. 1 Host specificity of *D. argenteopilosa*

*Each value is the mean of five replicates with error bars indicating standard error of mean (SEM).

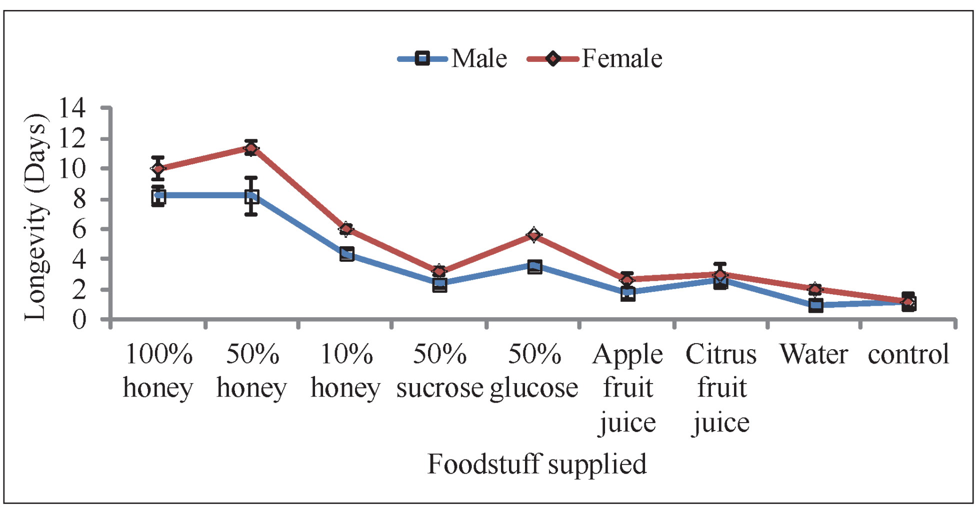

Fig. 2 Adult longevity of *D. argenteopilosa* with different foodstuffs

*Each value is the mean of five replicates with error bars indicating standard error of mean (SEM).

Host density for optimum parasitization

S. litura caterpillars (4-5 day old) were exposed in densities of 10, 20, 30, and 40 towards mated females of *D. argenteopilosa* for 24 hrs in oviposition cage 25x25x25 cm (LxWxH). 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 *S. litura*, *H. armigera*, *M. separata* and *A. janata*. The hosts were placed in the oviposition cage for 24 h. Hosts were released in 20 densities 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 experiments were carried out at 25±2°C, 60±5% RH and 12hr photoperiod. During the course, castor leaves were provided as a food to the caterpillars of *S. litura* and other appropriate food for other experimented host species, while the parasitoids were fed with 50% honey solution. Each experiment was repeated 5 times for confirming the result. The statistical analysis was made by one way ANOVA using the statistical software package SAS 9.3(32) English. The percent values were transformed to arcsine values before analysis.

RESULTS AND DISCUSSION

D. argenteopilosa was most effective in controlling the caterpillars of *S. litura* than other biocontrol agents associated with particular pest. The results of host specificity experiment (Fig. 1) revealed that the parasitoid prefer *S. litura* as the primary host with 42.00% parasitism. Among tested hosts, parasitoid showed 19.00 percent parasitism for *H. armigera*, 15.00 percent parasitism for *M. separata* and 6.00 percent parasitism for *A. janata*. The order of preference for parasitism shown by the parasitoid was *S. litura*> *H. armigera* > *M. separata* > *A. janata*. Adult longevity of *D. argenteopilosa* with different foodstuff were analyzed and plotted (Fig. 2.) Parasitoid survived longer with 50% honey solution with maximum male: female longevity ratio (1: 1.39). 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 parasitoid caused highest mortality in the second instar caterpillars (Table 1). The caterpillars of 3-6 days old are preferred for parasitism whereas, beyond 12 days old were not attacked by the parasitoid. Four day old caterpillars were attacked most with high percent parasitism (39.00%).

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 43.00 percent parasitism,

Table 1. Host age related parasitism by *D. argenteopilosa*

Host age (days)	% Parasitism	% Mortality	% Moth emergence
1	4.00 (±2.20)[ef]	7.00 (±3.70)[a]	89.00 (±2.50)[ab]
2	10.00 (±3.70)[de]	8.00 (±1.20)[a]	82.00 (±3.70)[abcd]
3	23.00 (±3.70)[abc]	8.00 (±1.00)[a]	69.00 (±3.00)[de]
4	39.00 (±2.50)[a]	9.00 (±2.90)[a]	52.00 (±1.90)[e]
5	28.00 (±3.70)[ab]	5.00 (±2.50)[a]	67.00 (±4.60)[de]
6	23.00 (±3.40)[abcd]	9.00 (±1.20)[a]	68.00 (±2.70)[cde]
7	13.00 (±0.00)[bcd]	11.00 (±5.10)[a]	76.00 (±5.10)[bcd]
8	11.00 (±1.90)[cde]	8.00 (±3.40)[a]	81.00 (±1.90)[abcd]
9	10.00 (±1.90)[cde]	9.00 (±3.30)[a]	81.00 (±4.60)[abcd]
10	3.00 (±1.20)[ef]	10.00 (±3.30)[a]	87.00 (±2.40)[a]
11	3.00 (±2.00)[ef]	7.00 (±2.70)[a]	90.00 (±2.50)[abc]
12	0.00 (±0.00)[f]	11.00 (±4.00)[a]	89.00 (±4.00)[a]
13	0.00 (±0.00)[f]	6.00 (±3.40)[a]	94.00 (±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).

Table 2. Host density dependent parasitism by *D. argenteopilosa*

Host density	% parasitism	% Mortality	% Moth emergence
10	29.00 (±1.61)[b]	31.00 (±0.24)[a]	40.00 (±1.61)[a]
20	43.00 (±1.12)[a]	18.00 (±1.47)[a]	39.00 (±2.38)[b]
30	35.67 (±0.84)[a]	15.33 (±0.61)[a]	49.00 (±1.14)[ab]
40	27.80 (±0.87)[ab]	14.60 (±0.30)[a]	57.60 (±1.16)[ab]
50	22.00 (±0.43)[ab]	15.50 (±0.37)[a]	62.50 (±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).

compared to those produced from other host densities 10, 30 and 40 with 29.00, 35.67, 27.80 and 22.00 mean percentage of parasitism (Table 2).

Bhosale and Bhosale (2019) reported the host density 20 of *Plutella xylostella* (L.) (Plutellidae: Lepidoptera) for obtaining maximum progeny production (41.00%) of the parasitoid *Diadegma insulare* (Cameron). Likely, Sathe and Bhosale (2011) reported the host density 100 for obtaining maximum progeny production (38.50%) of the parasitoid *D. insulare*. Similarly, Cardona and Oatman (1971), reported 90 host density of *Keiferia lycopersicella* (Walsinghum) as optimum number for maximum parasitism by *Pseudapanteles* (=*Apanteles*) *dignus* Muesebeck. In *P. diguns*, they reported the percentage of parasitization increased with the increase in number of hosts (30, 60 and 90) up to host density 90 per replicate. A decrease in parasitization observed in all replicates when 120 larvae were offered. In present study percent parasitism was found decreasing beyond 20 host density that suggesting the suitability of the larval number. In present findings the parasitoid preferred *S. litura* later *H. armigera*, *M. separata* and then *A. janata*. Similarly, Pawar *et al.* (1989), studied the parasitism of *C. chlorideae* on *H. armigera*, they found average percentage parasitism of first to third instar larvae, which are only parasitised by parasitoid, parasitism found on associated crop 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) stated the host age preference of *C. chlorideae* towards four lepidopterous host species *Prodenia ridinia* (Craner), *Prodenia praefica* Grote, *Trichopulsia ni* (Hubner) and *Pseudoletia unipuncta* (Hawarth). They reported that caterpillars 1-8 day old of all hosts were susceptible for parasitism, 2-6 day old being most acceptable. In present findings 2-9 day old caterpillars of *H. armigera* were susceptible, 3-7 day old caterpillars readily accepted and 4-5 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. In present findings 20 host density shows maximum parasitism (43.00%). Eliopoulos (2007), studied the importance of food supplements for *Venturia canescens* ichneumon parasitoid of stored product pests and found honey is the best supplement for *in-vitro* parasitoid rearing.

D. argenteopilosa has been successfully initiating the biocontrol program for managing the *S. litura*. Parasitoid can be mass reared in laboratory scale on 50% honey solution. For getting maximum progeny of parasitoid exposed towards second instar *S. litura* caterpillars with 20 host density. The mass rearing of parasitoid *D. argenteopilosa* may initiate the biocontrol programme for *S. litura*.

ACKNOWLEDGEMENTS

Author is thankful to Coordinator, Department of Agrochemicals and Pest Management, Shivaji University, Kolhapur (Maharashtra) for providing necessary facilities and Golden Jubilee Research Fellowship, Shivaji University, Kolhapur (Maharashtra) for providing financial assistance to research project.

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(Received October 14, 2019; revised ms accepted April 09, 2020; printed June 30, 2020)