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Influence of weather factors on the extent of parasitization of *Campoletis chlorideae*, larval parasitoid of *Helicoverpa armigera*

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Abstract
The field experiments were carried out to study the influence of weather factors on the extent of Parasitization of *Campoletis chlorideae*, larval parasitoid of *Helicoverpa armigera.* Parasitization of *H. armigera* larvae by *C. chlorideae* was first observed during 1st SW (01-01-14 to 07-01-14) and it remained active upto 11th SW (12-03-14 to 18-03-14).
Parasitisation (15%) was recorded during 3rd SW (15-01-14 to 21-01-14), 5th SW (29-01-14 to 04-02-14) and 8th SW (19-02-14 to 25-02-14). Minimum parasitisation (05%) was recorded during 1st SW (01-01-14 to 07-01-14) and 11th SW (12-03-14 to 18-03-14). Maximum parasitisation (20%) was recorded during 4th SW (22-01-14 to 28-01-14), 7th SW (12-02-14 to 18-02-14) and 9th SW (26-02-14 to 04-03-14). During these period, maximum and minimum temperature and morning and evening relative humidity ranged from 22.3 to 24.8 ^{0}C, 9.5 to 14.3 ^{0}C, 88 to 91% and 41 to 61%, respectively.

Keywords: *H. armigera*, *Campoletis chlorideae*, Larval parasitoid, Parasitization

Introduction
Campoletis chlorideae is an important early larval endoparasitoid of many noctuid species, and has been widely reported as a potential biological control agent for *H. armigera* in China, Korea, and India in chickpea cropping system [1, 2]. *C. chlorideae* oviposits in early instars of *H. armigera* larvae but prefers second and third instar and pupates outside the host in the form of a cocoon [3]. The average rate of parasitism by *C. chlorideae* on early instars of *H. armigera* larvae were 23.7% [4].
H. armigera is a polyphagus pest and the ability of the pest to thrive on diverse host plants is an adaptive advantage for its better survival in the ecosystem [5] which is achieved by its high mobility, fecundity and capacity to develop resistance to a wide spectrum of chemical insecticides [6]. Hence, Biological control is recognized as one of the best alternatives for controlling insect pests. Insect predators and parasitoids are the most important naturally occurring biological control agents of insect and mite pests in most of the crop ecosystems [7]. The development of resistance to chemical pesticides and negative impact of pesticides on the environment has prompted several researchers to evaluate alternative methods for the control of important agricultural pests. Keeping in mind the above facts this paper describes the field observations on the parasite and its role in the natural control of *H. armigera*.

Materials and Methods
Field experiment was conducted at the experimental field of Dept. of Entomology, Adhartal, JNKVV, Jabalpur during *Rabi* 2013-14, under randomized block design. Chickpea variety JG-12 was sown on 14th November, 2013 in a plot size of 10 x 9.9 m with a spacing of 30x10cm and having 33 number of rows. Other agronomic practices were followed as per local recommendation.
Observations on natural enemy, *Campoletis chlorideae* were recorded by collecting 10 young (2nd to 3rd instar) larvae once in a standard week which were reared in the laboratory. The number of larvae parasitized and larval parasitoid emerged were recorded and percent parasitization of *Helicoverpa armigera* larvae were calculated [19]. Observations were continued till the availability of the *H. armigera* larva or mortality of the crop, whichever was earlier. At the same time a corresponding weekly record of meteorological data viz. minimum and maximum temperature, morning and evening relative humidity, total rainfall and number

of rainy days per week, wind speed, sunshine, morning and evening vapour pressure and evaporation were maintained. The influence of different meteorological parameters on immature stages of gram pod borer was studied by graphical super imposition technique.

Statistical Analysis

All the data was subjected to statistical analysis after appropriate transformation as suggested by [8].

Results and Discussion

Perusal of the data (Table 1) revealed that the parasitization of *H. armigera* larvae by larval parasite, *Campoletis chloridae* was first recorded (5%) during 1st SW (01-01-14 to 07-01-14) and was recorded upto 11th SW (12-03-14 to 18-03-14) [9, 10]. The parasitization attained its first peak (20%) during 4th SW (22-01-14 to 28-01-14) [11, 12]. During this period (4th SW) the maximum and minimum temperature, morning and evening relative humidity, wind speed, sunshine, morning and evening vapour pressure and evaporation were 22.3 ^{0}C, 10.6 ^{0}C, 91%, 61%, 3.8km/hr, 6.6hr, 10.7mm, 12.2mm, and 1.90mm, respectively. There was no rainfall received during this week. However, the maximum and minimum temperature, morning and evening relative humidity, wind speed, sunshine, morning and evening vapour pressure and evaporation of preceding week (3rd SW) were 22.2 ^{0}C, 12.3 ^{0}C, 95%, 68%, 4.4km/hr, 4.2hr, 11.8mm, 13.6mm and 1.70mm, respectively. There was 6.8mm rainfall during this week, which occurred in one day.

Second peak of parasitization was attained (20%) during 7th SW (12-02-14 to 18-02-14) [13, 14] when maximum and minimum temperature, morning and evening relative humidity, wind speed, sunshine, morning and evening vapour pressure and evaporation were 23.9 ^{0}C, 9.5 ^{0}C, 88%, 41%, 3.8km/hr, 7.7hr, 9.4mm, 8.0mm and 2.90, respectively. There was 12.0mm rainfall received during this week, which occurred in two days.

Third peak of parasitization was attained (20%) during 9th SW (26-02-14 to 04-03-14) [15-17] when maximum and minimum temperature, morning and evening relative humidity, wind speed, sunshine, morning and evening vapour pressure and evaporation were 24.8 ^{0}C, 14.3 ^{0}C, 91%, 60%, 4.6km/hr, 7.1hr, 13.3mm, 14.2mm and 2.40mm, respectively. There was 58.2mm rainfall received during this week, which occurred in four days.

Correlation studies

Same week

Correlation computed with parasitization and weather data of the same week revealed that morning and evening relative humidity, rainfall, number of rainy days and wind speed exhibited positive correlation (r=0.34, 0.17, 0.45, 0.48 and 0.54, respectively) with parasitization by *C. chloridae*, but statistically found to be non-significant (Table 2).

Further, maximum and minimum temperature, sunshine, morning and evening vapour pressure and evaporation showed negative correlation (r= -0.49, -0.05, -0.05, -0.28, -0.19 and -0.05, respectively) with parasitization by *C. chloridae*, but statistically found to be non-significant (Table 2).

Preceding week

Correlation computed with parasitization of one week and abiotic factors of the preceding week revealed that minimum temperature morning and evening relative humidity, sunshine, rainfall, number of rainy days, wind speed and evening vapour pressure exhibited positive correlation (r=0.01, 0.57, 0.34, 0.12, 0.01, 0.09, 0.30 and 0.25, respectively) with parasitization by *C. chloridae*, but statistically found to be non-significant (Table 2).

Further, maximum temperature, morning vapour pressure and evaporation showed negative correlation (r= -0.06, -0.03 and -0.07, respectively) with parasitization by *C. chloridae*, but statistically found to be non-significant (Table 2).

Several workers have reported similar findings that, the maximum parasitization of 20% was recorded during 4th SW (22-01-14 to 28-01-14), 7th SW (12-02-14 to 18-02-14) and 9th SW (26-02-14 to 04-03-14) and the extent of parasitization ranged from 5 to 20%. The active period of the parasite was from January to mid March. The present findings are in conformity with the findings of [18, 2].

Table 1: Extent of parasitization of *Helicoverpa armigera* larvae by *Campoletis chlorideae* on chickpea at Jabalpur during *rabi* 2013-2014.

Dates		Standard Week	Parasitization by *C. chlorideae* (%)
From	To		
01/01/14	07/01/14	1	05
08/01/14	14/01/14	2	10
15/01/14	21/01/14	3	15
22/01/14	28/01/14	4	20
29/01/14	04/02/14	5	15
05/02/14	11/02/14	6	10
12/02/14	18/02/14	7	20
19/02/14	25/02/14	8	15
26/02/14	04/03/14	9	20
05/03/14	11/03/14	10	10
12/03/14	18/03/14	11	05

Table 2: Correlation co-efficient (r) between abiotic factors and parasitization of *Helicoverpa armigera* larvae by *C. chlorideae*.

Weather factors	Correlation coefficient (r)	
Max. Temp. (^{0}C)	-0.49 NS	-0.06 NS
Min. Temp. (^{0}C)	-0.05 NS	0.01 NS
Morning RH (%)	0.34 NS	0.57 NS
Evening RH (%)	0.17 NS	0.34 NS
Sunshine (hrs)	-0.05 NS	0.12 NS
Rainfall (mm)	0.45 NS	0.01 NS
No. of rainy days	0.48 NS	0.09 NS
Wind speed (km/hr)	0.54 NS	0.30 NS
Morning vapour pressure (mm)	-0.28 NS	-0.03 NS
Evening vapour pressure (mm)	-0.19 NS	0.25 NS
Evaporation (mm)	-0.05 NS	-0.07 NS

NS- Non significant

Conclusion

The active period of the parasite was from January to mid March. Maximum 20% population of *H.armigera* we can control by using *Campoletis chlorideae*, larval parasitoid of Helicoverpa armigera.

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