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EFFECT OF HOST'S *HELICOVERPA ARMIGERA* (HUBNER) LARVAL AGE ON THE LIFE TABLE OF THE PARASITOID *COMPOLETIS CHLORIDEAE* UCHIDA (HYMENOPTERA: ICHNEUMONIDAE)

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ABSTRACT: The longevity, fecundity, oviposition frequency, developmental period and progeny sex ratio of the parasitoid *Campoletis chlorideae* were significantly altered by host's *Helicoverpa armigera* larval age. The best longevity of parasitoid and off spring proportion is maximumin2ndinstar. The range of survival of the parasitoid and longevity is 6-10 days. The oviposition was maximum on first day followed by a marked linear decrease in the successive days of her life span. The total developmental period is lowest in 2nd instar larvae. When *Campoletis* oviposited into in 2nd larvae they grow most rapidly. The sex ratio of off springs in F1 generation is also age dependent. The first to third days female dominates over the male and th and 5th days almost equal. .The female parasitoid completes her life cycle in 16 to 18 days.

KEYWORDS: Life Table, Longevity, Fecundity, Sex ratio, Developmental period, *Helicoverpa armigera, Compoletis Chlorideae.*

INTRODUCTION

The gram posd borer *Helicoverpa armigera* (Hubner) is an important pest of chickpea and causes considerable damage to this crop[1,2], it is active on the crop right from germination till the crop is harvested. During the vegetative stage of the crop, the pest incidence is low and the crop recovers, but during the pod formation stage, the pest attack resuts in considerable yield loss. The parasitoid *Compoletis chloride* is an effective bio-control agent against *H. armigera* and parasitises the moth's larval stage[3]. The parasitoid *C. chlorideae* helps in suppressing the pest population on chickpea.

For a successful biological control of insect pests their parasitoid are required in large number[5,6]. The possibility of mass production of natural enemies is hampered by gradual decrease in vigour[7,8] and after several successive generations the culture must be renewed with parasitoid in nature. Among effective control measures, the use of chemicals against insect pests are available[9,10] yet owing to its rapid multiplication[6,11] the release of natural enemies is very essential, but the knowledge of longevity, fecundity and oviposition frequency, developmental period and progeny sex ratio of the parasitoid is also very important prior to release purposes[12].

The objective of our research is to gain relevant information about the effect of host's larvalage on the longevity, fecundity and oviposition frequency, developmental period and progeny sex ratio of the parasitoid *C. chlorideae*. This information will be useful in the mass production of *C. chlorideae* for inoculative orinnundative release to control *H. armigera* in the field.

MATERIALS AND METHODS

The parasitoid, *C. chlorideae* and its host, *H. armigera* were reared on *Cicer arietinum* Linn in the laboratory at 22±4^{0}C, 70±10% RH and 10h light; 14h dark phtoperiod (Kumar *et al.,*[13]. The first instarslarvae to 4th instars larvae of the host were drawn from the maintained culture and were utilised as hosts. One day old, mated female parasitoid, satiated with a 30% honey solution, and experienced T'Hart *et al.,*[14] were used in the experiments.

To study the longevity, fecundity and oviposition frequency, developmental period and progeny sex ratio of the parasitoid *C. chlorideae,* 4 healthy potted *C. arietinum* (chickpea) plants were arranged and marked as A, B, C and D. 100 healthy larvae of the each instars (Ist insars to IVth instars) were transferred separately from culture to each potted plant. These potted plants were covered by open mouthed bell jars (Ca 20 cm diameter x 30 cm height) and a small piece of sponge socked in a 30% honey solution was hanged inside it (Plate 1) 4 females parasitoid were introduced separately in the above bell jars for 24 hrs. The opening of the bell jars were closed with muslin cloth and tightened with rubber bands. At the end of every 24 hrs the potted host plants were replaced by fresh ones having 100 healthy larvae of each host larval stage throughout the life span of the parasitoid.

Aplotted host plant *Cicer arietinum* Linn having larvae of *Helicoverpa armigera* covered with Bell Jar

The food was changed daily till the commencement of the experiment the potted plants were arranged serially day wise in the insectaries (Ca 120 x 40 x 110 cm) Abidi *et al.,*[6] for the further development and were examined daily. The cocoons when formed were carefully transferred singly in to marked sterilized glass vials (Ca 2 x 1.25 cm) with leaves of host plant (Chickpea) to provide moisture to the opening eggs[13,15] until emergence. The mouth of the glass vials were kept plugged with absorbent cotton. The experiment was replicated 5 times with new female parasitoid and 100 healthy larvae of the each hosts larval age. Because of chance of super parasitisation[16] or and larval mortality[17], the resulting number of parasitoid express the value of fecundity[6,18]. After enclosing the parasitoid were counted, sexed and analyzed statistically. The progeny sex ratio was calculated as number of sons out of total emergent's. The cocoons which did not yield a parasitoid were not considered[19].

RESULTS AND DISCUSSION

The longevity, fecundity and oviposition frequency developmental period and offspring sex ratio are the important qualities influencing the parasitoid behaviour. The host's age significantly affect the longevity, fecundity & oviposition frequency, developmental period and progeny sex ratio of the endolarval parasitoid *C. chlorideae.* The female parasitoid prefers young larvae and generally oviposition in 2nd and 3rd instar larvae was maximum than Ist and 4th instar larvae. Due to the 2nd instar larvae was most preferred by parasitoid *C. chlorideae*[13,19].

The female parasitoid when comes near the host, is attracted towards it. This attraction of the parasitoid to the host is mainly due to colour of the host[20,21]. The host selection process of the parasitoid primarily mediated through chemical stimuli[22]. The semio chemicals that mediate interspecific interactions particularly between hosts and parasitoid are known as kairomones. The kairomones stimulate the host seeking response of the parasitoid, thus play a significant role in host location and host acceptance by the parasitoid. Kairomones affect the fecundity, longevity and rate of parasitisation of the parasitoid[23].

The parasitoid *C. chlorideae* preferred 2nd instar larvae of the host *H. armigera* because this stage, in addition to having more food than first instar and better quality of food resources than 3rd instar for supporting the development of the parasitoid, emanates more host seeking stimulant. The large size of the host, kairomones, hardness of the host cuticle and defence mechanism of 3rd and 4th instar larvae was play an important role in the host – stage preference by the parasitoid.

Longevity

The longevity of the parasitoid is maximum in 2nd instar larval age (mean value = 8.8+1.720, range 7-10 days) followed by 3rd instar (mean value = 8.2+1.469, range 7-10 days), Ist instar (mean value = 7.8+2.227, range 6-10 days) and 4th instar (mean value = 7.4+1.496, range 6-10 days) (Fig.1, Table 1) of the host *H. armigera.*

Like other parasitoid under similar ecophysical conditions[24], *C. chlorideae* also survived for 10 days. The longevity of the parasitoid is maximum in the 2nd instar (8.8±1.720, Range 7 – 10 days) due to its better quality and amount of food resources available in this stage, followed by 3rd instar (8.2±1.469, Range 7 – 10 days), Ist instar (7.8±2.227, Range 6 – 10 days) and 4th larval age (7.4±1.496, Range 6 – 10 days) of the lost.

Fecundity & oviposition frequency

The host age affected fecundity of the progeny of *C. chlorideae*. Table 2 and Fig. 2 shows the fecundity & oviposition frequency of the parasitoid *C. chlorideae* on the difference host's larval age.

Table 1. Longevity (in days) of parasitoid *Campoletis chlorideae* on the different larval age of the host *Helicoverpa armigera.* Each entry is the mean of 5 replicates. (mean ± SD)

Host Age	Longevity (in days)	Range (in days)
I instar	7.8 ± 2.227	6-10 days
II instar	8.8 ± 1.720	7-10 days
III instar	8.2 ± 1.469	7-10 days
IV instar	7.4 ± 1.496	6-10 days

Table 2. Total fecundity and oviposition frequency of female *Campoletis chlorideae* put with 100 hosts of different larval age of *Helicoverpa armigera*. Each entry is the mean of 5 replicates (means±SD)

Oviposition in successive days	Number of offspring emerged			
	1st instar	2nd instar	3rd instar	4th instar
1	35.8±2.786	42.0±2.549	39.0±2.280	31.0±3.464
2	28.6±2.728	33.8±2.713	31.0±3.464	22.8±2.925
3	20.2±2.713	25.0±4.243	22.8±2.925	13.2±1.720
4	12.2±1.720	18.0±2.828	15.2±3.429	7.4±1.624
5	8.0±1.414	12.6±2.728	10.0±2.0	4.8±1.720
6	5.8±1.327	9.0±2.280	7.2±2.315	3.6±1.356
7	3.2±1.166	4.2±1.166	3.8±1.166	2.8±1.720
8	2.8±0.748	4.0±1.414	2.8±0.748	2.2±1.327
9	2.2±1.327	2.8±1.720	2.2±1.327	1.6±1.019
10	1.6±1.019	2.2±1.166	1.6±1.019	1.0±0.632
Total	**120.4**	**153.6**	**135.6**	**90.4**
Regression – y = a+bx				
A	1.803	1.885	1.868	1.698
B	-1.444	-1.367	-1.468	-1.513
R	-0.953	-0.934	-0.939	-0.971
P	0.001	0.001	0.001	0.001

Table 3. Developmental period (in days) of parasitoid *Campoletis chlorideae* on the different larval age of the host *Helicoverpa armigera.* Each entry is the mean of 5 replicates (means±SD)

Stage of development	1st instar	2nd instar	3rd instar	4th instar
From oviposition to cocoon formation	8.8±1.16	7.6±1.02	8.0±1.41	9.2±1.16
From cocoon formation to emergence	7.0±1.41	5.8±0.75	6.4±1.20	7.4±1.02
Total developmental period (from oviposition to emergence)	15.8±2.48	13.4±1.01	14.4±2.05	16.6±1.35

Table 4. Sex ratio (number of sons/number of total progeny) of the parasitoid *Campoletis chlorideae* put with 100 hosts of different larval age of *Helicoverpa armigera*. Each entry is the mean of 5 replicates (means±SD).

Oviposition in successive days	Sex ratio of the parasitoid			
	1st instar	2nd instar	3rd instar	4th instar
1	0.278±0.019	0.242±0.018	0.265±0.032	0.295±0.025
2	0.332±0.034	0.305±0.031	0.320±0.033	0.341±0.017
3	0.396±0.045	0.358±0.023	0.385±0.015	0.407±0.041
4	0.495±0.030	0.476±0.029	0.488±0.031	0.520±0.060
5	0.550±0.042	0.545±0.033	0.549±0.024	0.584±0.092
6	0.629±0.038	0.613±0.066	0.626±0.065	0.667±0.107
7	0.687±0.047	0.677±0.180	0.684±0.107	0.714±0.119
8	0.714±0.119	0.710±0.119	0.714±0.119	0.727±0.367
9	0.727±0.367	0.714±0.119	0.727±0.367	0.750±0.389
10	0.750±0.389	0.727±0.367	0.750±0.389	0.800±0.472
Regression – y = a+b log x				
A	0.207	0.171	0.192	0.217
B	0.530	0.557	0.546	0.553
R	0.973	0.972	0.973	0.971
P	0.001	0.001	0.001	0.001

The value of fecundity was calculated by counting the total number of emergents from Ist to last day of her life span. As the successive day of oviposition increases the number of emerging offsring decreases significantly in all the larval instars of the host *H. armigera.* The total number of emerging offspring was maximum in 2nd instar (y = 1.885-1.367 x, r = -0.934,P< 0.001, mean value = 153.6) followed by 3rd instar (y = 1.868-1.468 x, r = 0.939, P < 0.001, mean value = 135.6), Ist instar (y = 1.803 – 1.444 x, r = -0.953, P < 0.001, mean value = 120.4) and 4th instar (y = 1.698-1.513, r=-0.971, P < 0.001, mean value = 90.4) of the host. The oviposition was maximum in Ist day followed by a significant linear decrease. In first day of oviposition, in the 2nd instar larvae (42.0±2.549) followed by 3rd instar larvae (39.0±2.280),Ist instar larvae (35.8 ±2.786) and 4th instar larvae (31.0±3.469) of the host (Table 2, Fig. 2).

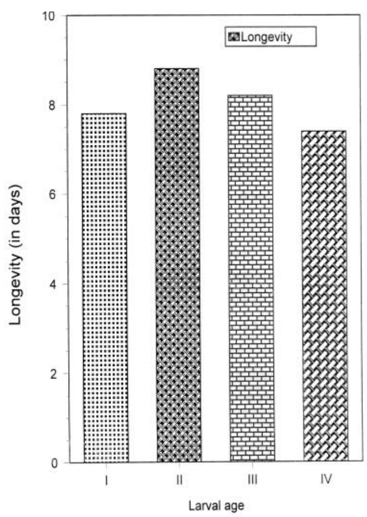

Fig 1. Longevity (In days) of *Campoletis chlorideae* on the different larval age of the host *Helicoverpa armigera.*

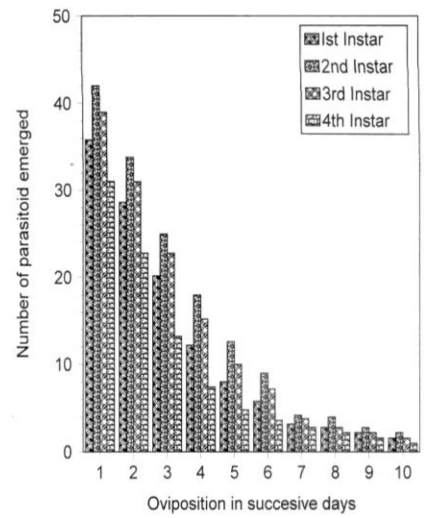

Fig 2. Total fecundity and oviposition frequency of female *Campoletis chlorideae* put with 100 hosts of different larval age of *Helicoverpa armigera.*

The females are more productive from Ist to 6th day after emergence resulting into 140.4 energents out of 153.6 in the 2nd instar larvae, followed by 125.2 emergent out of 135.6 in 3rd instar larvae, 110.6 emergent out of 120.4 in Ist instar larvae and 82.8 energents out of 90.4 in the 4th instar larvae of the host. As shown in Table 2 and Fig. 2 the females of *C. chlorideae* oviposit throughout their life. During their last days (7 – 10 days) very less number of emergents were obtained in each larval stage of the host (II instar – 13.2, III instar – 10.4, I instar – 9.8 and 4th instar -7.6) (Table 2).

Since the total number of eggs laid (realized fecundity) or all the eggs present in the ovaries (potential fecundity), either do not develop due to non viability of the eggs or super parasitism as in the former case or all the eggs are not laid as in the latter case, do not provide an adequate proportion of females available in the fourth coming generations for interacting with the hosts. Therefore, emphasis has been given to record either the number of cocoon or emergence as a measure of fecundity[6,18]. Number of emergent's has been considered as a better parameter of fecundity in the present investigation[5,6]. This method furnishes the basic information required to estimate the number of female offspring that each female produces for the next generations under the experimented conditions. The average fecundity (in terms of emergents) of *C. chlorieae* was maximum in 2nd larval instars (153.6) followed by 3rd instar (135.6), Ist instar (120.4) and 4th instar (90.4) of the host. Which is very high in comparision to some parasitoids[25,26] and less fecund than other parasitoid[9]. However it has been reported that the fecundity of the parasitoid depends upon several external and internal factors, viz. host preference[24], host species preference[27], temperature[28,29,30], host size[31], density of the host and parasitoid[32,33], nutrition of the parasitoid during its larval development[34], treatment of insecticides[35], host age[36,37,38] and the co-presence of males along with the females[6].

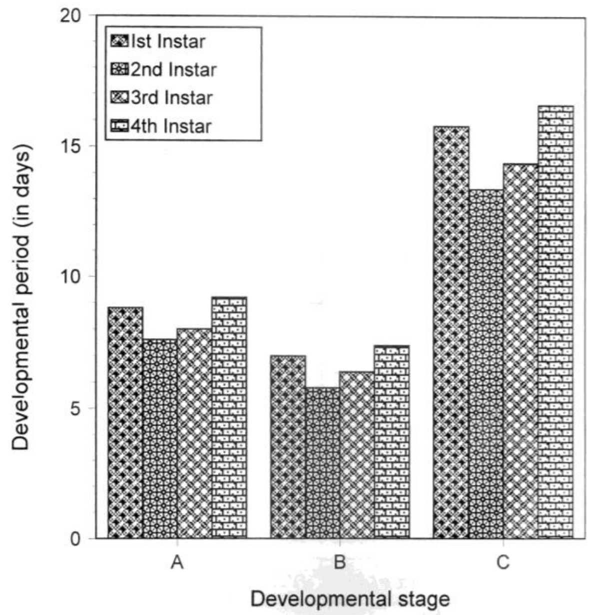

Fig 3. Developmental period (in days) of parasitoid *Campoletis chlorideae* on the different larval age of the host *Helicoverpa armigera*
A= Duration from oviposition to cocoon formation
B= Duration from to cocoon formation to emergence
C=Total development Period

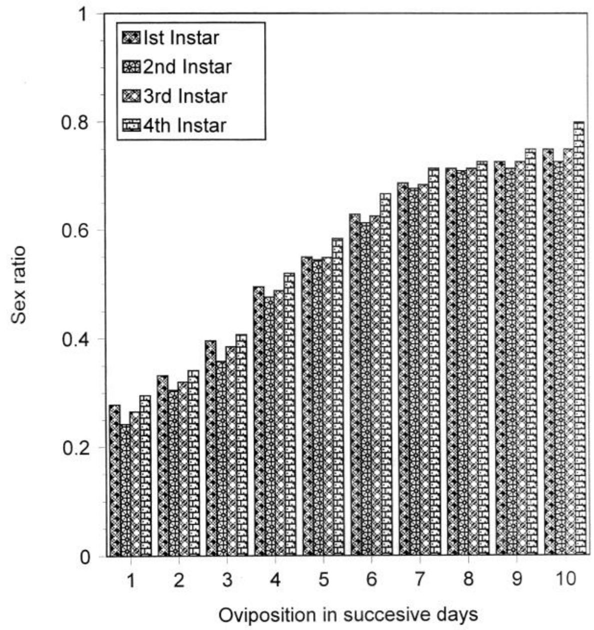

Fig 4. Sex ratio (number of sons/number of total progeny) of the parasitoid *Campoletis chlorideae* put with 100 hosts of different larval age of *Helicoverpa armigera*

Developmental period

The period from oviposition to cocoon formation and from cocoon formation to emergence was considered as total developmental period of the parasitoid. The host age increases the total developmental period increases (Table 3, Fig. 3). The total developmental period was lowest in 2nd larvalage (13.4±1.019) followed by 3rd larval age (14.4±2.059), Ist larval age (15.8±2.482) and 4th larval age (16.6±1.356) of the host (Table 3).

The developmental period of the parasitoid varies from species to species. The host age significantly influence the developmental period of the progeny. The host age increases the total development period (period from oviposition to emergence) was increases and is lowest in 2nd instar and highest in 4th larval instar of the host. The female parasitoid showed exponential increase in volume irrespective of whether *C. chlorideae* parasitized Ist, 2nd, 3rd and 4th instar hosts. When *C. chlorideae* oviposited into 2nd instar larvae they grew most rapidly and when parasitizing 4th instar larvae they grew most slowly due to its more food resources for its development[39]. The developmental period of the parasitoid depends upon photoperiod[40], temperature[41], host species[17] and the treatment of insecticides[9] and host age[42].

Progeny sex ratio

The sex ratio of the offspring of the parasitoid in F_1 generation is age dependent. As the age of the parasitoid increases, the proportion of male offsprings increases significantly in all the larval instar (Table 4, Fig. 4). The Ist to 3rd day's female dominates over the males. The first day proportion of male offspring was minimum followed by a significant linear increase (24.2% in 2nd instar followed by 26.5% in 3rd instar, 27.8% in Ist instar and 29.5% in 4th instar). However, on the whole the first 3 days the proportion of male offspring is lowest in her life span, then on the 4th and 5th days the proportion of male and female offspring was almost equal, after that male dominates over the female till the last day of her oviposition (Table 4).

The sex ratio (no. of male/number of total progeny) was minimum in 2nd instar larvae ($y = 0.171+0.557 \log x$, $r = 0.972$, $P < 0.001$) followed by 3rd instar larvae ($y = 0.192+0.546 \log x$, $r = 0.973$, $P < 0.001$). 1st instar larvae ($y = 0.208+0.530 \log x$, $r = 0.973$, $P < 0.001$) and 4th instar larvae ($y = 0.217+0.354 \log x$, $r = 0.971$, $P < 0.001$) of the host *H. armigera.*

The sex ratio of the offspring of the parasitoid in F1 generation is age dependent. As the age of the parasitoid increases the sex ratio (number of males/number of total progeny) increases significantly. The proportion of female was maximum on first 3 days of her reproductive period, and then it decreases. The females *C. chlorideae* copulate usually soon after emergence[43]. However on the whole the first 3 days the proportion of male offspring is lowest in her life span, then on the 4th and 5th days the proportion of male and female offspring was almost equal, after that male dominates over the female till the last day of her oviposition (Table. 4).

The dominance of male rogeny on the sixth day indicates that sperm supply in the female spermatheca is probably exhausted by then[17] and/or a delay in oviposition when the sperms may have greater difficulty in entering the eggs either because the eggs are losing their regular shape due to resorption[44], or because the eggs might not be as active due to ageing or because the eggs themselves might contain certain sperm attracting material, which may be depleted with age[45]. However, the last two suggestions need experimental evidence to support them. A similar decrease in the parasitoid has been reported by Force & Messenger[46] and Hofsvang & Hagvar[17].

The effect of host age on the progeny sex ratio have found not only for larval parasitoid but also for egg and pupal parasitoid[47]. In addition the sex ratio of the offspring of the parasitoid depends upon a number of factors viz. environmental factor[48], post-copulatory period following insemination[45], host and parasitoid densities[5], variability of the males that inseminates the female[49], host size[50], nutrient sources[51], parental age[52], host plants[53] and the co-presence of the males along with the females[54]. The longevity, fecundity and oviposition frequency, developmental period and progeny sex ratio of the parameters by which the fitness of progeny is generally measured[12]. The results thus demonstrate that host age had a greater effect on the reproductive success of females than on that of males.

The result discussed so for reveal that *C. chlorideae* is an effective bio-control agent against *H. armigera* as the parasitoid has a higher longevity and fecundity with female biased sex ratio. The host age significantly effect the longevity, fecundity and oviposition frequency, developmental period and progeny sex ratio of the parasitoid *C. chlorieae*. The offspring production was greater in 2^{nd} instar than other instars, due to other instars may provide lesser nutrient for offspring development. It is recommended that laboratory data may be used for constructing the life and fecundity table and can also be used to calculate the basic population statistics for *C. chlorideae*.

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