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Research Article

Performance of *Trichogramma chilonis* Ishii on different hosts

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ABSTRACT: The laboratory experiment was conducted during 2017-2018 to study the different biological attributes of *Trichogramma chilonis* Ishii as influenced by host eggs of different ages. Significantly maximum percent egg parasitization was noticed on eggs of *Helicoverpa armigera* (Hübner) with 62.39 percent which was at par with the *Corcyra cephalonica* (Stainton) eggs (60.36 percent). This was followed by *Earias vittella* Fabricius 46.31 percent. Less parasitized eggs were recorded in *Leucinodes orbonalis* Guenée (10.35 percent). Age of host eggs significantly affected the parasitization by *T. chilonis*. The maximum parasitization (58.87 percent) was noticed in fresh eggs i.e. 24 hrs old followed by 48 hrs (44.91 percent) while 72 hrs old eggs were less preferred by *T. chilonis* and could parasitize only 30.56 percent. Development period for parasitoid ranged between 8.66 to 9.44 days on different host eggs. The highest adult parasitoid longevity (7.22 days) was observed from the parasitized eggs of *H. armigera* which was at par with *C. cephalonica* (7.10 days), *E. vittella* (6.88 days) and *L. orbonalis* (6.88 days). However, the different lepidopteran eggs as well as age of host eggs did not show significant differences pertaining to percent adult parasitoid emergence. Fresh host eggs of 24 hrs could produce more female progeny of *T. chilonis* (54.30 percent) compared to 72 hrs old eggs (42.65 percent). The sex ratio (male: female) of emerging parasitoid progeny was observed highest on 24 hrs old eggs (1:1.55) followed by 48 hrs old eggs (1:1.23) while lowest sex ratio was observed on the eggs of 72 hrs old age (1:0.95). The maximum per day fecundity of *T. chilonis* was noticed on the 24 hrs old eggs (6.75) followed by 48 hrs old eggs (4.80). The lowest fecundity (2.05) of *T. chilonis* was observed on the 72 hrs old eggs, whereas the highest male-female ratio and fecundity was noticed on eggs of *E.vittella* among different hosts.

KEY WORDS: *Corcyra cephalonica, Earias vittella,* Host eggs, *Helicoverpa armigera, Leucinodes orbonalis, Trichogramma chilonis*

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INTRODUCTION

The hymenopteran parasitoid, *Trichogramma chilonis* Ishii (Hymenoptera: Trichogrammatidae) is considered as an important biological control agent of insects pests in greenhouse and field crops. It is a very efficient parasitoid and has the ability to give 100 percent parasitism depending upon the availability of favorable conditions. Over 200 insect species are parasitized by various strains of trichogrammatids (Tanwar *et al*., 2006). The *Trichogramma* species can be integrated with the other control measures and mass reared economically and conveniently in the insectaries on factious hosts. Many a times, the natural field population of *Trichogramma* is not sufficient enough to prevent pest population from reaching economic injury level. Hence, they are reared and released in the infested field as biological control agent (Knutson, 2000). The efficiency of *T. chilonis* can be studied in the laboratory by assessing its biological attributes *i.e.* adult longevity, development period, fecundity, emergence, parasitism ability and sex ratio as influenced by different host eggs. Moreover, the study on impact of aging of host eggs on the biological traits of *T. chilonis* may be important for overall efficiency in terms of crop protection.

MATERIAL AND METHODS

The experiment was conducted in Factorial Completely Randomized Design (FCRD) with twelve treatments, two factors and three replications at Biocontrol laboratory, Department of Entomology, Dr. Panjabrao Deshmukh Krishi Vidyapeeth Akola during 2017- 2018 to study the biological attributes of egg parasitoid, *T. chilonis* as influenced by the different hosts and to assess its performance on host eggs of different ages. Larvae of lepidopteran pests *viz; Helicoverpa armigera* (Hübner), *Earias vittella* Fabricius and *Leucinodes orbonalis* Guenée were collected from different host plants and reared under laboratory conditions with a temperature of 27±1°C and relative humidity of 60±5 percent for obtaining eggs for the purpose of experimentation. The laboratory culture of *Corcyra cephalonica* (Stainton) was obtained from the Biocontrol Laboratory, Department of Entomology, Akola. Eggs obtained were separated out in different groups

i.e., 24, 48, 72 hrs old eggs, respectively for three replications *i.e.*, 30 eggs per replication. Similarly, other groups were made as per the need of the treatments. The desired sized empty cards were smeared with gum and 30 host eggs were stuck on each card. These cards were then kept into glass tube (15×2.5cm). These host eggs were exposed to two gravid females of *T. chilonis.* The following observations were recorded.

Number of eggs parasitized

In laboratory condition out of 30 eggs exposed for parasitization, parasitized eggs were recorded by counting the blackened eggs (Singh *et al*., 1998). The data recorded was converted into percentage and percent egg parasitization was calculated.

Development period for parasitoid

The duration between exposures of host eggs to parasitoid females till *Trichogramma* adult emergence was recorded in laboratory condition.

Adult longevity in days

Newly emerged adult parasitoids were kept in a small glass vial (7.5 x 1.21 cm) with streak of honey on its inner wall and strip of eggs. The adult longevity was worked out from the day of emergence until death.

Fecundity

Number of host eggs parasitized by the gravid female was counted and fecundity was determined. As per the method described by Miura and Kobayashi (1995), the number of eggs parasitized by a single female per day was used to express fecundity of *T. chilonis.*

Sex ratio

To determine sex ratio, the emerged adults after death were categorized into male and female under a microscope based on the morphological characters

Female: Antennae clubbed with few short hairs on flagellum.

Male: Antennal hairs tapering and moderately long

Percent adult emergence

Out of total parasitized host eggs, the number of parasitoids emerged were counted on the basis of emergence hole and percent adult emergence was determined.

$$\text{Percent adult emergence} = \frac{\text{Number of black eggs with emergence hole}}{\text{Number of parasitized host eggs}} \times 100$$

RESULTS AND DISCUSSION

Percent egg parasitization

The data presented in Table 1 pertaining to percent egg parasitized by *T. chilonis* revealed that among the different hosts maximum percent parasitization (62.39 percent) was recorded on *H. armigera* eggs which were found at par with *C. cephalonica* eggs (60.36 percent). This was followed by *E. vittella* (46.31 percent). The eggs of *L. orbonalis* were recorded with lowest (10.35 percent) parasitization under laboratory conditions. While the data on percent parasitization of *T. chilonis* on host eggs of different ages revealed that age of host eggs significantly affected the parasitization. Maximum parasitization (58.87 percent) was noticed in fresh eggs i.e., 24 hrs old which was followed by 48 hrs old eggs (44.91 percent). The eggs of 72 hrs old were less preferred by *T. chilonis* and could parasite only (30.56 percent). From this experiment it was confirmed that freshly laid host eggs were more vulnerable to the attack by egg parasitoid but as the host embryo advances in its development, such eggs were less preferred. This might be due to the behavioural response of the female parasitoid in selecting freshly laid eggs for oviposition. The results on the interaction effect indicated that among all the treatments, 24 hrs old eggs of *H. armigera* were significantly more accepted by *T. chilonis* recording highest (79.01 percent) egg parasitization, which was at par with 24 hrs old eggs of *C. cephalonica* (78.88 percent). Whereas,

Table 1. Percent parasitization by *Trichogramma chilonis* on host eggs of different ages

Treatments	Interaction (A×B)			Factor 'A' (Host)
	Egg Parasitization (%)			
	24 hrs	48 hrs	72 hrs	
H. armigera	79.01 (63.48)	61.22 (52.07)	44.44 (41.80)	62.39 (52.45)
E. vittella	61.11 (51.42)	47.78 (43.72)	30.05 (32.47)	46.31 (42.54)
L. orbonalis	15.53 (23.19)	8.88 (17.10)	6.66 (14.95)	10.35 (18.42)
C. cephalonica	78.88 (62.66)	61.11 (51.42)	41.11 (39.87)	60.36 (51.32)
Factor 'B' (Age of host eggs)	58.87 (50.19)	44.91 (41.08)	30.56 (32.27)	

	Factor ' A'	Factor ' B'	Interaction (A×B)
'F' test	Sig.	Sig.	Sig.
SE(m)±	0.57	0.50	1.00
CD (p=0.05)	1.70	1.48	2.96

Note: Figures in parentheses are corresponding arc sin transformation values

48 hrs old eggs of *H. armigera, C. cephalonica* and *E. vittella* were next in preference by *T. chilonis* and could parasitize 61.22, 61.11 and 47.78 percent eggs, respectively. 24 hrs, 48 hrs and 72 hrs old eggs of *L. orbonalis* recorded significantly lowest i.e., 15.53, 8.88, and 6.66 percent parasitization, respectively.

These findings are in corroboration with the work of Mehendale (2009) who studied the effect of different host eggs for mass production of *T. chilonis*. Among the host accepted, maximum per cent eggs parasitization was noticed in *H. armigera* (94.98 per cent) followed by *E. vittella* (91.97 percent) and *C. cephalonica* (71.97 percent). Further it was reported that host eggs age from 0-1 hrs to 24-25 hrs old were highly preferred for parasitization by *T. chilonis*. Similarly, Puneeth *et al*. (2013) reported that the parasitization rate of *T. chilonis* was found to be 61.17±1.77 percent on *C. cephalonica* eggs. Whereas, according to Niranjana *et al*. (2015), *T. chilonis* could not parasitize *L. orbonalis* eggs. The age of host eggs may influence the performance of egg parasitoids used in biological control (Pak,1986), since eggs may undergo morphological and physiological changes that may interfere with their acceptance by the female (Godin and Boivin, 2000; Colazza, 2010). As the host egg is in a transitional stage of development, the parasitoid must kill the embryo and prevent its development, and then subsequently oviposit its eggs (Jarjees and Merritt, 2004).

Table 2. Development period of *Trichogramma chilonis* on host eggs of different ages

Treatments	Interaction (A×B)			Factor 'A' (Host)
	Development Period in Days			
	24 hrs	48 hrs	72 hrs	
H. armigera	8.33 (2.88)	9.66 (3.10)	10.33 (3.21)	9.44 (3.06)
E. vittella	8.33 (2.88)	9.00 (3.00)	9.33 (3.05)	8.88 (2.97)
L. orbonalis	7.66 (2.82)	9.00 (3.00)	9.33 (3.05)	8.66 (2.95)
C. cephalonica	8.66 (2.94)	9.33 (3.05)	9.66 (3.10)	9.21 (3.03)
Factor 'B' (Age of host eggs)	8.24 (2.97)	9.24 (3.03)	9.66 (3.10)	

	Factor ' A'	Factor ' B'	Interaction (A×B)
'F' test	Sig.	Sig.	Sig.
SE(m)±	0.02	0.02	0.04
CD (p=0.05)	0.06	0.05	0.11

Note: Figures in parentheses are corresponding square root transformation values

Development period of *T. chilonis* on different hosts

The data presented in Table 2 shows development period of parasitoid as influence by different host eggs.The data obtained revealed that development period of *T. chilonis* was shorter (8.66 days) when reared on the eggs of *L. orbonalis* which was found at par with eggs of *E. vittella* (8.88 days) and *C. cephalonica* (9.21 days). The longer period (9.44 days) for development of parasitoid was recorded on eggs of *H. armigera*.

Whereas, development period of *T. chilonis* was longer (9.66 days) when reared on 72 hrs old host eggs which was followed by the 48 hrs old host eggs i.e. 9.24 days. While it was shorter (8.24 days) when reared on 24 hrs old host eggs. Whereas, the data on interaction effect revealed that among all the treatments, development period of *T. chilonis* was shorter (7.66 days) when reared on 24 hrs old *L. orbonalis* eggs which was at par with 24 hrs old eggs of *H. armigera* (8.33 days) and *E. vittella* (8.33 days), this was followed by 48 hrs old eggs of *H. armigera, E. vittella,* and *C. cephalonica.* The total development period of parasitoid on 72 hrs old eggs of *H. armigera* was 10.33 days. Development of embryo of the egg parasitoid *Trichogramma* mostly depends on nutrition they get in the host egg. Thus host egg age is limiting factor in this sense as more yolk will be available in the fresh eggs than in older eggs. These findings are in accordance with the work carried out by Rathi and Ram (2000) found that the development period of *T. chilonis* was longer (11.2 days) when reared on the eggs of *H. armigera* and shorter (9.3 days) on eggs of *C. cephalonica.* Similarly, Budhwant *et al.* (2008) reported that development period of *T. chilonis* ranged between 8.94 to 9 days when reared on different lepidopteran eggs (*H. armigera, P. demoleus* and *S. litura*) of different age group. However, Dileep (2012) revealed that the total development period of parasitoid on eggs of *S. litura* was 11.17 days and shortest 9.33 days on the eggs of *C. cephalonica*.

Adult longevity

Data presented in Table 3 regarding adult longevity of *T. chilonis* reared on the eggs of different hosts revealed that the highest adult longevity (7.22 days) was observed from the parasitized eggs of *H. armigera* which was at par with *C. cephalonica* (7.10 days), *E. vittella* (6.88 days) and *L. orbonalis* (6.88 days). Whereas, *T. chilonis* adult lived longer (7.74 days) when reared on the 72 hrs old host eggs. This was followed by 48 hrs old eggs (7.16 days). The shorter (6.16 days) adult longevity of *T. chilonis* was recorded from 24 hrs old host eggs. These finding are in corroboration with the work of Shirazi (2006) who reported that *T. chilonis* female longevity was 9.5±1.03 days when exposed to eggs of *C. cephalonica* and honey. Whereas, Budhawant *et al*. (2008)

Table 3. Adult longevity of *Trichogramma chilonis* on the host eggs of different ages

Treatments	Interaction (A×B)			Factor 'A' (Host)
	Adult longevity in days			
	24 hrs	48 hrs	72 hrs	
H. armigera	6.33 (2.51)	7.33 (2.70)	8.00 (2.82)	7.22 (2.68)
E. vittella	6.00 (2.44)	7.00 (2.64)	7.66 (2.76)	6.88 (2.60)
L. orbonalis	6.00 (2.44)	7.00 (2.64)	7.66 (2.76)	6.88 (2.60)
C. cephalonica	6.33 (2.51)	7.33 (2.70)	7.66 (2.76)	7.10 (2.66)
Factor 'B' (Age of host eggs)	6.16 (2.48)	7.16 (2.67)	7.74 (2.75)	

	Factor ' A'	Factor ' B'	Interaction (A×B)
'F' test	Sig.	Sig.	N.S
SE(m)±	0.02	0.02	0.04
CD (p=0.05)	0.08	0.07	_

Note: Figures in parentheses are corresponding square root transformation values

recorded 7.33 days longevity of adult *T. chilonis* reared on the eggs of *H. armigera*. Further it was reported that adult *T. chilonis* longevity was 7.61 and 6.83 days when exposed to 72 hrs and 24 hrs old host eggs, respectively. Whereas, Ram and Rathi (2000) observed that male and female parasitoid of *T. chilonis* lived longer (5.2 and 9.4 days) when reared on the eggs of *E. vittella.*

Fecundity of *Trichogramma chilonis* on the eggs of different host

The data presented in Table 4 revealed significance differences among the hosts regarding fecundity of *T. chilonis*. The result revealed that out of 30 eggs exposed to one gravid female of *T. chilonis*, parasitized on an average 5.33 egg of *H. armigera* per day per female this was found at par with the eggs of *C. cephalonica* (4.97 eggs/female) and *E. vittella* (4.70 eggs/female). The lowest fecundity (2.43 eggs/female) of *T. chilonis* was noticed on the eggs of *L. orbonalis*. Whereas, the data on fecundity of *T. chilonis* when exposed to the host eggs of different ages revealed that maximum fecundity of parasitoid was noticed on the 24 hrs old host eggs i.e. 6.75 eggs/day/female followed by 48 hrs old host eggs (4.80 eggs/female). The lowest fecundity (2.05 eggs/female) of *T. chilonis* was observed on the 72 hrs old eggs. The results on interaction effect indicated that among different treatment combinations 24 hrs old eggs of *H. armigera* were significantly more accepted by *T. chilonis* with highest fecundity i.e., 7.33 eggs per day per female this was found at par with 24 hrs old eggs of *C. cephalonica* (7.00 eggs/female) and *E. vittella* (6.66 eggs/female). Whereas, 48 hrs old eggs of *H. armigera, C. cephalonica* and *E. vittella* were next in preference for fecundity by *T. chilonis.* The eggs of *L. orbonalis* were less preferred by parasitoid *T. chilonis* with fecundity of 4.33, 2.66, 0.66 eggs per day per female, respectively. These results find support in the work of Shirazi (2006) reported life time fecundity of *T. chilonis i.e*., 61.9 eggs/female when exposed to eggs of *C. cephalonica*. Moreover, Miura and Kobayashi (1995) reported that percent oviposition of *T. chilonis* was highest on the one-day-old host eggs, and decreases as the host eggs older. In 3-day-old host eggs, it is possible that the embryo is already developing and occupying most of the total volume of the egg, with a high level of sclerotization, which increases the protection of the host and decreases the amount of food available for the development of a *Trichogramma* larva inside the egg (Jarjees and Merritt, 2004)

Percent adult emergence of *Trichogramma chilonis*

The data presented in Table 5 revealed that the results obtained were statistically non-significant indicating that different host eggs and different age of host eggs does not showed any significant differences in percent adult emergence of *T. chilonis.* These results find support in the work carried out by earlier worker Rathi and Ram (2000) who recorded 93.30 and 90.90 percent *T. chilonis* adult emergence when reared on *C. cephalonica* and *H. armigera*, respectively.

Table 4. Fecundity of *Trichogramma chilonis* on host eggs of different ages

Treatments	Interaction (A×B)			Factor 'A' (Host)
	Fecundity /Per day/female			
	24 hrs	48 hrs	72 hrs	
H. armigera	7.33 (2.79)	5.66 (2.48)	3.00 (1.87)	5.33 (2.38)
E. vittella	6.66 (2.67)	5.33 (2.41)	2.30 (1.67)	4.70 (2.25)
L. orbonalis	4.33 (2.19)	2.66 (1.77)	0.66 (1.05)	2.43 (1.67)
C. cephalonica	7.00 (2.73)	5.33 (2.40)	2.60 (1.77)	4.97 (2.30)
Factor 'B' (Age of host eggs)	6.75 (2.60)	4.80 (2.26)	2.05 (1.59)	

	Factor ' A'	Factor ' B'	Interaction (A×B)
'F' test	Sig.	Sig.	Sig.
SE(m)±	0.05	0.04	0.08
CD (p=0.05)	0.14	0.12	0.25

Note: Figures in parentheses are corresponding to square root transformation values

Whereas, Dileep (2012) noticed 89.48 percent emergence of *T. chilonis* on the eggs of *C. cephalonica*.

Percent female progeny of *T. chilonis*

The data presented in Table 6 revealed that the maximum percent female parasitoid progeny was noticed from *E. vittella* (49.87 percent) which was at par with *H. armigera* (49.66 percent) and *C. cephalonica* eggs (49.21 percent). The lowest percent of female parasitoid progeny was observed from *L. orbonalis* (44.44 percent).Whereas, significantly maximum percent female progeny (54.30 percent) was observed in 24 hrs old eggs.While 48 hrs old eggs recorded 47.07 percent female progeny. The minimum percent female progeny i.e., 42.65 percent was recorded from 72 hrs old eggs. While among all the treatment combinations 24 hrs old eggs of *E. vittella* recorded maximum percent *T. chilonis* female progeny (56.02 percent) which was at par with 24 hrs old eggs of *H. armigera* (55.80 percent), *C. cephalonica* (55.40 percent) and *L. orbonalis* (50 percent). The lowest percent (38.88 percent) female progeny was observed on the 72 hrs old eggs of *L. orbonalis.* The earlier worker Rathi and Ram (2000) recovered higher female population from emerged adults of *T. chilonis* from the eggs of *A. moorei* (74.90 percent) followed by *E. vittella* (73.30 percent), *H. armigera* (71.50 percent) and lowest (68.70 percent) from eggs of *C. cephalonica*. Similarly, Dileep (2012) recorded 60 percent female population of *T. chilonis* from the eggs of *C. cephalonica*. Moreover, it was reported that the host eggs of age 0-1 hr, 6-7 hrs and 12-13 hrs produced 69.28, 68.62 and 67.19 percent *Trichogramma* females, respectively which were at par with each other. Whereas, host egg age 18-19 hrs, 24-25 hrs and 30-35 hrs produced 65.46, 63.07 and 61.26 percent females, respectively which were significantly superior over rest of the egg ages. Thereafter the percent female emergence declined drastically from 36-37 hrs (59.24 percent), 42-43 hrs (56.10 percent), 48-49 hrs (50.75 percent), 54-55 hrs (43.53 percent) and 60-61 hrs (21.80 percent). Further egg age 66-67 hrs and 72-73 hrs even could not produce significant adults and those emerge were all males. Whereas, Singh *et al*. (2001) reported that, *T. exiguum* females were found to be predominant up to 60-61 hrs old host eggs. Whereas, it was above 75 percent in the host age group from 0-1 hr to 48-49 hrs. However, Mehendale (2009) reported maximum female recovery in egg age 0-1 hr to 18-19 hrs old. Thus, these findings strongly support the present result.

Sex ratio (Male: Female)

The data depicted in Table 7 pertaining to sex ratio of *T. chilonis* reared on different host eggs revealed that the maximum female parasitoid recovery was noticed from the parasitized eggs of *E. vittella* (1:1.06) which was at par with *H. armigera* (1:1.03) and *C. cephalonica* (1:0.98). While 1:0.66 sex ratio of *T. chilonis* was noticed from the eggs of *L. orbonalis.* Whereas, the data on sex ratio of *T. chilonis* when reared on the host eggs of different ages revealed significant

Table 5. Percent adult emergence of *Trichogramma chilonis* on host eggs of different ages

Treatments	Interaction (A×B)			Factor 'A' (Host)
	Emergence of adult *T. chilonis* (%)			
	24 hrs	48 hrs	72 hrs	
H. armigera	91.63 (72.83)	89.41 (70.48)	89.92 (73.43)	90.49 (72.25)
E. vittella	92.64 (74.50)	90.63 (72.43)	88.33 (70.05)	90.53 (72.23)
L. orbonalis	78.33 (62.29)	47.77 (53.41)	66.66 (51.48)	64.25 (55.72)
C. cephalonica	91.28 (73.18)	88.83 (71.10)	91.87 (71.60)	90.66 (72.01)
Factor 'B' (Age of host eggs)	88.47 (70.70)	79.16 (62.66)	84.19 (66.68)	

	Factor ' A'	Factor ' B'	Interaction (A×B)
'F' test	N.S	N.S	N.S
SE(m)±	3.04	2.64	5.28
CD (p=0.05)	_	_	_

Note: Figures in parenthesis are corresponding arc sin transformation values

Table 6. Percent female progeny of *Trichogramma chilonis* on host eggs of different ages

Treatments	Interaction (A×B)			Factor 'A' (Host)
	Female progeny (%)			
	24 hrs	48 hrs	72 hrs	
H. armigera	55.80 (48.10)	47.73 (43.52)	45.45 (41.65)	49.66 (44.42)
E. vittella	56.02 (48.45)	48.71 (44.26)	44.90 (41.50)	49.87 (44.73)
L. orbonalis	50.00 (45.00)	44.44 (41.75)	38.88 (38.50)	44.44 (41.75)
C. cephalonica	55.40 (48.28)	47.43 (43.13)	44.81 (40.38)	49.21 (43.93)
Factor 'B' (Age of host eggs)	54.30 (47.46)	47.07 (43.17)	42.65 (41.01)	

	Factor ' A'	Factor ' B'	Interaction (A×B)
'F' test	Sig	Sig	Sig
SE(m)±	0.83	0.72	1.44
CD (p=0.05)	2.45	2.12	4.24

Note: Figures in parentheses are corresponding arc sin transformation values

Table 7. Sex ratio of *Trichogramma chilonis* on the host eggs of different ages

Treatments	Interaction			Factor 'A' (Host)
	Sex Ratio			
	24 hrs	48 hrs	72 hrs	
H. armigera	1:1.22	1:1.05	1:0.83	1:1.03
E. vittella	1:1.25	1:1.05	1:0.90	1:1.06
L. orbonalis	1:1.00	1:0.66	1:0.33	1:0.66
C. cephalonica	1:1.20	1:0.94	1:0.80	1:0.98
Factor 'B' (Age of host eggs)	1:1.55	1:1.23	1:0.95	

	Factor ' A'	Factor ' B'	Interaction (A×B)
'F' test	Sig.	Sig.	Sig.
SE(m)±	0.06	0.05	0.10
CD (p=0.05)	0.18	0.16	0. 32

differences regarding the recovery of female parasitoid. Sex ratio in *T. chilonis* was 1:1.55, 1:1.23, and 1:0.95 in 24 hrs, 48 hrs, and 72 hrs old eggs, respectively.

While the results of interaction effect revealed that sex ratio in *T. chilonis* on 24 hrs old eggs of *E. vittella* was 1:1.25 which was at par with 24 hrs old eggs of *H. armigera* (1:1.22), *C. cephalonica* (1:1.20), *L. orbonalis* (1:1.00) and 48 hrs old eggs of *H. armigera* (1:1.05), *E. vittella* (1:1.05) and *C. cephalonica* (1:0.94), respectively. Thereafter, the proportion of female progeny reduced drastically as revealed in 72 hrs old eggs of *E. vittella* (1:0.90), *H. armigera* (1:0.83), *C. cephalonica* (1:0.80) and *L. orbonalis* (1:0.33). The present results find support in the work carried out by the earlier worker Bhargavi (2015) revealed that the maximum female parasitoid recovery was noticed from *S. litura* eggs (0.15:0.83) followed by *H. armigera* (0.17:0.81) and less female parasitoid recovery was noticed from *C. cephalonica* eggs (0.21:0.78). Similarly, Dileep (2012) reported that maximum female parasitoid recovery was noticed from *S. litura* eggs (1:2.1) and less female parasitoid recovery was noticed from *C. cephalonica* eggs (1:1.53). Moreover, they reported that maximum females were emerged from egg age 0 to 1 hr (1:2.25) followed by 6 to 7 hrs (1:2.13) and 12 to 13 hrs (1:2.04). As the egg age prolonged the sex ratio was male biased as revealed in egg age 54 to 55 hrs (1:0.76) and 60 to 61 hrs (1:0.27) and even no female adult noticed from egg age 66 to 67 hrs and 72 to 73 hrs.

CONCLUSION

From the results of the present study it is concluded that in 24 hrs old *H. armigera* eggs maximum percent parasitization by *T. chilonis*, highest adult parasitoid longevity and highest number of eggs parasitized by one gravid female per day was noticed. However, maximum female parasitoid recovery was noticed from the parasitized eggs of *E. vittella* which was at par with *H. armigera*. These results are of great importance for the release of *T. chilonis* as they will help the parasitoid to be released at the most appropriate time to best contribute to the efficient control of *pests* in the field. Moreover, accurate knowledge of parasitoid biological traits may be important for overall efficiency in terms of crop protection.

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