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Efficacy of *Trichogramma pretiosum* and *Trichogramma japonicum* reared on two different factitious hosts and its response to different colours of Trichocard

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ABSTRACT

The effect of two hosts and different colours of trichocard on the parasitising efficiency of *Trichogramma pretiosum* and *T. japonicum* was studied at the lab setting of 28 ± 2° C temperature and 75 ± 5 % relative humidity. In the present investigation, different biological parameters of *T. pretiosum* and *T. japonicum* reared on factitious hosts (*Corcyra cephalonica* and *Galleria mellonella)* were evaluated. The results revealed significant parasitisation of *T. pretiosum* on both hosts with 85.33 % (*C. cephalonica)* and 72.67 % (*G. mellonella)* parasitisation, respectively. The per cent parasitisation of *T. japonicum* on *G. mellonella* eggs was found to be significantly higher *i.e.,* 72.33 % as compared to 60.67 % on *C. cephalonica*. Parasitoids reared on these two factitious hosts were used for checking the ovipositional preference of *T. pretiosum* and *T. japonicum* on different colours of trichocard. White, blue, yellow, purple, green, and red were the colours tested. The results showed that trichocards of white and green colour are better for mass production of *Trichogramma* spp.

1. Introduction

Trichogramma species (Hymenoptera: Trichogrammatidae) are major natural enemies of many insect pests (Smith, 1996). *Trichogramma* have been reared using a variety of factitious host eggs, including eggs of Eri-silkworm, *Samia cynthia* ricini Donovan, (Lepidoptera: Saturniidae) (Pu *et al*., 1956), Rice moth, *Corcyra cephalonica* Stainton, (Lepidoptera: Galleriidae) (Qiu *et al*., 1980), Chinese oak silkworm, *Antheraea pernyi* Guerin-Meneville, (Lepidoptera: Saturniidae) (Wang, 2001), Angoumois grain moth, *Sitotroga cerealella* Olivier, (Lepidoptera: Gelechiidae) (Naixin *et al*., 2002, Zheng *et al*., 2003). Important species including *T. japonicum* and *T. ostriniae* are best mass-reared using *C. cephalonica* and *S. cerealella,* respectively (Hongyin *et al*., 2000; Naixin *et al*., 2002; Zhang *et al*., 2015). If other insect species could generate more parasitoids having higher fecundity or longer longevity, they would make better or more desired hosts (Marston and Ertle, 1973). An accurate estimation of host compatibility is essential for a successful and effective biological control programme. Numerous research have been conducted to access whether other agricultural pests and factitious hosts are suitable for rearing of *Trichogramma*. Even though rearing of parasitoids on the factitious host is an important step, repeated rearing on the same host may reduce its effectiveness against the particular target insect pest after it is being sent out onto the agricultural field (Corbet, 1985). *Galleria mellonella* (L.), is an appealing alternative option since the eggs are acceptable to various *Trichogramma* species, the females have high fecundity and moreover, the larvae can be easily reared (Dutky *et al*., 1962). Higher fecundity, longevity, emergence rate of adults, sex ratio (*i.e*., proportion of female progeny), host-searching ability, host choice for the target species and adaptability to weather conditions in the particular area are typically used to select populations for inundative release. A population having these traits is referred to be a natural enemy of high quality since it is believed that they are ecologically significant for these parasitoids when introduced inundatively.

Although *Trichogramma* is possibly the most extensively researched natural enemy genus, little is known about their visual detection and influence of colours on their biology. Colours can be used for short-range foraging (Lobdell *et al*., 2005). Plant colour has been shown to influence the orientation and feeding responses of a variety of insects. Phytophagous insects may favour a particular colour

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or intensity and hue of colour in their preferred plants (Moerick, 1969). *Trichogramma* spp. may use visual cues such as plant colour in their selection process, as has been observed for several hymenopteran parasitoids from families such as Braconidae (Wackers, 1994) and Aphelinidae (Romeis and Zebitz, 1997). Like most other hymenopteran species studied, *Trichogramma* can detect differences in light intensity and wavelength. The colour of trichocards influences the parasitism efficiency of *T. chilonis* (Singh *et al.*, 2001). The present experiment has been conducted to learn about the egg-laying responses of *Trichogramma pretiosum* and *T. japonicum* to different coloured cards with the primary objective that a proper egg card colour may encourage the parasitoid to lay more eggs on the egg cards that contain its host and thereby increasing the level of parasitisation in the process. The field success is dependent on their performance, which can be altered by laboratory mass raising procedures. (Cherif *et al.*, 2021).

2. Materials and Methods

This study was carried out at Entomology Laboratory of College of Post Graduate Studies, CAU(I), Umiam, Meghalaya from 2020-2022.

Rearing of Factitious hosts

C. cephalonica Stainton (Lepidoptera: Pyralidae) and *G. mellonella* (Lepidoptera: Pyralidae) are valued as one of the potential laboratory hosts for various biocontrol agents, so, these two were selected as factitious hosts. Initial culture of *C. cephalonica* were obtained from State Biological Laboratory, Upper Shillong, Meghalaya. These were reared in a standard diet containing rice along with ground nut and yeast powder as main ingredients according to the techniques given by Lalitha and Ballal (2015). The initial culture of *Galleria mellonella* was taken from ICAR-National Bureau of Agricultural Insect Resources (ICAR-NBAIR), Bengaluru. It was reared on artificial diet containing wheat bran, corn meal, honey, glycerine and yeast as main ingredients following the techniques given by Jones *et al.* (2002). Fresh eggs of both the hosts were collected regularly and used for both the experiments and also for maintaining the insect host cultures.

***Trichogramma* parasitoids**

Trichogramma pretiosum and *T. japonicum* nucleus culture was obtained from the State Biological Control Laboratory, Upper Shillong and reared for about 5-6 generations (*i.e.*, about 2 months) on both the experimental factitious hosts prior to carrying out the tests. The rearing temperature was kept at 28 ± 2°C and 75% relative humidity. The wasps were given freshly laid host eggs on a daily basis for egg laying. As nourishment for the adult parasitoids, a 10% honey solution was fed.

Experimental Technique

In order to check various biological parameters on the two hosts, freshly collected eggs of *C. cephalonica* and *G. mellonella* have been used. The collected eggs (30 numbers) of each hosts were glued on cards (1x2 cm) separately and were UV irradiated for about 45 mins. Glass vials (5 ml) were placed with individual egg cards and were exposed to two adult pre-mated females of both the *Trichogramma* spp. separately. *Trichogramma* adults were fed a 10% solution of honey that was applied to the side of the vials. Then, the vials were covered to prevent and stop adult wasps from potentially escaping. The female wasps were allowed to oviposit into the host eggs and removed after 24 hours of introduction. The eggs that were exposed to the parasitoids and left to develop were subjected to the similar conditions used for maintaining the parasitoid colonies. The experiment was replicated 20 times for each host.

For checking the ovipositional preference on different coloured egg cards, six different colours were chosen. In order to make the coloured egg cards, 50 freshly laid UV-irradiated *C. cephalonica* and *G. mellonella* eggs were adhered together on respective coloured cards of 1x2 cm with the help of 10 % acacia gum. No-choice test was conducted by placing each egg card in a glass vial (5 ml) and two pre-mated female adults were selected and introduced into each vial separately. For multiple choice test, the coloured egg cards were kept equidistantly on a container where the centre held a small card with 30 numbers of parasitoid eggs on it. These eggs were already parasitised and likely to emerge. 10% honey solution in a fine streak was smeared on the walls of the container as adult diet and covered to prevent the adult parasitoids from escaping. The parasitoid wasps were allowed access to the eggs for a whole day. The parasitised egg cards were then taken out, placed in separate vials, and observed for further development of the parasitoid. The parasitised eggs became black in about 4 days, and the parasitisation rate was recorded till 8th day. Adult emergence was observed by examining the emergence hole on the egg. For both the choice and no-choice tests, the experiment was repeated three times.

Parasitoid efficiency measurements

A stereoscopic microscope was used to count the parasitised (blackened) eggs four days after the females were removed. Additionally, until no parasitoids emerged, the eggs were examined every day to check the exit of *Trichogramma* adults. By counting emergence holes from black eggs, we were able to calculate the adult emergence rate. The adults were each kept in a glass vial without food or water to determine the longevity (from the time of emergence until death). Under a microscope, fully developed dead adults were examined to determine the female percentage of progeny. The percentage of parasitization and the percentage of adult emergence were noted in order to evaluate the preference for oviposition among the various trichocard colours.

Statistical analysis

Before analysis, data with percentage values were arcsine transformed to homogenise variances. For the observation on various biological parameters of *T. pretiosum* and *T. japonicum* on the two factitious hosts, comparision were made using a paired *t*-test. The significant difference level in all tests was 5 % ($P \leq 0.05$).

For the ovipositional preference on different colours of Trichocard, the observations were analyzed by using analysis of variance followed by Tukey's honest significant difference (HSD) test at $P \leq 0.05$ for all trials. All statistical analysis was done with SPSS software.

3. Results and Discussion

Biology of *Trichogramma japonicum* and *Trichogramma pretiosum* on two host egg cards

Experiments were conducted with no choice condition providing the two host egg cards individually to *T. pretiosum* and *T. japonicum* adults for parasitisation and the observations recorded on per cent parasitisation, per cent adult emergence, longevity, sex ratio, fecundity and developmental period were studied, which have been discussed in the subsequent section of the paper.

Per cent parasitisation

The parasitised eggs of both the hosts were identified on the basis of their colour change from white/cream to dark brown/ black under microscope. The percentage of *T. pretiosum* that parasitised *C. cephalonica* and *G. mellonella* eggs was 85.33 and 72.67%, respectively (Table 1). Furthermore, the parasitisation percentage of *T. japonicum* on *G. mellonella* eggs was found to be significantly higher (72.33 %) than on *C. cephalonica* eggs, (60.67 %) (Table 2).

These findings concur with those of Prabhulinga *et al.*, (2013), who studied the biological parameters of *T. pretiosum* and found that the parasitisation rate on *C. cephalonica* eggs was 76.3 %. Boldt and Marston (1974) found 43.70 ± 6.20 % of blackened eggs due to *T. pretiosum* parasitisation on *G. mellonella* eggs. As per Navarajan (1978), the parasitisation rate on *C. cephalonica* eggs due to *T. japonicum* ranged from 71.33 to 79.33 %. As reported by Boldt (1974), *T. evanescens* parasitism rates varied when reared on different hosts.

Per cent adult emergence

Adult emergence rates were found to be significantly higher in *C. cephalonica* (63.00 %, 59.95 %) than in *G. mellonella* (55.76 %, 54.77 %) for *T. pretiosum* and *T. japonicum*, respectively (Table 1 and 2). According to Dileep (2012), *T. chilonis* adult emergence on *C. cephalonica* eggs appeared to be 89.48 %.

Sex Ratio

More than 60 % of the progeny of all effectively parasitised Lepidopteran species seem to be female (Hoffman, 1975). The ratio of male to female *T. pretiosum* progeny from the present study was found to be significantly different with mean values of 1:1.37 and 1:1.91 in *C. cephalonica* and *G. mellonella*, respectively. For *T. japonicum*, the female parasitoid recovery was also recorded higher for *G. mellonella* (1:1.98) than *C. cephalonica* (1:1.33).

The earlier worker, Mehendale (2009) observed that the *T. chilonis* sex ratio was 1:1.40 in *S. litura* eggs and 1:1.30 in *C. cephalonica*. Similarly, Dileep (2012) noticed higher female parasitoid recovery (1:2.1) in *S. litura* and *C. cephalonica* eggs had lower female parasitoid recovery (1:1.53). Boldt and Marston (1974) also reported 51.50 ± 7.60 % female progeny of *T. pretiosum* reared on *G. melonella* eggs. However, *T. chilonis* from *S. litura* and *C. cephalonica* eggs had sex ratios of 1:1.40 and 1:1.30, respectively, according to Mehendale (2009). A large number of females must always be produced in order to increase the mass production of *Trichogramma* wasps for an effective biological control programme. The development of thelytokous *Trichogramma* lines may improve methods of biological control (Zhou *et al.*, 2020).

Adult longevity

In this study, the longevity of adult *T. pretiosum* recorded was 2.30 and 2.75 days in *C. cephalonica* and *G. mellonella* eggs, respectively. Adult *T. japonicum* lived for an average period of 2.50 and 2.75 days when developed from eggs of *C. cephalonica* and *G. mellonella*, respectively. Although the difference is reported non-significant, adult longevity was found to be slightly higher when it developed from *G. mellonella* eggs. These slight variations are caused by differences in the nutrient content of the eggs in these intermediate hosts, the parasitoids might have got an additional supply of nutrients from the bigger host.

Boldt and Marston (1974) also observed that females from *G. mellonella* eggs survived an average of 50% longer than those from *S. cerealella* eggs. According to Hasan *et al.* (2019), *G. mellonella* is a better host for the larval ectoparasitoid *Harbobracon hebetor* owing to the size and longevity of the larvae. However, the total lifespan of the wasps in the field might be very different from what was found in the laboratory. The longevity of adults can also be boosted by feeding (Narayanan and Mookherjee, 1955) as Bai *et al.* (1992) reported that large *T. pretiosum* can survive without a supply of carbohydrates just as long as smaller ones.

Total Development Period

The data recorded a variation in development period of *Trichogramma* species when reared on different hosts. Total development period of both *T. pretiosum* and *T. japonicum* on *C. cephalonica* was completed in a shorter duration of 10.80 and 11.20 days, respectively compared to *G. mellonella i.e.*, 13.20 and 14.45 days, respectively.

According to Rathi and Ram (2000), rearing *T. chilonis* on *H. armigera* eggs resulted in a longer (11.20 days) development period and a shorter (9.30 days) when reared on eggs of *C. cephalonica*. Budhwant *et al.* (2008) observed that *T. chilonis* required 8.94 to 9.00 days to emerge out of several lepidopteran host eggs (*S. litura, P. demoleus* and *H. armigera*) of different ages. In addition, Dileep (2012) also observed that on *S. litura* eggs, parasitoids took 11.17 days to fully develop, while on *C. cephalonica* eggs took 9.33 days

Fecundity

The maximum lifetime fecundity of *T. pretiosum* was recorded to be significantly higher in *C. cephalonica* (60.05) than *G. mellonella* (55.25). The average progeny per female of adult *T. japonicum* was 51.95 in *C. cephalonica* and 53.75 in *G. mellonella*, showing a non-significant difference. The difference in progeny produced may also be due to the nutritive quality present in the host which the *Trichogramma* female feed during its development. Regarding this,

Rajmohan and Jayaraj (1973) stated that fecundity might be influenced by the nutritive value of the food consumed during both larval and adult stages. The difference in fecundity is also observed between both the parasitoid species irrespective of the host. It may be due to the influence of size of the *Trichogramma* female adult.

Boldt and Marston (1974) also stated that if *T. evanescens* or *T. pretiosum* were to be utilized for control programmes, *G. mellonella* would make the ideal host. According to the availability of nutrients in smaller hosts like *S. cerealella*, the size of the parasitoid seems to be metabolically constrained (Barrett and Schmidt, 1991). When a larger host receives a small number of eggs, the larvae usually die because they are unable to utilize all of the resources (Strand and Vinson, 1985). A wasp adjusts the quantity of eggs it distributes in larger hosts by estimating the size of the host when it first passed over the host (Schmidt and Smith, 1987). The rate of development of the parasitoid influence fecundity and longevity also in addition to size (Colinet *et al.* 2007).

Table 1. Comparative biology of *T. pretiosum* on *Corcyra cephalonica* and *Galleria mellonella*

T. pretiosum					Paired *t*-test[a]	
Biological Parameters	*Corcyra cephalonica*		*Galleria mellonella*		*t*	P ($p \leq 0.05$)
	Mean	Range	Mean	Range		
Per cent parasitisation	85.33 (67.48)	70.00-100	72.67 (58.48)	46.67-93.33	5.20	<.001
Per cent Adult Emergence	63.00 (52.54)	48.15-70.83	55.76 (48.31)	46.43-72.73	3.48	.002
Sex Ratio (M : F)	1:1.37	1:0.82-1:2.00	1:1.91	1:1.17-1:2.67	4.16	.001
Longevity (Days)	2.30	1-4	2.75	1-4	1.53	<.001
Total Development Period (Days)	10.80	9-13	13.20	10-16	4.91	<.001
Fecundity (Numbers)	60.05	54-72	55.25	47-61	3.55	.002

[a] Results from paired *t*-test comparing biological parameters for two hosts; df=19

(Figures in parenthesis are corresponding arcsine transformed value)

Table 2 Comparative biology of *T. japonicum* on *Corcyra cephalonica* and *Galleria mellonella*

T. japonicum					**Paired t-test[a]**	
Biological Parameters	***Corcyra cephalonica***		***Galleria mellonella***		***t***	**P ($p \leq$ 0.05)**
	Mean	**Range**	**Mean**	**Range**		
Per cent parasitism	60.67 (51.28)	46.67-76.67	72.33 (58.78)	53.33-90	3.60	.002
Per cent Adult Emergence	59.95 (50.75)	55.56-70	54.77 (47.75)	47.37-64	3.61	.002
Sex Ratio (M : F)	1:1.33	1:0.71-1:2.33	1:1.98	1:1.25-1:2.67	3.76	.001
Longevity (Days)	2.50	1-4	2.75	1-4	.90	**NS**
Total Development Period (Days)	11.20	9-13	14.45	9-17	9.17	<.001
Fecundity (Numbers)	51.95	46-66	53.75	49-61	1.42	**NS**

[a] Results from paired *t*-test comparing biological parameters for two hosts; df=19
(Figures in parenthesis are corresponding arcsine transformed value)

Response of *Trichogramma* to different colours of tricho-cards

This study's purpose was to determine how different coloured cards, which were used to fix the host eggs, affected the biological characteristics of *Trichogramma pretiosum* and *T. japonicum*, such as the percentage of parasitisation and percentage of adult emergence. With an objective of observing how different coloured tricho-cards affect egg-laying behaviour, two experiments were conducted *i.e.*, no-choice test and multiple-choice test for the cards with eggs of two factitious hosts. The parasitisation percentage and adult emergence were recorded on six trichocards of different colours *viz.* white, yellow, blue, purple, green and red.

Per cent parasitisation on different coloured cards

Under no choice condition, for *T. pretiosum,* maximum parasitisation was observed on white-coloured *C. cephalonica* egg cards recording 60.67 % parasitisation. Least parasitisation was recorded in red coloured *G. mellonella* egg cards with 17.33 %, however, it was at par with red coloured *C. cephalonica* egg cards with 18.00 % parasitisation. For *T. japonicum,* among the different coloured-host egg cards, maximum parasitisation was recorded on green-coloured *C. cephalonica* cards (62.00 %). Red-coloured *G. mellonella* egg cards (19.33 %) were found to have the lowest parasitisation rate but were at par with purple-coloured *G. mellonella* egg cards (21.33 %) (Table 3).

Under multiple-choice experiment, for *T. pretiosum,* maximum parasitisation was observed on white-coloured *C. cephalonica* egg cards recording 58.00 % parasitisation which was at par with yellow-coloured *C. cephalonica* egg cards with 54.67 %. Least parasitisation was recorded in purple coloured *G. mellonella* egg cards which recorded 14.00 %. For *T. japonicum,* maximum parasitisation was also observed on white-coloured *C. cephalonica* egg card (63.33 %). Least parasitisation was recorded in blue coloured *G. mellonella* egg cards with 20.67 %, however, it was at par with purple coloured *G. mellonella* egg cards with 21.33 % parasitisation (Table 4).

According to Romeis *et al.* (1998), the colour vision of insects were described by three characteristics: intensity (reflected energy), hue (dominant wavelength), and saturation (spectral purity of the reflected light). For orientation, phytophagous insects perceive all three characteristics, either singly or in combination. Similar colour vision in Hymenoptera has been demonstrated to be influenced by intensity (Hollingsworth *et al.*, 1970), hue (Autrum *et al*, 1979), and/or saturation, which could explain why the tested hymenopteran parasitoid, *T. japonicum* and *T. pretiosum* was influenced by different colour cards. The colour of the trichocards has a significant impact on the parasitism effectiveness of *Trichogramma chilonis* (Singh et al., 2001).

The results of present findings are supported by the earlier worker, Baitha and Sinha (2002), the rate of egg deposition in the first three days was found highest on green (88.64 %) trichocard, followed by the white (84.62 %) trichocard.

Per cent adult emergence on different coloured cards

The data on per cent adult emergence under no-choice test revealed that maximum adult emergence for *T. pretiosum* was recorded on green-coloured *C.*

cephalonica egg cards (62.73 %) which was found to be at par with yellow-coloured *C. cephalonica* egg cards (61.20 %). For *T. japonicum*, red-coloured *C. cephalonica* egg card was most effective recording significantly maximum 62.00 % followed by yellow-coloured *C. cephalonica* egg cards with 59.13 % adult emergence. Least percent adult emergence was observed in purple-coloured *G. mellonella* egg card with 37.50 % (Table 3).

Under multiple-choice test, for *T. pretiosum* maximum emergence was recorded in white-coloured *C. cephalonica* egg card (68.79 %) followed by yellow-coloured *C. cephalonica* egg card (60.91 %). For *T. japonicum*, treatment of blue-coloured *C. cephalonica* egg card was observed to be most effective (60.81 %) followed by green-coloured *C. cephalonica* egg card (58.96 %). Least adult emergence was recorded in purple-coloured *G. mellonella* egg cards with 29.17 % (Table 4).

Similarly, according to Baitha and Sinha's findings from 2002, *T. chilonis* adult were more likely to emerge on green-coloured cards (76.49%). Bhattacharya *et al.*, (2003) also reported that mint green cards had the highest adult emergence rate (88.06%), followed by golden yellow and white (88.04% and 87.76%) under single choice test, indicating the role of colour in influencing the performance of *T. chilonis*.

The response to different colours can also be supported by their influence on other insects. Some researches on the impact colour of trap on capturing beneficial insects shows a range of different results. The efficiency of green, red, yellow, blue and white traps in attracting beneficial species of insects in apple orchards was studied by Wallis and Shaw (2008). They observed that yellow traps drew more parasitic wasps, blue traps drawn more *Bombus* spp. (bumble bees), and white traps lure more *Apis mellifera* L. (honey bees) and *Lasioglossum*, *Hylaeus* spp. (native bees). However, Chen *et al.* (2004) reported that in their experiments with broccoli, blue traps attract more hoverflies than yellow or white traps. Nectar colour may have an impact on how well *Trichogramma* perform, as was the case with *T. carverae*, which benefited from white alyssum nectar, which increased fecundity and parasitism in comparision to certain other nectar colours (Begum *et al.*, 2004; Cherif *et al.*, 2021).

Table 3. Percent parasitisation and per cent adult emergence of *T. pretiosum* and *T. japonicum* under No-Choice test

Colour	Host eggs	*T. pretiosum*		*T. japonicum*	
		Per cent Parasitisation	Per cent Adult Emergence	Per cent Parasitisation	Per cent Adult Emergence
White	*C. cephalonica*	60.67 (51.19) ^{a}	57.07 (49.06) ^{abc}	34.00 (35.66) ^{abc}	56.88 (48.95) ^{abc}
	G. mellonella	51.33 (45.76) ^{abc}	53.24 (46.86) ^{abc}	32.00 (34.39) ^{ab}	54.24 (47.43) ^{abc}
Yellow	*C. cephalonica*	36.00 (36.85) ^{bcde}	61.20 (51.48) ^{ab}	40.67 (39.62) ^{bc}	59.13 (50.29) ^{bc}
	G. mellonella	32.67 (34.72) ^{cde}	45.69 (42.52) ^{bc}	31.33 (33.98) ^{ab}	54.72 (47.72) ^{abc}
Blue	*C. cephalonica*	54.67 (47.71) ^{ab}	57.34 (49.22) ^{abc}	50.67 (45.39) ^{cd}	57.38 (49.25) ^{abc}
	G. mellonella	28.00 (31.86) ^{de}	48.57 (44.18) ^{abc}	34.00 (35.63) ^{abc}	45.14 (42.21) ^{abc}
Purple	*C. cephalonica*	28.67 (32.33) ^{de}	56.11 (48.52) ^{abc}	27.33 (31.50) ^{ab}	46.51 (42.99) ^{abc}
	G. mellonella	26.00 (30.56) ^{de}	49.43 (44.67) ^{abc}	21.33 (27.42) ^{a}	37.50 (37.74) ^{a}
Green	*C. cephalonica*	52.00 (46.16) ^{abc}	62.73 (52.38) ^{a}	62.00 (51.99) ^{d}	54.43 (47.55) ^{abc}
	G. mellonella	38.00 (38.03) ^{bcd}	52.83 (46.63) ^{abc}	29.33 (32.68) ^{ab}	40.28 (39.34) ^{ab}
Red	*C. cephalonica*	18.00 (24.73) ^{e}	48.38 (44.10) ^{abc}	31.33 (33.89) ^{ab}	60.78 (51.23) ^{c}
	G. mellonella	17.33	41.90	19.33	46.46

		(24.12) e	(40.34) c	(26.01) a	(42.93) abc

(Figures in parenthesis are corresponding arcsine transformed values)

The Tukey HSD test does not reveal significant differences between means in columns with the same letter after them (P ≤ 0.05)

Table 4. Percent parasitisation and per cent adult emergence of *T. pretiosum* and *T. japonicum* under Multiple Choice test

Colour	Host eggs	*T. pretiosum*		*T. japonicum*	
		Per cent Parasitisation	**Per cent Adult Emergence**	**Per cent Parasitisation**	**Per cent Adult Emergence**
White	*C. cephalonica*	58.00 (49.61) f	68.79 (56.08) a	63.33 (52.83) d	57.23 (49.23) b
	G. mellonella	48.67 (44.23) ef	53.11 (46.79) a	33.33 (35.24) abc	54.38 (47.58) b
Yellow	*C. cephalonica*	54.67 (47.68) f	60.91 (51.31) a	32.00 (34.34) ab	54.21 (47.42) b
	G. mellonella	30.67 (33.59) bcd	48.22 (43.98) a	28.67 (32.29) ab	39.37 (38.70) ab
Blue	*C. cephalonica*	18.67 (25.47) ab	57.01 (49.03) a	34.67 (36.02) abc	60.81 (51.27) b
	G. mellonella	46.67 (43.05) ef	46.05 (42.72) a	20.67 (27.00) a	53.33 (46.92) ab
Purple	*C. cephalonica*	27.33 (31.52) abc	56.59 (49.06) a	27.33 (31.39) ab	39.13 (38.71) ab
	G. mellonella	14.00 (21.61) a	48.48 (44.13) a	21.33 (27.36) a	29.17 (32.59) a
Green	*C. cephalonica*	46.00 (42.70) def	57.88 (49.54) b	42.00 (40.37) bc	58.96 (50.17) b
	G. mellonella	36.00 (36.84) cde	52.64 (46.52) a	34.00 (35.65) abc	42.59 (40.69) ab
Red	*C. cephalonica*	37.33 (37.61) cde	48.81 (44.31) a	51.33 (45.76) cd	57.94 (49.61) b
	G. mellonella	24.67 (29.76) abc	45.92 (42.64) a	30.67 (33.58) ab	46.90 (42.75) ab

(Figures in parenthesis are corresponding arcsine transformed values)

The Tukey HSD test does not reveal significant differences between means in columns with the same letter after them (P ≤ 0.05)

Results from our studies indicate that *G. mellonella* possess many desirable characteristics and has the potential for being used in mass production of the parasitoid, *Trichogramma spp*. Also, these findings highlighted the usage of white tricho-cards appropriate for *Trichogramma pretiosum* and *T. japonicum* mass production in the laboratory. Green coloured cards also support maximum rate of oviposition in case of *T. japonicum* and maximum adult emergence in *T. pretiosum*. This coloured egg card may encourage the parasitoid female to lay additional eggs. Blue and yellow -coloured cards can also perform well as compared to others. Thus, it can be concluded that be green, blue and yellow cards can be use alternatively with white colour cards in mass production of *Trichogramma*.

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