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Research Article

Fate of the released trichocards in sugarcane vis-à-vis ant predation

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ABSTRACT: The egg parasitioid *Trichogramma chilonis* is released as Trichocards during inundative releases against sugarcane borers. A study was undertaken to assess the fate of these cards in the field after their release. Results revealed that the eggs, whether they were unparasitized or freshly parasitized or those had turned black due to parasitization had failed to deter the predators, regardless of the age of the crop on which the cards were placed. In the present study, the ant species found predating on the eggs in the *Corcyra cephalonica* cards and Trichocards were *Monomorium aberrans* Forel., *Camponotus compressus* F., and *Solenopsis geminata*_(F.). The predation did not vary based on the time interval allowed to lapse in the field. These findings show that the predator activity was random and that the encounter was by chance. When the cards were placed in net bags and tied to the plant, there was complete protection of the *Corcyra* cards and Trichocards. However, the time required for handling and tying these guarded bags for each release rendered it impractical. Hence, the Trichocards should either be released after the cards show at least 2% of the parasitoid emergence or had completed emerging just before release, to have maximum safety on the field.

KEY WORDS: *Trichogramma chilonis, Corcyra cephalonica*, safety, parasitoids, predation, ants, sugarcane

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INTRODUCTION

Trichogramma chilonis Ishii has long been used as inundative releases against lepidopterous pest in India and routinely released for shoot and inter node borers of sugarcane. Though several methods have been tried and practiced for release of the parasitoid, the commonest method used in India, is the release of the parasitoid as Trichocards, *i.e*., as the parasitized *Corcyra cephalonica* Stainton eggs pasted on to chart paper bits and stapled to the sugarcane leaves.

In sugarcane, weekly as well as fortnightly releases of the *T. chilonis* has been recommended for the management of different lepidopterous borers (Kalyanasundaram *et al*., 1993; Geetha, 2010). However, this mode of release resulted in some gap or lull in the parasitoid activity because of which some fraction of egg population of shoot borer, *Chilo infuscatellus* Snellen or inter node borer, *Chilo sacchariphagus indicus* (Kapur) was not targeted at (Mukunthan, 2006). Thus, it would be more effective to release Trichocards containing parasitized *C. cephalonica* eggs of different parasitoid ages or of differential emergence rather than having parasitoids emerging on the same day (time) and perishing together. However, it is not known what happens to the cards and the eggs contained therein sometime after it is left in the field. Since, the eggs in the parasitoid card (Trichocard) may harbour the parasitoid in different stages of development when the cards are stapled onto the plant, the parasitoid in the card will be exposed to abiotic and biotic factors which may or may not result in loss of eggs (parasitoids) in the field. In sugarcane field, the activity of three species of ants were found to be common during the crop duration and several times it had been observed by this author the ants were attending to and feeding on the eggs in the cards thus stapled.

Though, many authors reported that predation on parasitized eggs in the field may reduce the effectiveness of releases (Bento *et al*., 1998; Gomez *et al*., 1998; Pereira *et al*., 2004; Suh *et al*., 2000), as quoted by Pereira *et al*. (2004) the direct impact of predators on *Trichogramma* releases has not been well documented. Hence, this study was conducted to assess the fate of the cards the field to determine a. whether the current practice of stapling the Trichocards will result in loss of parasitoids with lapse of time b. whether crop growth has an impact on the safety of the parasitoid cards and c. if there was predation of cards by ants, will there be any discrepancy of predation on the unparasitized cards, freshly parasitized cards and the trichocards with the eggs that have turned black (parasitoid pupae).

MATERIALS AND METHODS

The effect of parasitization on eggs in the Trichocards from being attacked by ants, the major source of risk for

these cards was assessed for duration of seven days in two tests. The fate of a. the cards which were exposed for 24 hrs to the parasitoid and b. cards that had turned black due to parasitization was studied on sugarcane crop of different ages, *viz*., 45 days, 4 months, 6 months, 8 months and 10 months in comparison to c. cards with unparasitized and sterilized eggs of *C. cephalonica*. In the first set of experiments, the fate of Trichocards with parasitized eggs that had blackened (pupal stage of the parasitoid) was assessed in comparison to unparasitized and sterilized *C. cephalonica* egg cards. The former is the usual stage of the parasitoid that is released in the field. However, another experiment was carried out to assess whether the act of parasitization itself protects the parasitized eggs on the cards from predation. Hence, in the second set of experiments, freshly parasitized Trichocards were compared against the unparasitized *C. cephalonica* cards.

Experiment 1: At least 100 eggs of a) UV-sterilized *C. cephalonica* (UP) and b) UV-sterilized *C. cephalonica* eggs which had turned black (BE) due to parasitization by *T. chilonis* (pupal stage of parasitoid development; 4 day old parasitized card) were pasted in individual yellow chart paper cards of size 8 x 3 cm per replication and eight such replications were used for each treatment. The respective cards were stapled onto ventral side of the leaves at half the plant height at each age of crop tested. Seven sets of both unparasitized and parasitized cards with eggs that had turned black were placed in the field at 10m distance of each other, of which each set was collected at 24h interval for 7 days (the maximum time required for emergence of adults from the freshly parasitized cards) to assess impact of exposure of the cards as done normally during inundative releases. The number of eggs that were left safe in the card at the time of recovery was observed and percent recovery was worked out.

Experiment 2: Atleast 100 eggs of a) unparasitized (UP), UV-sterilized *C. cephalonica* and b) UV-sterilized *C. cephalonica* eggs which were exposed to *T. chilonis* (FP) for 24h were pasted in individual yellow chart paper cards of size 8 x 3 cm per replication and eight such replications were used for each replication and the experiment was laid as in the style of the experiment 1. After retrieval of cards, the freshly parasitized cards were incubated in the ambient temperature (28±2°C) for three days to observe the percent of parasitized eggs and unparasitized eggs which was done to see whether the predators could sense and avoid parasitized eggs from unparasitized eggs and if so, what is the proportion of parasitization required to thwart the predatory attempts. When there was emergence in the parasitized cards which is indicated by the emergence hole in the egg, it was accounted as an egg/parasitoid left safe.

Both the experiments were conducted on sugarcane crop of different ages, i.e, 45 days, 4 months, 6 months, 8 months and 10 months to understand the impact of crop canopy and its influence on predator activity, thus, the safety of eggs i.e., either unparasitized or freshly parasitized or parasitized *C. cephalonica* eggs that have turned black.

To understand the safety of the eggs when covered with a "net-bag", a similar set of cards (with sterilized unparasitized *C. cephalonica* eggs, freshly parasitized *C. cephalonica* eggs and parasitized eggs that have turned black) were placed in separate "mosquito- net- bags", were stapled on to sugarcane leaves and retrieved at 24h interval for seven days.

The data on the per cent of eggs recovered were subjected to angular transformation. Transformed data was analysed for the effect of a) duration of exposure (number of days the cards were left in the field) within a certain age crop b) crop canopy (age of the crop) on the exposure of the cards to predation, through one-way ANOVA (SPSS version 11.5) and the treatment means were compared by S-N-K test (Student- Newman-Keul test; $P = 0.05$). Comparison of means between % eggs retrieved in a) unparasitized cards vs freshly parasitized cards and b) unparasitized cards vs parasitized cards that had turned black on each of day of retrieval within each crop age was done by "t" (independent samples) test (SPSS version 11.5).

RESULTS AND DISCUSSION

The parasitoids were not safe from the predatory activity of ants which were observed to be the only major hazard to the naked eggs on the cards. The predation was at random, unpredictable and swift raid which was independent of a) time of exposure b) the status of the eggs in the trap cards as well as c) the canopy of crop growth (crop age). On the other hand, the cards which were placed in mosquito net bags were completely free of predation.

Safety of UP and BE

In the experiment 1 (Table 1) on 45 day old plants, there was 0.0 to 17.51% of UP *C. cephalonica* eggs that were safe during the seven days exposure period while it was 0.0 to 32.38% among the % of BE that were left safe in the seven days period. There was no significant differences between the UP and BE on any of the days

tested except for the first 24hrs when the percent of UP (17.51) was significantly more than the BE (10.39). The number of days of exposure also did not have any significant differences in case of BE, while, there were overlapping random significant differences in the per cent of UP left safe.

Similar trend of no effect of the period of exposure was proven on four months and six months crop with no significant differences in predation in UP. However, significant differences were noticed on rare occasions in BE though that too was independent of period of exposure. Between UP and BE there were no differences in predation on any particular day of exposure. On eight month and 10 month old crop period of exposure showed some significant differences in predation but, there was no difference in predation due to the status of the cards except in case of 10 month old crop wherein there was statistical difference between UP and BE on day 7 (Table 1).

The high values of S.E (Standard error) of egg predation in all the time periods tested in different ages of crop, further indicated the extremely arbitrary activity of ants and their impact of percent eggs left safe. These results of chaotic predation by ants irrespective of crop age or exposure time are in contradiction to the results of earlier workers. As the time of exposure increased, so were the significant increases in predation of *Sitotroga cerealella* Olivier during inundative releases of *Trichogramma cacoeciae* (Pereira *et al*., 2004).

Safety of UP and FP

There was no distinction followed by the ants in predating eggs on the cards with FP or UP in all ages of crop, except on day 1 in 45 days old crop, the former having significantly more percent of eggs left safe which could be incidental. In the experiment 2 (Table 2), it could be seen that the percent UP that remained in the card, varied from 0 to 28.73 in 45 days old crop when kept for 1-7 days, the rate of safety not being proportional to the number of days the cards were exposed. Similar trend was observed on the 4 months old crop (4.52-70.61% in UP and 10.44-70.88% in FP) also which had dense tillers covering the ground. The percent eggs left free from predation was relatively higher, but, insignificantly different over periods (1-7days) of exposure. Again, on 6 months old crop the predation was high with less than 25% of eggs being safe within 24 hrs of exposure (Table 2). However, on 8 months old crop and 10 months old crop more than 40% of eggs were safe for 48 hrs. In FP too, insignificant differences seen among the periods of exposure of cards on 45 days old crop and 6 months old crop, though on 4 months old crop, 8 months old crop and 10 months old crop some overlapping significant differences proportionate to the most of time periods tested (1-7 days).

When the retrieved cards of freshly parasitized eggs were incubated in the laboratory, the percent parasitized eggs (indicated by blackening of eggs and subsequent emergence holes of adults) and unparasitized eggs could be arrived at (Table 3). Though, largely the number of eggs retrieved had been parasitized, it was not the function of parasitization that had afforded protection, but, chance, as seen by the total effect of insecurity as compared in Table 1 and 2.

Ant activity in terms of attendance to mealy bugs and whiteflies has been recorded in sugarcane in India. Large number of ants was usually seen associated with mealy bugs, of which, the black ant, *Camponotus compressus* F., was the most commonly observed species by the author. Another species associated is *Solenopsis geminata* (F.) (Ram Mohan Rao, 1942). Jayanthi (1986) observed two other species *viz.*, *Monomorium aberrans* Forel., and *Tetraponeura rufonigr*a Jerdon near the mealy bug infested canes, though, the exact role played by these were not known. Whitefly patches were attended by four species of ants*, viz*., *C. compressus*, *Crematogaster brunnea* Sm., *Crematogaster* sp.*, Tapinoma indicus* For., (Prasad, 1954; David and Banerji, 1981). Because of such "attendance" duty, ants are a hindrance to biocontrol.

According to Itioka and Inoue (1996), certain generalist ant species tend to reduce the effectiveness of parasitoid and thus, help the pest to flourish. This may be true of attendant ants of Homoptera preventing the parasitoid activity, while, in case of borers they are fellow competitors of food as they too are natural egg predators of sugarcane borers. Of these, fire ants, *Solenopsis* spp. are among the most prevalent (Fowler *et al*., 1991).

Ant predation of eggs of several stem borers of sugarcane has been recorded abroad (Teran, 1980; Bonhof *et al.*, 1997; Goebel *et al.*, 1999) and India (Easwaramoorthy *et al*., 1983). Natural predation by fire ant *Solenopsis* spp. had been so high that manipulation of its population for control of the sugarcane borer, *Diatraea saccharalis* (Fabr.) in Brazil had been attempted by Rossi and Fowler (2002). *C. compressus*, *M. aberrans*, *Pheridlogetor* spp., are found to feed on shoot borer eggs (Ananthanarayana and David, 1982). In addition to these three species, five species of ants (*Camponotus rufoglaucus* (Jerdon), *T. rufonigr*a, *Oecophylla smargdina*

Table 1. Experiment 1: percent black eggs left safe in the field after specified period of time in unparasitized cards as compared to parasitized cards turned black

Time allowed (Days)	Percent eggs left safe in (Mean ± S.E) £		t (sig. 2 tailed)♣
	UP	BE	
	45 days old crop*		
1	17.51 ± 8.93 b	10.39 ± 5.32a	0.523NS
2	7.73 ± 6.66 ab	18.04 ± 9.28a	0.273 NS
3	3.52 ± 3.52 ab	32.38 ± 13.47a	0.065 NS
4	2.48 ± 1.99 ab	24.93 ± 12.70a	0.147 NS
5	0.0 0± 0.00 a	13.89 ± 9.58a	0.159 NS
6	3.49 ± 1.88 ab	9.69 ± 7.28a	0.528 NS
7#	0.0 ± 0.0a	0.00 ± 0.00a	
	4 months old crop*		
1	44.29 ± 10.95a	72.36 ± 12.57b	0.105 NS
2	20.89 ± 10.08a	40.89 ± 12.23ab	0.278 NS
3	33.69 ± 14.48a	32.13 ± 12.91ab	0.897 NS
4	15.85 ± 9.88a	36.71 ± 14.34ab	0.318 NS
5	17.08 ± 11.59a	24.43 ± 12.69ab	0.695 NS
6	7.64 ± 5.18a	9.20 ± 8.47a	0.942 NS
7	25.2 ± 13.13a	21.70 ± 11.47ab	0.903 NS
	6 months old crop*		
1	14.53 ± 8.70a	28.67 ± 10.65a	0.323 NS
2	21.25 ± 8.23a	23.52 ± 12.22a	0.968 NS
3	10.01 ± 7.00a	39.53 ± 14.21a	0.086 NS
4	11.61 ± 7.16a	31.03 ± 11.53a	0.190 NS
5	5.49 ± 5.49a	14.09 ± 9.73a	0.469 NS
6	5.98 ± 5.98a	8.45 ± 8.45a	0.848 NS
7	2.67 ± 2.67a	16.89 ± 11.26a	0.292 NS
	8 months old crop		
1	69.97 ± 9.88 b	78.06 ± 8.33 c	0.429 NS
2	39.67 ± 13.89 ab	49.00 ± 13.77 bc	0.677 NS
3	37.54 ± 12.69 ab	64.27 ± 11.21 bc	0.131 NS
4	39.74 ± 13.71 ab	75.42 ± 8.98 bc	0.045 NS
5	19.60 ± 9.37 a	39.17 ± 13.48 ab	0.310 NS
6	5.68 ± 5.16 a	12.75 ± 6.66 a	0.429 NS
7	0.69 ± 0.69 a	4.55 ± 3.08 a	0.323 NS
	10 months old crop		
1	43.91 ± 9.84 b	58.01 ± 7.65 c	0.192 NS
2	33.41 ± 10.74 b	54.55 ± 10.30 c	0.132 NS
3	30.87 ± 8.41 b	43.17 ± 10.65 c	0.318 NS
4	37.62 ± 8.01 b	36.41 ± 7.46 bc	0.949 NS
5	17.10 ± 7.02 ab	16.63 ± 8.90 ab	0.874 NS
6	5.23 ± 2.73 a	10.37 ± 2.92 ab	0.132 NS
7	0.77 ± 0.52 a	2.78 ± 1.30 a	0.022 S

£ Treatment means were compared by S-N-K test (Student- Newman- Keul test; $P = 0.05$); Means in a column (within a specific crop period within either UP/ BE) followed by the same alphabet are not significantly different.

*Not statistically significant; # Since S.E. is 0, t value cannot be computed.

♣ Comparison between UP and BE within a particular period of exposure in a given crop age

Table 2. Experiment 2: Percent eggs left safe in the field after specified period of time in unparasitized cards as compared to freshly parasitized cards

Time allowed (Days)	Percent eggs left safe in (Mean ± S.E) £		t (sig. 2 tailed)♣
	UP	BE	
	45 days old crop*		
1	3.71 ± 3.71 ab	19.34 ± 6.39 a	0.01 S
2	19.29 ± 6.76 b	15.50 ± 8.34 a	0.55 NS
3	4.76 ± 3.01 ab	11.94 ± 3.95 a	0.103 NS
4	23.73 ± 9.48 b	8.49 ± 5.23 a	0.175 NS
5	7.28 ± 3.40 ab	21.84 ± 7.49 a	0.150 NS
6	7.92 ± 5.01 ab	8.84 ± 5.12 a	0.939 NS
7	0.0 ± 0.0 a	2.22 ± 0.97 a	0.027 NS
	4 months old crop		
1	70.61 ± 11.45 b	70.08 ± 12.12 c	0.920 NS
2	37.36 ± 13.98 ab	52.12 ± 13.35 abc	0.396 NS
3	41.56 ± 15.88 ab	58.05 ± 12.17 bc	0.427 NS
4	43.73 ± 14.72 ab	27.21 ± 10.98 abc	0.478 NS
5	21.67 ± 12.12 ab	10.44 ± 9.65 a	0.509 NS
6	18.50 ± 12.37 ab	19.34 ± 11.49 ab	0.886 NS
7	4.52 ± 4.52 a	19.93 ± 11.90 ab	0.238 NS
	6 months old crop*		
1	21.80 ± 8.70	42.28 ± 14.16	0.337 NS
2	12.19 ± 8.19	21.40 ± 9.47	0.425 NS
3	9.80 ± 6.00	24.07 ± 12.60	0.411 NS
4	13.03 ± 9.25	19.14 ± 10.04	0.662 NS
5	6.45 ± 5.30	17.58 ± 11.86	0.470 NS
6	0.00 ± 0.00	4.69 ± 4.69	0.331 NS
7	8.61 ± 8.61	8.56 ± 8.56	0.997 NS
	8 months old crop		
1	68.28 ± 12.84 b	83.93 ± 6.12 c	0.323 NS
2	57.79 ± 13.20 b	57.80 ± 13.44 bc	0.997 NS
3	55.55 ± 10.71 b	64.10 ± 11.25 bc	0.640 NS
4	32.20 ± 10.57 ab	42.03 ± 14.11 ab	0.730 NS
5	12.50 ± 7.91 a	20.07 ± 9.70 a	0.553 NS
6	2.19 ± 1.50 a	5.13 ± 4.52 a	0.725 NS
7	0.00 ± 0.00 a	8.37 ± 8.37 a	0.331 NS
	10 months old crop		
1	64.40 ± 7.18 d	71.10 ± 4.73 e	0.439 NS
2	42.38 ± 7.77 c	49.61 ± 6.22 d	0.449 NS
3	27.49 ± 6.70 bc	35.34 ± 6.32 cd	0.415 NS
4	23.85 ± 4.38 bc	33.16 ± 3.84 cd	0.134 NS
5	13.71 ± 7.07 ab	23.24 ± 5.02 bc	0.124 NS
6	8.46 ± 4.16 ab	13.35 ± 5.26 ab	0.459 NS
7	1.33 ± 0.92 a	4.19 ± 2.06 a	0.256 NS

£ Treatment means were compared by S-N-K test (Student- Newman- Keul test; $P = 0.05$); Means in a column (within a specific crop period within either UP/ BE) followed by the same alphabet are not significantly different.

*Not statistically significant; # Since S.E. is 0, t value cannot be computed.

♣ Comparison between UP and BE within a particular period of exposure in a given crop age

Table 3. Percent unparasitized and parasitized eggs found safe in (retrieved) freshly parasitized cards

Time allowed (Days)	Proportion of eggs left safe in FP(Mean±S.E)	
	% parasitized eggs	% unparasitized eggs
	45 days old crop	
1	63.49 ± 11.72	16.51 ± 5.75
2	26.59 ± 13.54	3.42 ± 1.77
3	46.46 ± 12.13	24.04 ± 8.68
4	17.70 ± 11.80	2.30 ± 1.55
5	40.94 ± 12.21	19.36 ± 7.11
6	36.47 ± 15.00	2.54 ± 1.79
7	22.60 ± 12.32	7.38 ± 5.77
	4 months old crop	
1	67.48 ± 11.61	12.68 ± 3.55
2	47.63 ± 8.73	32.37 ± 6.50
3	74.21 ± 9.66	15.79 ± 5.32
4	45.97 ± 13.30	14.03 ± 5.90
5	24.47 ± 12.96	5.53 ± 4.52
6	31.86 ± 13.29	8.14 ± 4.30
7	23.80 ± 12.31	6.20 ± 3.86
	6 months old crop	
1	39.64 ± 13.47	10.35 ± 4.34
2	28.93 ± 12.22	11.07 ± 5.51
3	25.89 ± 13.21	3.45 ± 2.20
4	24.43 ± 12.60	4.57 ± 3.34
5	16.61 ± 11.12	4.39 ± 2.95
6	6.53 ± 6.53	3.47 ± 3.47
7	5.38 ± 5.38	4.62 ± 4.62
	8 months old crop	
1	67.76 ± 3.30	32.24 ± 3.30
2	50.07 ± 11.52	19.93 ± 5.68
3	68.78 ± 11.75	8.52 ± 1.87
4	44.21 ± 14.78	5.79 ± 2.27
5	23.68 ± 12.28	6.33 ± 3.98
6	0.07 ± 0.07	0.03 ± 0.03
7	1.73 ± 1.73	8.27 ± 8.27
	10 months old crop	
1	28.69 ± 2.86	71.35 ± 2.86
2	25.82 ± 3.11	74.18 ± 3.11
3	33.90 ± 5.58	56.05 ± 7.43
4	25.49 ± 4.40	71.54 ± 4.94
5	27.28 ± 4.85	62.72 ± 7.93
6	19.96 ± 6.24	50.05 ± 11.80
7	13.84 ± 6.04	26.15 ± 10.88

Fabr., *S. geminata*, *Anopleolepis longipes* Jerdon) are predators on *Chilo sacchariphagus indius* eggs (Easwaramoorthy *et al*., 1984).

That, the ants are competitors for *T. chilonis* have been proven earlier. Keeping in view of predation by ants, releases of *T. chilonis* has been suggested to be done when the natural predation by ants is very low (Goebel *et al*., 2010). In the study, it is also proven that their indiscriminate predation destroys *T. chilonis* which may be happening in nature, i.e., the eggs parasitized by the parasitoids may also be eaten up by the ants.

In the present study, the three species of ants found predating on the eggs in the *C. cephalonica* cards and Trichocards were *M. aberrans, C. compressus* and *S. geminata.* Ants have been reported to be important predators of *Sitotroga cerealella* eggs, parasitized by *Trichogramma exiguum* Pinto and Platner, and significantly reduced the control of sugarcane borers (Gomez *et al*., 1998). In other crops also, the efficacy of inundative releases of different species of *Trichogramma* suffered due to predation on parasitized eggs (Bento *et al*., 1998; 1999; Pereira *et al*., 2004; Suh *et al*., 2000).

In the present study, though, other predators *viz*., *Paederus fuscipes* (early stages of crop) and several species of coccinellids were observed, they were never found feeding on the *C. cephalonica* eggs with or without parasitism by *T. chilonis*. Rarity of such predation by predators other than ants on released cards had earlier been reported (Pereira *et al*., 2004).

Effect of plant age on the predation

There was no difference in the activity of ants among the crops of different ages barring the distinct low activity in the 8 months old crop which afforded better protection of eggs in the first three days of exposure of UP and the day 1, 3 and 4 BE in the experiment 1 (Table 4). The differences in predation on any day other than the first day (24h) were found to be insignificantly varying in crop of other ages. On first day, the per cent eggs safe were the lowest on 45 days old crop and 6 months old crop and significantly different from that on crops of 4 months, 8 months and 10 months whether the cards were UP or FP.

In the experiment 2, it could be seen that except on day one, there was no effect of age of the crop seen in the predation on UP or FP by ants (Table 5). This is in contrast with the results obtained by Pereira *et al*. (2004) who found increased predation of *T. cacoeciae* with increase in time. However, in their studies the predation decreased after 3 days of exposure time. Ant predation of eggs in sugarcane was observed to be 70-100% on six months old crop (Goebel, 1999). There was direct proportionate impact of time lapse on the predation of *Ephestia kuehniella* Zeller eggs parasitized by *T. exiguum* placed in pine plantations and higher herbaceous ground cover had significantly more predation than the other microhabitats (Orr *et al*., 2000). However, no such distinction in ant activity was noticed in the present study.

Effect of protective bags on safety of *Corcyra* cards and Trichocards

Irrespective of age of the crop as well as the status of the eggs (UP, FP and BE), 100 percent protection was observed throughout the seven days exposure due to the mosquito-net bags. The ants did neither attend nor attempted to enter the bags. However, making the bags (not available commercially) and tying them to sugarcane shoot or stalk was cumbersome, time- consuming and labourious, more so in grown-up crop. Elsewhere in the world, in order to prevent ants from feeding on parasitized eggs, dispensers with tiny holes have been tested by Goebel *et al.* (2010). These boxes may be with tiny holes less than 3 mm to prevent the entry of ants, the major source of predation. However, such dispensers may not be economical in Indian context and for multiple releases necessary for effective *C. s. indicus* management (Geetha *et al.,* 2009, 2010). A formulation of waxed cardboard capsules (about 5 cm^3) each containing *T. exiguum* developing inside *E. kuehniella* eggs was developed by Orr *et al*., (2000). Four small holes made during the encapsulation process were large enough for adults to escape, but, small enough to prevent most predators from entering the capsules. But, ants found their way into this encapsulation also. The ants apparently gained entry to the capsules by chewing the perimeter of capsules and widening the holes. However, the same encapsulation technique helped prevention of predation by ants on *Trichogramma brassicae* in corn (Orr, 1993) or on *T. exiguum* in cotton (Suh *et al.*, 1998). Because of such crop- based variability in performance of encapsulation, it is imperative to arrive at a device suitable for releases in sugarcane by trial and error.

Ant repellants with effective amount of a carboxylic acid selected from the group consisting of 2-methyl-hexanoic acid and trans-2-hexenoic acid, for use on several surfaces have been patented (United States Patent 5648390) which is claimed to be of “great value for preventing fire ants from attacking various biological control agents, such as parasitic wasps, which are used to control a host of

Table 4. Impact of age of the crop on the safety of the *Corcyra* cards and Trichocards: Experiment 1

Days allowed	Age of the crop $				
	45 days	4 months	6 months	8 months	10 months
			% eggs safe in UP		
1	17.51 ± 8.93 A	44.29 ± 10.95 AB	14.53 ± 8.70 A	69.97 ± 9.88 B	43.91 ± 9.84 AB
2	7.73 ± 6.66 AB	20.89 ± 10.08 AB	21.25 ± 8.23 A	39.67 ± 13.89 B	33.41 ± 10.74 AB
3	3.52 ± 3.52 A	33.69 ± 14.48 A	10.01 ± 7.00 A	37.54 ± 12.69 B	30.87 ± 8.41 AB
4*	2.48 ± 1.99	15.85 ± 9.88	11.61 ± 7.16	39.74 ± 13.71	37.62 ± 8.01
5*	0.0 0 ± 0.00	17.08 ± 11.59	5.49 ± 5.49	19.60 ± 9.37	17.10 ± 7.02
6*	3.49 ± 1.88	7.64 ± 5.18	5.98 ± 5.98	5.68 ± 5.16	5.23 ± 2.73
7	7.73 ± 6.66 A	25.2 ± 13.13 B	2.67 ± 2.67 AB	0.69 ± 0.69 AB	0.77 ± 0.52 AB
	% eggs safe in BE				
1	10.39 ± 5.32 A	72.36 ± 12.57 B	28.67 ± 10.65 A	78.06 ± 8.33 B	58.01 ± 7.65 B
2*	18.04 ± 9.28	40.89 ± 12.23	23.52 ± 12.22	49.00 ± 13.77	54.55 ± 10.30
3	32.38 ± 13.47 A	32.13 ± 12.91 B	39.53 ± 14.21 A	64.27 ± 11.21 B	43.17 ± 10.65 AB
4	24.93 ± 12.70 A	36.71 ± 14.34 AB	31.03 ± 11.53 AB	75.42 ± 8.98 B	36.41 ± 7.46 AB
5*	13.89 ± 9.58	24.43 ± 12.69	14.09 ± 9.73	39.17 ± 13.48	16.63 ± 8.90
6*	9.69 ± 7.28	9.20 ± 8.47	8.45 ± 8.45	12.75 ± 6.66	10.37 ± 2.92
7*	0.00 ± 0.0	21.70 ± 11.47	16.89 ± 11.26	4.55 ± 3.08	2.78 ± 1.30

$ One way ANOVA; Treatment means were compared by S-N-K test (Student- Newman- Keul test; $P = 0.05$);
Means in a row followed by similar alphabets are not significantly different.
* Treatment means are not significantly different.

crop pests". Experiments with prior application of such substances could pave way for possible protection of inundatively released parasitoids.

Several factors limit the efficacy of *T. chilonis* in the field during the inundative releases (Smith, 1996; Mukunthan, 2006), of which, the successful distribution of the parasitoid within the target field is solitary factor that is in the control of the user. In order to execute this, the parasitoid should be protected from its natural predator, the ants for survival and dispersal. Hence, a parasitioid – dispensing mechanism would ensure safety of the parasitoid in the field. It would also be useful to release parasitized eggs with different stages of development of *T. chilonis* so as to have continuous emergence and availability of *T. chilonis* to target shoot borer or inter node borer eggs from over lapping broods in the cropping season. Presently, it is advisable to release the Trichocards 24hrs after adult emergence or at least after 2% of the adult emergence from the source container, so that, by the time the cards are placed in the field, the parasitoids would be able to escape predation.

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Table 5. Impact of age of the crop on the safety of the Corcyra cards and Trichocards: Experiment 2

Days allowed	Age of the crop $				
	45 days	4 months	6 months	8 months	10 months
			% eggs safe in UP		
1	3.71 ± 3.71 A	70.61 ± 11.45 AB	21.80 ± 8.70 A	68.28 ± 12.84 B	64.40 ± 7.18 AB
2	19.29 ± 6.76	37.36 ± 13.98	12.19 ± 8.19	57.79 ± 13.20	42.38 ± 7.77
3	4.76 ± 3.01	41.56 ± 15.88	9.80 ± 6.00	55.55 ± 10.71	27.49 ± 6.70
4	23.73 ± 9.48	43.73 ± 14.72	13.03 ± 9.25	32.20 ± 10.57	23.85 ± 4.38
5	7.28 ± 3.40	21.67 ± 12.12	6.45 ± 5.30	12.50 ± 7.91	13.71 ± 7.07
6	7.92 ± 5.01	18.50 ± 12.37	0.00 ± 0.00	2.19 ± 1.50	8.46 ± 4.16
7	0.0 ± 0.0	4.52 ± 4.52	8.61 ± 8.61	0.00 ± 0.00	1.33 ± 0.92
	% eggs safe in FP				
1	19.34 ± 6.39 A	70.08 ± 12.12 B	42.28 ± 14.16 A	83.93 ± 6.12 B	71.10 ± 4.73 B
2	15.50 ± 8.34	52.12 ± 13.35	21.40 ± 9.47	57.80 ± 13.44	49.61 ± 6.22
3	11.94 ± 3.95	58.05 ± 12.17	24.07 ± 12.60	64.10 ± 11.25	35.34 ± 6.32
4	8.49 ± 5.23	27.21 ± 10.98	19.14 ± 10.04	42.03 ± 14.11	33.16 ± 3.84
5	21.84 ± 7.49	10.44 ± 9.65	17.58 ± 11.86	20.07 ± 9.70	23.24 ± 5.02
6	8.84 ± 5.12	19.34 ± 11.49	4.69 ± 4.69	5.13 ± 4.52	13.35 ± 5.26
7	2.22 ± 0.97	19.93 ± 11.90	8.56 ± 8.56	8.37 ± 8.37	4.19 ± 2.06

$ One way ANOVA; Treatment means were compared by S-N-K test (Student- Newman- Keul test; P = 0.05);
Means in a row followed by similar alphabets are not significantly different.
* Treatment means are not significantly different.

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