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International Journal of Current Research
Vol. 9, Issue, 09, pp.56898-56901, September, 2017

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

RELATIVE COMPETITIVENESS FOR PROGENY PRODUCTION IN *TRICHOGRAMMA CHILONIS* VERSUS *TRICHOGRAMMA JAPONICUM* ON *CORCYRA CEPHALONICA* EGGS

***,[1]Judy, S., [1]Sithanantham, S., [2]Sanjayan, K. P. and [1]Manikandan, K. R.**

[1]Sun Agro Biotech Research Centre, 3/1798, Main Road, Madanandapuram, Porur, Chennai-600125
[2]Guru Nanak College, Department of Advanced Zoology & Biotechnology, Velachery Main Road, Chennai- 600 042, India

ARTICLE INFO

Article History:
Received 17th June, 2017
Received in revised form
09th July, 2017
Accepted 23rd August, 2017
Published online 29th September, 2017

Key words:

Trichogramma,
Progeny production,
T.chilonis,
T.japonicum,
Competitiveness.

ABSTRACT

Mass reared trichogrammatid egg parasitoid species are deployed globally for augmentative biocontrol of many lepidopteran crop pests. In India, *Trichogramma chilonis* Ishii is being recommended for release against of many caterpillar pests, while *T. japonicum* with longer ovipositor is advocated against yellow stem borer in rice or top borer in sugarcane to reach the eggs which are covered by the moth scales. When these two Trichogrammatid species either co- occur in crop ecosystems or are released simultaneously in the same target crop , their relative progeny production will depend both on their innate fecundity and also the competitive ability of the females to parasitise the available host eggs in the same niche. In the first laboratory study, mated females of two species-*T.chilonis* and *T.japonicum* were kept, both alone (6:0 and 0:6) and together in ratios of 3:3, 5:1, 1:5, for oviposition on equal numbers of eggs of the factitious host, *Corcyra cephalonica*.. The progeny produced had more numbers of *T.chilonis* than *T.japonicum* across most ratios. The two species were which case the progeny production was greater when *T.chilonis* was allowed access first instead of *T.japonicum* first. successive, which confirmed that *T.japonicum* as both less fecund and less competitive for progeny production with *Trichogramma chilonis.*

Citation: Judy, S., Sithanantham, S., Sanjayan, K. P. and Manikandan, K. R. 2017. "Relative competitiveness for progeny production in *Trichogramma chilonis* versus *Trichogramma japonicum* on *Corcyra cephalonica* eggs", *International Journal of Current Research*, 9, (09), 56898-56901.

INTRODUCTION

In augmentative biological control using repeated releases of *Trichogramma* species is mainly against caterpillar pest especially borers, there is likelihood of two different egg parasitoids competing for oviposition /survival in the same target hosts (Vinson, 1972; 1976). Such competition may be between genera as in *Telenomus* Vs. *Trichogramma* or between two species, like *Trichogramma chilonis* Ishii Vs. *Trichogramma japonicum* Ashmead, which may be present already or released concurrently in overlap to control different genera of Lepidopteran pests in the same target crop ecosystem. In sugarcane, for instance, *T.chilonis* is recommended for biocontrol of the internode borer (*Chilo sacchariphagus indicus),* while *T.japonicum* is recommended for release against the top shoot borer (*Scirphophaga excerptalis*) (Sithanantham *et al*., 2013). These two target pests can occur in overlap during the 5th to 10th month age of the crop and there is scope for competition between the two species (*T.chilonis* and *T.japonicum*). As illustrated by Vinson (1972) the two parasitoids may compete for survival even at their immature stages while co-inhabiting the same insect host. Accordingly, it is preferable to assess the nature and extent of the competitiveness between the female adults of the two species for oviposition access to the same host eggs and also between their embryos inside the host eggs for survival In a further such study by Tavares and Voegele (1990), the inter-specific competition among three trichogrammatid species had been elucidated, using eggs of the laboratory host (*Ephestia kuehniella*). The present laboratory study has been initiated to assess the competition pattern between *T.japonicum* and *T.chilonis*, using the eggs of the factitious host-*Corcyra cephalonica* as a model.

******Corresponding author:* **Judy, S.**
Sun Agro Biotech Research Centre, 3/1798, Main Road, Madanandapuram, Porur, Chennai-600125

MATERIALS AND METHODS

The nucleus cultures of *T.chilonis* versus *T.japonicum* were sourced from the national bureau of Agricultural Insect Resources (ICAR-NBAIR), Bangalore, India and colinies maintained in the laboratory on the eggs of the factitious host-*Corcyra cephalonica* Stainton as per standard protocols described by Nagaraja (2013).

1. Concurrent Exposure Study

In this laboratory study, six mated females of each species (*T.chilonis* and *T.japonicum*) were kept in individual vials (5cm dia), both alone (6:0 and 0:6) and together in ratios of 3:3, 5:1, 1:5. In each tube UV treated host eggs were introduced in 3 different intervals (24 hr, 48 hr and 72 hr). In each tube approximately 300 UV treated *C.cephalonica* eggs were provided and after 3 days of access to the Tricho adults the cards were kept for progeny production observation.

2. Alternative Exposure Study

In this laboratory study, the competitiveness at the immature (egg, larval) stages was compared by availing the *C. cephalonica* eggs for a spell of 6 or 12 hours for oviposition by one species and allowing the other species access to the same eggs for similar duration. The vice-versa situation as well as single species access for 6 or 12 hours oviposition were also kept for comparison and the number of adult progeny emerged was recorded (in 6 replications).

RESULTS

1. Concurrent exposure study

The data showed significant differences in the progeny numbers produced per female when kept alone and at different ratios with the other species both in the case of *T.chilonis* and also for *T.japonicum* (Table.1).

for *T.chilonis* compared to 9.73 for *T.japonicum*. These results indicated that the overall fecundity of *T.chilonis* was greater than *T.japonicum,* without reference to competition between the two species, since each adult was provided independent and abundant access host eggs. The competition between *T.chilonis* and *T.japonicum* during concurrent access to host eggs when equal in ratio (3:3) was evident in progeny production for day 1 (15.4 Vs 10.2) day 2 (9.5 Vs 7.1) and day 3 (6.2 Vs 4.2). The overall progeny production when *T.chilonis* was more dominant (5:1 ratio) was 13.97, which was reduced to 10.37 when it was competing with equal number of *T.japonicum*. On the contratry, when *T.japonicum* adults were dominant, the respective progeny production was 8.33 and 5.63 per adult. In general, the reduction in progeny due to adult competition appeared to be greater in *T.japonicum* than *T.chilonis*. The overall effect of competition at 3 different ratios along with no competition as influencing the progeny production per female per day (average of 3 days) for *T.chilonis* and *T.japonicum* is illustrated in (Fig.1). It is evident that in both the species the presence of the other species caused reduced progeny production in relation to the proportion of the competing species. This trend confirms that the per female progeny in case of both species may be reduced due to either disturbance from oviposition or by post embryonic competition for survival within the host egg. In the case of *T.chilonis* the effect of such ratios on progeny production is illustrated for each of the 3 day ages of the adult. The progeny produced by day 1adults is reduced significantly in Day 2 and Day 3 respectively even in the absence of competition (Fig.2) Further the reduction due to competition by *T.japonicum* was only

Table 1. Mean progeny production in two *Trichogramma* species (*T.chilonis* and *T.japonicum*) in concurrent exposure

	T.chilonis			*Mean*	*T.japonicum*			*Mean*
Treat ments	Day1	Day2	Day3		Day1	Day2	Day3	
T1(3:3)	15.40	9.50	6.20	10.37	10.20	7.10	4.20	7.17
	(22.71)	(17.67)	(14.04)	(18.14) b	(18.45)	(15.23)	(11.45)	(15.04)b
T2(5:1)	18.30	13.50	10.10	13.97	8.70	8.30	5.60	9.17
	(25.06)	(20.92)	(18.41)	(21.46)a	(17.03)	(16.57)	(13.50)	(17.21)a
T3(1:5)	12.90	8.20	3.90	8.33	13.60	5.10	3.10	5.63
	(20.92)	(16.36)	(10.20)	(15.82)c	(21.55)	(12.87)	(9.86)	(13.25)c
T4(6:0)	19.10	14.10	11.10	14.77	13.80	9.30	6.10	9.73
	(25.84)	(22.01)	(19.42)	(22.42)a	(21.77)	(17.56)	(14.18)	(17.84)a
Mean	16.43	11.33	7.83	11.86	11.58	7.45	4.75	7.92
	(23.63)A	(19.24)B	(15.51)C	(19.46)	(19.70)A	(15.56)B	(12.25)C	(15.84)

T.chilonis: CD (p=0.05): Treatment: 1.90**; Days: 1.65** *T.japonicum:* CD (p=0.05): Treatment: 1.07**; Days: 0.93**

Table 2. Progeny number in alternative exposure in two *Trichogramma* species

Treatments	*T.chilonis*	*T.japonicum*	Mean
T1-6Hrs (*T.chilonis* +*T.japonicum*)	100.00	14.60	57.30
	(18.22)a	(10.94) d	(14.58)b
T2-12Hrs (*T.chilonis* + *T.japonicum*)	94.20	31.00	62.60
	(17.85)a	(13.22)c	(15.54)b
T3-6Hrs (*T.japonicum* + *T.chilonis*)	7.40	57.40	32.40
	(9.02)d	(15.36)b	(12.19)d
T4-12Hrs (*T.japonicum* + *T.chilonis*)	9.40	84.00	46.70
	(9.97)d	(17.54)a	(13.75)c
T5-6Hrs (alone)	107.80	91.00	99.40
	(18.74) a	(17.59)a	(18.17)a
T6-12Hrs (alone)	115.20	85.60	100.40
	(19.04) a	(17.68)a	(18.36)a

*CD:(p=0.05)Treatments:23.33** ; Treatment× strains:32.99***

The mean progeny adults emerging when there was no competition for *T.chilonis* during the 3 days of adult life was 19.1, 14.1 and 11.1, for the first, second and third days of adult life respectively, compared to *T.japonicum* which recorded 13.8, 9.3 and 6.1 respectively (Table.1) Further the overall per day progeny emergence for the 3 days cumulatively was 14.77

slight in T2 followed by T1 while T3 was still maintaining reduction in progeny production being not so high although there is maximum dominant by *T.japonicum*. Similar comparison of competing ratios for *T.japonicum* is summarised in Fig. 3. The overall trend of effect of competing ratios was mostly similar to *T.chilonis* however the per adult progeny

production when competing with *T.chilonis* was much lower (about 9.0) compared to *T.chilonis* (about 12.0).

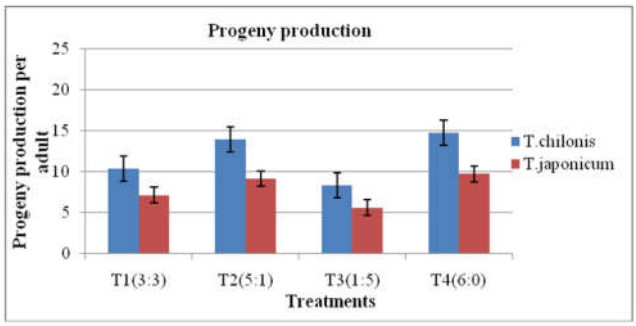


Fig.1. Overall per adult progeny production between two *Trichogramma* species (*T.chilonis* and *T.japonicum*) in concurrent exposure

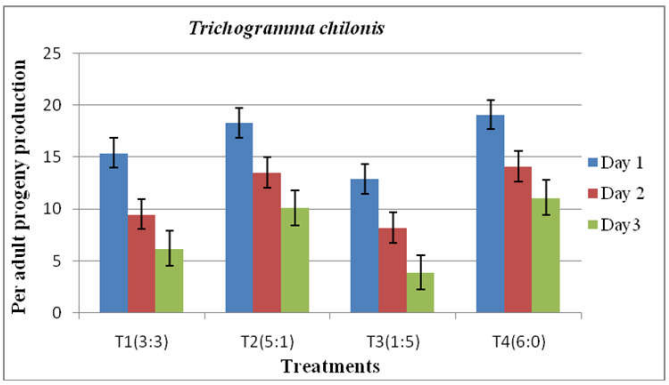


Fig:2. Per adult daily progeny production of *T.chilonis* in concurrent exposure study

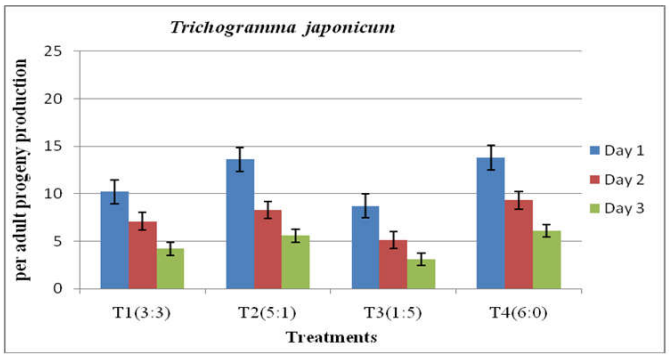
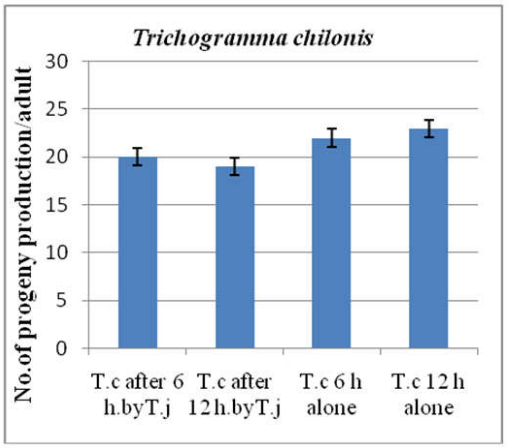


Fig. 3. Per adult daily progeny production of *T.japonicum* in concurrent exposure study



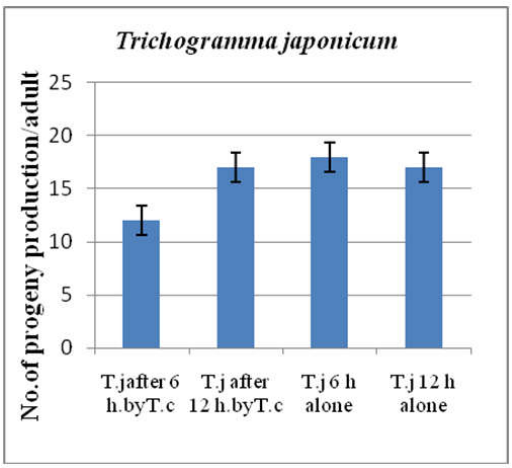


Fig.4. Alternate exposure competitiveness effect on per adult progeny production between two *Trichogramma* species

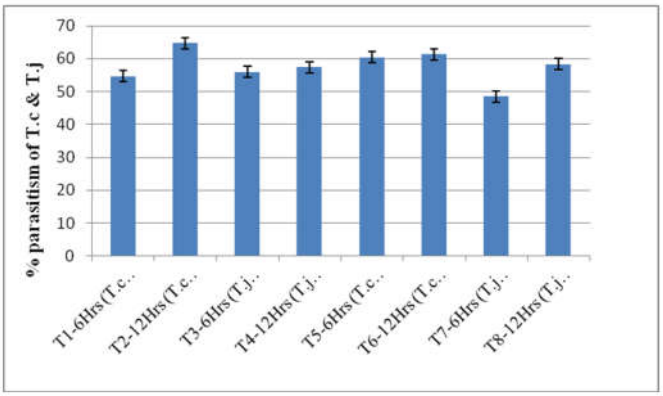


Fig. 5. Overall percentage parasitisation to alternative exposure effect of two *Trichogramma* species combined

2. Results of alternative exposure study

The results (Table.2) showed that overall the progeny numbers of *T.chilonis* in the absence of competition with *T.japonicum* was greater (108 -115 for 6-12 hrs access) compared to when *T.chilonis* access was followed by *T.japonicum* by 6 hrs and 12 hrs, the *T.chilonis* progeny numbers ranging 94-100. On the other hand, for *T.japonicum* in the absence of *T.chilonis*, the progeny numbers were in the range of (86-91), while when succeeded for access to the same host eggs by *T.chilonis*, it was distinctly lower in range (32-47). These results clarified that the progeny number of *T.chilonis* was less affected when succeeded by access to *T japonicum* than the vice versa. Apparently, the greater reduction in progeny numbers in *T.japonicum* suggests possible greater post embryonic competition by *T.chilonis* for survival. This is adequate evidence for the apparent superiority of *T.chilonis* in progeny production is at least partly due to greater post-embryonic survival in competition with *T.japonicum*.In the successive host egg access study, progeny production by *T.japonicum* was lower when the same host eggs were allowed access by *T.chilonis* after 6 hrs, while such adverse effect was not so distinct under exposure after 12 hrs (Fig.4), showing that post-embryonic competition by *T.chilonis* over *T.japonicum* could occur more after shorter oviposition exposure period (6 hrs) than when longer (12 hrs). In the overall percentage parasitisation (blackened eggs) of vice-versa situation, the *Trichogramma* species access to the host eggs in 12 hrs. exposure to *T.chilonis* after exposure to *T.japonicum* was

64.7% compared to *T.chilonis* for 12 hrs alone (61.3%) and 6 hrs alone (60.4%) (Fig.5). Whereas when access by *T.japonicum* after exposure to *T.chilonis* (58.3%) which was close to the progeny production when *T.japonicum* was allowed access for 12 hrs alone (57.4%) and 6 hrs alone *T.japonicum* (56.0%). In this alternative exposure study *T.chilonis* was evidently more competitive compared to *T.japonicum,* and we can, infer that post embryonic competition could occur more actively during 6 hrs alternative exposure than 12 hrs alternative exposure.

DISCUSSION

The present results are apparently the first report confirming that *T.japonicum* is not only less fecund, but also less competitive with *T.chilonis* for progeny production and there is evidence that such competition could also occur at post embryonic stage within the host egg. This is new information comparing these two species, whereas an earlier study (Sasaba, 1965) has compared *T.japonicum* with some other trichogrammatid species for inter-species competition. Similar reports of greater fecundity in *T.chilonis* compared to *T.japonicum* have earlier reported by Ghosh *et al.* (2015). Although Tavares and Voegele (1990) studied the three other trichogrammatid species (*T.embryophagum* Hartig, *T.maidis* Pintureau & Voegele and *T.buesi* Voegele) for such competition in another laboratory host (*Epheslia kuehniella* Zeller), they have also confirmed the present results indirectly that the relative competitiveness between species depending on the timing /duration of access to the host eggs for oviposition.

The present results may be followed up by further studies to distinguish whether the competition is extrinsic as observed by Cabello *et al.* (2011) comparing *Trichogramma brassicae* (idiobiont egg parasitoid) with *Chelonus oculator* (koinobiont egg-larval parasitoid).It is significant that studies on *Spodoptera frugiperda* eggs by Tatiana *et. al.* (2012) showed that between the two egg parasitoids *(Trichogramma pretiosum* and *Telenomus remus)* there was no emergence of the other parasitoid species, which was subsequently provided access while the progeny for only limited to the species to which the eggs were first offer. Such difference in results with the present study suggest that mechanism for recognition of previous parasitisation on the same host may vary between genera of egg parasitoids. Studies by Li-ying *et al.* (1984) comparing *T.japonicum*, *T.confusum* and *T.dendrolimi* had indicated that all three species add exhibited ability to discriminate, but varied in the extent to which they could avoid superparasitism, by not ovipositing in the previously oviposited host egg. Although the present study was not directed at host discrimination, it appears preferable to consider this mechanism also in future studies as they may indirectly influence interspecies competition for the host egg. Shi-chou *et al.* (1993) also obtained comparable results when inter-specific competition when accessed for two types of host eggs (artificial host egg and eggs of *Antheraea pernyi*) for two species of egg parasitoids namely *T.dendrolimi* and *Anastatus japonicus*.

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