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Study of the biology of *Trichogramma chilonis* Ishii (Hymenoptera: Trichogrammatidae) in Mauritius

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ABSTRACT

Maruca vitrata F. is a serious pest of bean (*Phaseolus vulgaris* L.) in Mauritius. During the search of its natural enemies, *Trichogramma chilonis* Ishii was found to parasitize eggs of *M. vitrata* for the first time. Laboratory and field studies were conducted to study the biology of *T. chilonis* developed from *M. vitrata* eggs.

Trichogramma chilonis females lived for about 8.5 $\pm$ 0.7 days in laboratory and produced an average of 42.4 $\pm$ 1.3 eggs during their life time. They laid 80% of their egg complement within four days after emergence. However, egg production was highest on the first day. The sex ratio of emerging progeny was 1:2.2 (♂:♀).One-day old *M. vitrata* eggs were preferred for oviposition whereas 2 and 3-day old eggs for feeding. No parasitism was observed in 3-day old eggs. The combined effect of egg parasitism and feeding resulted in more than 77% mortality in one and two-day old eggs. Only one *T. chilonis* adult emerged from a parasitized egg.

The choice test showed that *T. chilonis* females had a preference for parasitizing eggs of *Helicoverpa armigera* Hb. to *M. vitrata* but did not oviposit in eggs of *Plutella xylostella* L. In the no-choice test, parasitism in eggs of *H. armigera* and *M. vitrata* was significantly higher than that in eggs of *P. xylostella*. Exposed eggs of *M. vitrata* and *H. armigera* in the field were parasitized by *T. chilonis* while those of *P. xylostella* were not.

KEYWORDS: *Trichogramma chilonis*, *Maruca vitrata*, biology, *Plutella xylostella*, *Helicoverpa armigera*, egg parasitism

1.0 INTRODUCTION

Maruca vitrata Fabricius (Lepidoptera: Pyralidae) is a serious pest of bean (*Phaseolus vulgaris* L.) in Mauritius (Unmole, 2007) and its control has so far been based on chemical insecticides (Abeeluck *et al*., 2004). To attempt of biological control of major pod borers (*Lampides boeticus* L., *Etiella zinckenella* Tr. and *M. vitrata*) on legumes, eight species of larval parasitoids were introduced in the country during the 1950's. Two of these species (*Bracon cajani* Mues. and *Eiphosoma dentator* F.) are reported to have contributed to the increase in harvestable pigeon pea crop from 40 to 70% (Greathead, 1971). However, low larval parasitism by these two species was reported by Unmole (2009) during an extensive survey on the abundance of *M. vitrata* and its natural enemies on bean.

Egg parasitoids play an important role in the control of lepidopterous pests (Li, 1994). Two trichogrammatid species (*Trichogrammatoidea eldanae* Viggiani and *Trichogramma evanescens* Westwood) are reported on eggs of *M. vitrata* in Africa and Philippines respectively (Aradokoun, 1996; Ulrichs *et al*., 2002). In Mauritius, Unmole (2009) investigated into the possible existence of egg parasitoids of *M. vitrata* in the field and reported *Trichogramma chilonis* Ishii on exposed sentinel eggs of *M. vitrata* freshly laid on bean plants. This represents the third *Trichogramma* species recovered from *M. vitrata* eggs.

Trichogramma chilonis (formerly referred as *Trichogramma australicum* Girault by Nagarkatti and Nagaraja (1971)) was introduced in Mauritius from India to control the spotted stem borer, *Chilo sacchariphagus* Bojer on sugarcane in 1964 (Greathead, 1971). It is now well established and is reported to be effective against *C. sacchariphagus* (Anon, 1993). However, it has also been reported on seven other lepidopterous pests in the country (Ganeshan and Williams, 2000). Studies have shown differences in biological parameters (developmental rate, survival rate and fecundity) among individuals of a particular *Trichogramma* species raised from different hosts (Lewis *et al*., 1976; Bigler *et al*., 1987; Kazmer and Luck, 1991; Miura and Kobayashi, 1995) and even in performance among strains of same *Trichogramma* species reared on the same host, *Plutella xylostella* L. (Guo *et al*., 1998). Thus, it is highly desirable to investigate into the biology of *T. chilonis* raised from *M. vitrata* eggs.

This paper reports on the biological parameters of *T. chilonis* developed from eggs of *M. vitrata* and its potential in inducing egg mortality in *M. vitrata* and the tomato fruitworm, *Helicoverpa armigera* Hb. and the diamondback moth, *P. xylostella*.

2.0 MATERIALS AND METHODS

Laboratory experiments were conducted at 24ºC-28ºC, 75-80% R.H to determine the fecundity and longevity of *T. chilonis* on *M. vitrata*, its preference for *M. vitrata*, *H. armigera* and *P. xylostella* eggs and egg mortality caused by parasitism and feeding. Studies on egg parasitism in the field were also conducted at Reduit Crop Research Station (CRS) of the Agricultural Research and Extension Unit (AREU) and selected growers' fields.

2.1 Insect cultures

A laboratory colony (F6) of *M. vitrata* was maintained from larvae initially collected from bean fields and reared on mung bean (*Vigna mungo* (L.) Hepper) sprouts for six generations. Moths (10-15 pairs) were placed in a rearing cage (13 x 12 x 13 cm in size) and fed on 10% sucrose solution.

A colony of *P. xylostella* was established from larvae collected in cabbage fields and reared on fresh cabbage leaves in fine nylon mesh cages (50 cm x 50 cm x 50 cm). Thirty pairs of moths were placed in a rearing cage (as above) and fed on 10% sucrose solution.

A colony of *H. armigera* was established from larvae collected in tomato fields and reared on soya diet (artificial diet). Four pairs of moths were placed in a rearing cage (as above) and fed on 10% sucrose solution.

Trichogramma chilonis was procured by exposing freshly laid *M. vitrata* eggs on bean plant in a field at Reduit CRS. Bean seeds were first seeded in plastic pots in a greenhouse. Three weeks after germination, a potted bean plant was placed in a cage with 25 pairs of *M. vitrata* moths for 24 h. Every week, a potted plant with eggs was exposed in an untreated pigeon pea plot (4 m x 4 m) for one month. After 48 h, the plant was brought to the laboratory and its leaves were cut and held in a glass jar. Parasitized eggs (black in colour) were kept in individual glass vials. Emerging parasitoids were sexed under a binocular microscope (x 20). A male and female were placed in a glass vial (5 cm x 1.8 cm diameter) and observed until mating was confirmed. The mated female (1-day old) was then transferred into another vial for use in laboratory experiments.

Oviposition substrates from the colonies of *M. vitrata*, *H. armigera* and *P. xylostella* were examined under a binocular microscope. Strips of substrates with 30 eggs (1-day old) of each pest species were marked with a fine tipped pen and cut for use in laboratory experiments.

To determine egg hatchability, four strips with 1-day old eggs of each of the three host species were held separately in individual 30-mL plastic containers. Eggs were examined daily and hatched eggs were counted.

Adult moths from the three colonies were used to procure eggs on potted tomato, cabbage and bean plants (vegetative stage). Twenty-five pairs of *M. vitrata* moths were released in a nylon mesh cage (72 cm x 72 cm x 72 cm) with a potted bean plant (vegetative stage/ 3 weeks after sowing) and fed on 10% sugar solution. After 24 h, the plant was removed and eggs on leaves were counted. To procure *P. xylostella* eggs on cabbage plant, one hundred and twenty pairs of *P. xylostella* moths were released in a similar cage with a potted cabbage plant (3 weeks after sowing). Similarly, twelve pairs of *H. armigera* moths were released in a similar cage with a potted tomato plant (vegetative stage/ 4 weeks after sowing).

2.2 Longevity and fecundity of female *Trichogramma chilonis*

A cut strip of substrate with *M. vitrata* eggs (n=30) was exposed to a mated female in a vial (5 cm x 1.8 cm diameter) with a streak of honey on its inner wall. The strip was replaced by a fresh one daily until death of the female. The removed strip was held in a 30-mL plastic container and observed daily for 5 days. Parasitized (black in colour) and unparasitized eggs were counted. This experiment was replicated 10 times. Only one *T. chilonis* emerged from a parasitized *M. vitrata* egg. As per the method described by Miura and Kobayashi (1995), the number of *M. vitrata* eggs parasitized by a single female was used to express fecundity of *T. chilonis*.

2.3 Effect of host egg age on parasitism by *Trichogramma chilonis*

A mated female was placed in a glass vial (5 cm x 1.8 cm diameter) with a streak of honey in its inner wall. One cut strip with 30 eggs was introduced in the vial for 24 h. The strip was then transferred to a 30-mL plastic container and observed daily. Parasitized, desiccated (cream in colour and slightly shrunk) and hatched eggs (translucent with a hole) were counted. Egg desiccation is reported as a result of *T. chilonis* females feeding on them (Vasquez *et al.*, 1997; Greenberg *et al.*, 1997) and such desiccated eggs are, henceforth, referred as those punctured and fed by *T. chilonis* females. This experiment was replicated 10 times for each age of egg (1, 2 and 3-day old).

2.4 Sex ratio of offspring of unmated females of *Trichogramma chilonis*

A cut strip with *M. vitrata* eggs was placed in a vial with a 1-day old unmated female. After 24 h, it was transferred to a 30-mL plastic container.

The test was replicated 10 times. Emerged *T. chilonis* adults were sexed under a microscope and recorded.

2.5 Laboratory study on host preference of *Trichogramma chilonis*

The host preference of *T. chilonis* was tested by offering the female the choice among eggs of *M. vitrata*, *H. armigera* and *P. xylostella* in glass vials (5 cm x 2.5 cm diameter). The level of parasitism was also tested under ‘no-choice’ conditions on 1-day old eggs of *M. vitrata*, *H. armigera* and *P. xylostella*.

2.5.1 Choice test

Three cut strips with *M. vitrata*, *H. armigera* and *P. xylostella* eggs (n=30 each) were placed in a glass vial with a mated female. After 24 h, each strip was held in a 30-mL plastic container. After five days, the number of parasitized, desiccated and hatched eggs was recorded. The experiment was replicated four times.

2.5.2 No-choice test

A cut strip with *M. vitrata* eggs was exposed in a glass vial with a mated female for 24 h. Parasitized, desiccated and hatched eggs were recorded as per the method described in the choice test. This test was also run with eggs of *H. armigera* and *P. xylostella*. The test was replicated four times with each of the three host eggs.

2.6 Recovery of *Trichogramma chilonis* at different locations

A potted bean plant with freshly laid *M. vitrata* eggs was exposed in a pigeon pea plot (4 m x 4 m) (local variety) not treated with insecticides for 48 h. The plant was then brought to the laboratory and its leaves with eggs were cut. Eggs on them were counted and held in a glass jar. After enumeration, 32 parasitized eggs were isolated in individual glass vials. Emerging parasitoids from each parasitized egg were counted, identified and sexed. Such exposure was undertaken four times at Réduit CRS and at seven sites in the North (two), East (two) and Central Plateau (three) (Table 4).

2.7 Parasitism in exposed eggs of *Helicoverpa armigera* and *Plutella xylostella*

A potted tomato plant with freshly laid eggs of *H. armigera* eggs was exposed in a tomato plot (3 m x 3m) variety MST 32/1 at flowering/fruiting stage not treated with insecticides. Similarly, a cabbage plant with *P. xylostella* eggs was set in a cabbage plot (3m x 3m) variety Crystal Boy not treated with insecticides. These egg exposures for both pests were replicated four times in same plots. A sample of parasitized eggs (n=32) was isolated and observed as described above.

3.0 STATISTICAL ANALYSIS

Data from selected experiments were arcsine transformed and analyzed by one way ANOVA with means separated by Student Newman Keuls Test (SAS 2004). The percentage of egg desiccation in the eggs exposed to *T. chilonis* was corrected with egg desiccation in the control using Abbott's (1925) formula. Total egg mortality was calculated as the sum of parasitized and desiccated eggs.

4.0 RESULTS

4.1 Biology of Trichogramma chilonis on Maruca vitrata eggs

Females provided with *M. vitrata* eggs and honey lived up to 13 days with an average life span of 8.5 $\pm$ 0.7 ($\pm$ SE) days. Mortality among the ten females was observed as from the seventh day after emergence and only one remained alive on the tenth (Fig. 1). A female laid her full complement of eggs within the first eight days after emergence with an average of 42.4 $\pm$ 1.3 ($\pm$ SE) and a maximum of up to 48 eggs. Thirty eight percent of these eggs were laid on the first day which was significantly higher than those on other days ($F=30.99$; $df=8,79$; $P<0.001$) (Fig. 1).

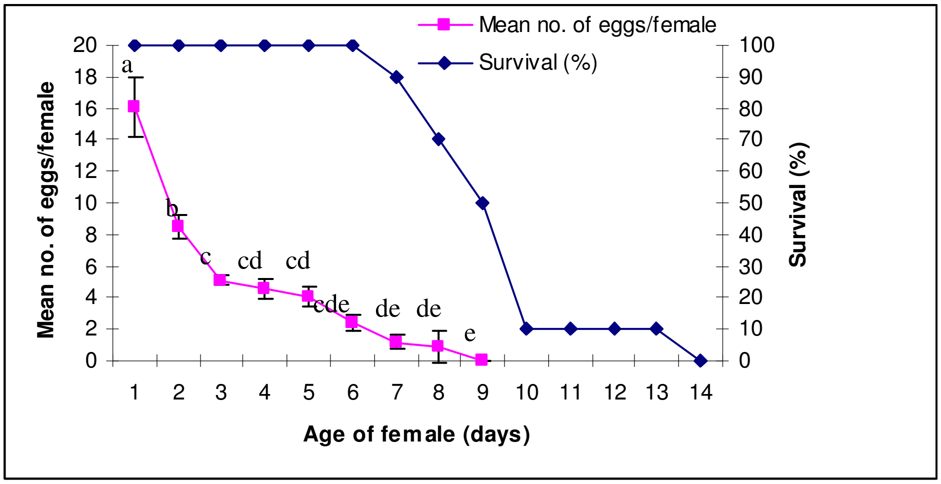

Fig. 1. Mean (± SE) number of eggs laid by a female throughout her lifetime and % survival of females *T. chilonis* reared on *M. vitrata* eggs

Females had laid 98.3% of their eggs by day eight and about 80% of their full complement of eggs within 4 days after emergence.

4.2 Effect of host egg age on parasitism by Trichogramma chilonis

Parasitism was observed in 1 and 2-day old eggs but not in 3-day old ones. The rate of parasitism in 1-day old eggs was significantly higher (56%) than that (26.3%) in 2-day old eggs (F=592.93; df=2, 29; P<0.001). Egg desiccation due to probing by females was significantly lower (23.2%) in 1-day old eggs but higher (>49%) in older ones (F=115.03; df=2,29; P<0.001) (Table 1).

Table 1. The effect of host age on parasitism by female *Trichogramma chilonis*

Age of eggs (days)	Mean parasitism (%)	% Egg mortality due to desiccation		Corrected egg mortality due to desiccation (%)	Total egg mortality (%)
		Exposed to *T. chilonis*	Control		
1	56.0 ± 2.5a	27.7 ± 1.1b	5.8 ± 0.9	23.2b	79.2
2	26.3± 1.5b	53.7 ± 1.4a	5.8 ± 0.9	50.8a	77.1
3	0.0± 0.0c	52.3 ± 1.5a	5.8 ± 0.9	49.4a	49.4

Within a coulumn, means (± SE) with same letter are not significantly different at p=0.05, Student Newman Keuls Test

Egg mortality due to egg parasitism and probing by *T. chilonis* females was high (77.1% in 1-day old and 79.2% in 2-day old). Parasitized eggs of *M. vitrata* (n=194) by unmated female gave rise to males only.

4.3 Host preference of Trichogramma chilonis

In the choice test, parasitism in *H. armigera* eggs was significantly higher (19.2%) than that in *M. vitrata* eggs (10.0%) (F=177.47; df=2,11; P<0.001) (Table 2).

Table 2. Percentage mortality in eggs of *Maruca vitrata*, *Helicoverpa armigera* and *Plutella xylostella* exposed to a mated *T. chilonis* female

Host species	% Egg parasitism *	% Egg desiccation		Corrected egg mortality due to desiccation (%)**	Total egg mortality (%)
		Exposed to *T. chilonis*	Control		
Choice test					
M. vitrata	10.0 ± 1.4b	28.4 ± 1.0a	5.8 ± 0.9	24.0a	34.0
H. armigera	19.2 ± 1.6a	27.5 ± 0.8a	6.3 ± 0.8	22.6a	41.8
P. xylostella	0.0 ± 0.0c	2.5 ± 0.8b	0.5 ± 0.3	2.0b	2.0
No-choice test					
M. vitrata	51.7 ± 5.7a	33.3 ± 2.7a	5.8 ± 0.9	29.2a	80.9
H. armigera	51.7± 5.6a	34.2 ± 0.9a	6.3 ± 0.8	29.8a	81.5
P. xylostella	7.5± 0.9b	5.9 ± 0.9b	0.5 ± 0.3	5.4b	12.9

Within a column, means (± SE) with same letter are not significantly different at p=0.05, Student Newman Keuls Test

The percentage of desiccated eggs of *P. xylostella* was significantly lower than that of *M. vitrata* and *H. armigera* eggs (F=210.62; df= 2,11; p< 0.001) (Table 2).

In the no-choice test, parasitism in eggs of *M. vitrata* and *H. armigera* was significantly higher than that in *P. xylostella* eggs (F=41.13; df=2,11; P<0.001) (Table 2). The percentage egg mortality due to desiccation was significantly lower in eggs of *P. xylostella* than that of *M. vitrata* and *H. armigera* eggs (F=59.25; df= 2,11; p< 0.001) (Table 2). Egg feeding contributed towards an increase in total egg mortality in eggs of *M. vitrata*, *H. armigera* and *P. xylostella* (Table 2).

4.4 Determination of parasitism in exposed eggs of Maruca vitrata, Helicoverpa armigera and Plutella xylostella in the field

Eleven bean plants with 2704 *M. vitrata* eggs were exposed in bean and pigeon pea plots at five sites. Parasitism was not observed in eggs (n=1487) exposed at four sites. But 750 out of the 1217 eggs exposed in pigeon pea plots were parasitized by *T. chilonis* with a mean parasitism rate of 55.7 $\pm$ 12.8. In *H. armigera* eggs exposed in tomato fields, 708 out of 1296 eggs were parasitized with a mean parasitism rate of 52.8 $\pm$ 9.0. No parasitism was observed in eggs of *P. xylostella* exposed in cabbage fields (Table 3). The sex ratio of the *T.chilonis* emerging from parasitized *M. vitrata* and *H. armigera* was 1:2.2 (♂: ♀) and 1: 0.7 (♂: ♀) respectively. Only one *T. chilonis* emerged from a parasitized *M. vitrata* egg while up to two individuals emerged from a parasitized *H. armigera* egg.

Table 3. Parasitism in *Maruca vitrata, Helicoverpa armigera and Plutella xylostella* eggs exposed in legume fields during February to March 2008

Site	Crop habitat	Host eggs exposed	No. of eggs exposed	No. of eggs parasitized	% parasitism
Réduit	Pigeon pea*	*M. vitrata*	305	150	49.2
			226	76	33.6
			246	117	47.6
			440	407	92.5
	Tomato*	*H. armigera*	248	80	32.3
			340	176	51.8
			348	178	51.1
			360	274	76.1
	Cabbage*	*P. xylostella*	493	0	0
			463	0	0
			485	0	0
			476	0	0
Lalmatie	Bean**	*M. vitrata*	205	0	0
			250	0	0
Cottage	Bean**	*M. vitrata*	117	0	0
			360	0	0
Belle Rose	Pigeon pea*	*M. vitrata*	217	0	0
			198	0	0
Nouvelle France	Bean*	*M. vitrata*	140	0	0

* No insecticide treatments
** Treated with lambda cyhalothrin and deltamethrin

5.0 DISCUSSION

The longevity of mated *T. chilonis* females exposed to *M. vitrata* eggs and honey (8.5 ± 0.7 days) in laboratory was comparable to that of *T. chilonis* females exposed to eggs of *C. cephalonica* Stn. (9.25 ± 1.03 days) and honey (Shirazi, 2006) but was comparatively greater than those exposed to *E. kuehniella* Zell. (5.0 ± 1.0 days) and *P. xylostella* eggs (6.0 ± 0.9 days) and honey (Miura and Koyabashi, 1995). Ruberson and Kring (1993) also observed that *T. pretiosum* females lived for about 3 days on honey but 11 days when exposed to bollworm eggs and honey. This prolonged lifespan can be attributed to their feeding on host eggs. When fed on honey alone, *T. chilonis* females lived for an average of 1.9 ± 0.6 days (Alias *et al*., 2004).

The fecundity of *T. chilonis* females (42.4 ± 1.3 eggs during lifetime) reared on *M. vitrata* eggs (this study) was similar to that of *T. chilonis* females on *P. xylostella* eggs (43.6 ± 5.1 eggs/female) (Miura and Koyabashi, 1995) but was comparatively lower than those on *E. kuehniella* (62.5 ± 7.9 eggs/female) and *C. cephalonica* (61.9 eggs/female) eggs (Miura and Koyabashi, 1995; Shirazi, 2006).

Trichogramma chilonis females exhibited an egg laying pattern similar to those reared on *E. kuehniella*, *P. xylostella* and *C. cephalonica* (Miura and Koyabashi, 1995; Shirazi, 2006). The higher rates of parasitism in eggs exposed during the first four days (highest being on the first day) indicate that young females are more fecund. The optimal age of a *T. chilonis* female for parasitism of *M. vitrata* eggs can be considered to be within the first four days after emergence.

The age of eggs of *M. vitrata* influenced parasitization rate of *T. chilonis* females. There was a significantly higher percent parasitism in young eggs (1-day old) and conversely, a higher percent egg desiccation in old ones (2-day and 3-day old). This demonstrates that females prefer young eggs for oviposition and old ones for feeding. Farid *et al.* (2001) also observed that *T. chilonis* females prefer 1-day old eggs of *Sitotroga cerealella* Oliv. for oviposition. In the field, *T. chilonis* females, as other trichogrammatids, are likely to encounter young and old eggs and can cause significantly high egg mortality by either ovipositing or feeding on them. Such increased egg mortality by other trichogrammatids in *P. xylostella* eggs has been reported by Vasquez *et al*. (1997).

In the choice test, *T. chilonis* females parasitized eggs of *H. armigera* and *M. vitrata* only. The significantly higher level of parasitism in *H. armigera* eggs indicates that females show a strong preference for the eggs of *H armigera* over *M. vitrata* probably due to size, shape, chorion thickness and architecture. The egg of *M. vitrata* (0.35 mm) and *P. xylostella* (0.25 mm) have relatively shorter diameter and are deflated in appearance compared to eggs of *H. armigera* (0.5 mm). Results of this study support those of Schmidt (1994) that egg size influences preference for parasitism.

This study showed that eggs of *M. vitrata* supported development of a single *T. chilonis* individual whereas those of *H. armigera* gave rise to a maximum of two. On its principal host egg, *C. sacchariphagus* (0.8 mm), in Mauritius, Williams (1983) reported an emergence ratio of three adult parasitoids. In *Daphnis nerii* L. whose eggs are even bigger (1.5 mm), an average of 12.4 adult *T. chilonis* has been recorded by Moore and Miller (2008). The emergence ratio of adult *T. chilonis* is influenced by the size of eggs of hosts, as also observed on other trichogrammatids by Manjunath (1988).

The exposure of sentinel eggs in field crops proved to be an appropriate method to detect the presence of *T. chilonis* in the field and determine the diversity of habitats where *T. chilonis* is found. The presence of *T.chilonis* at only one of the five study sites leads to presume that the naturally occurring population of *T. chilonis* is probably localized and its prevalence could be related to that of its principal host (*C. sacchariphagus*) and alternate ones. It can be also that *T. chilonis* were killed by broad-spectrum insecticides applied in fields. Toxic effects of such pesticides to adult trichogrammatids have been reported by Franz *et al*. (1980), Hassan *et al.* (1998) and Thomson *et al.* (2000). The pesticide free condition within the sugarcane ecosystem in Mauritius can explain the high level of parasitism in *C. sacchariphagus* eggs (Anon, 1993).

Even though *T. chilonis* is attracted to green leaf volatiles of cabbage and to synthetic sex pheromone of *P. xylostella* (Reddy *et al*., 2002), it did not parasitize eggs of this pest neither in the choice test nor in field exposures. On the other hand, it parasitizes eggs of *P. xylostella* in Japan and is even considered to be an important egg parasitoid (Okada, 1989). This leads to presume that the *T. chilonis* in Mauritius can be different from strains from Japan. The existence of different strains of *T. chilonis* in Reunion Island has been reported by Reay-Jones (2001).

The high level of parasitism (55.7%) in exposed *M. vitrata* eggs in the pigeon pea plot (vegetative stage) indicates that adult *T. chilonis* was present in this microhabitat. However, this result is contradictory to those reported by Romeis *et al.* (1996; 1999) who reported low rates of parasitism (1%) in *H. armigera* eggs on pigeon pea. In laboratory bioassays they showed that *T. chilonis* females did not respond to volatiles of pigeon pea plant at the vegetative stage and were repelled at the reproductive stage

(Romeis *et al.*, 2004). This leads to presume that the tritrophic interactions among *T. chilonis*, *M. vitrata* and host plants (pigeon pea and bean) in Mauritius probably differ from those reported elsewhere. Further in-depth research is required to clarify such tritrophic interactions in Mauritius.

This study has shown that the *T. chilonis* strain of Mauritius readily parasitizes and develops in young eggs of *M. vitrata*, feeds on older ones and cause a high rate of egg mortality. It also parasitizes eggs of *H. armigera* but not those of *P. xylostella*. Females of *T. chilonis* reared from *M. vitrata* eggs have a high reproductive potential (with a female biased sex ratio of their offspring) and lay most of their eggs within the first four days after emergence. This is an important attribute of *T. chilonis* as their longevity in the field is presumably shorter (about 4 days) than that (about 8 days) in the laboratory. As per these attributes, *T. chilonis* can be considered as a potential biological agent of *M. vitrata* in Mauritius. The information generated on its biology is valuable for the development of an IPM programme based on mass releases of *T. chilonis* and biopesticides.

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7.0 REFERENCES

- ABBOTT, W.S. 1925. A method of computing the effectiveness of an insecticide. *J. Econ. Entmol.* 18: 265-267

- ALIAS A., SCHILTHUIZEN M. AND SULAIMAN H. 2004. New Record of *Trichogramma Chilonis* Ishii (Hymenoptera: Trichogrammatidae) as an Egg parasitoid of the Cocoa Pod Borer, *Conopomorpha cramerella* (Snellen) (Lepidoptera: Gracillariidae) in Malaysia. *Malaysia Cocoa Journal*. 1: 86-88.

- ANON 1993. Report of the Mauritius Sugar Industry Research Institute. pp 87

- ARODOKOUN D.Y. 1996. Importance des plantes-hôtes alternatives et des ennemis naturels indigènes dans le contrôle biologique de *Maruca testulalis* Geyer (Lepidoptera:Pyralidae), ravageur de *Vigna unguiculata* Walp. PhD thesis, University of Laval, Québec. 181 pp.

- BIGLER F.A., MEYER A. AND BOSSHART S. 1987. Quality assessment in *Trichogramma maidis* Pintureau et Voegele reared from eggs of the factitious hosts *Ephestia kuehniella* Zell. And *Sitroga cerealella* (Oliver). *J. Appl. Entomol.* 104:340-353

- FARID, A., TILAL S., KHAN A.U., KHATTAK, ALAMZEB S.U. AND KARIMULLAH. 2001. Host age effect on oviposition preference and development of *Trichogramma chilonis* Ishii. *Pak. J. Biological Science*. 4:121-122

- FRANZ J.M., BOGENSCHUTZ H., HASSAN S.A., HUANG P., NATON E., SUTER H. AND VIGGIANI G., 1980. Results of a joint pesticide test programme by the working group: pesticides and beneficial arthropods. *Entomophaga*. 25: 231-236

- GANESHAN S. AND WILLIAMS J.R. 2000. Entomological parasitoids- Host records from Mauritius (2nd Revised edition). Mauritius Sugar Industry Research Institute. Occasional paper no. 36.

- GREENBERG, S.M., SHOWLER, A.T. AND LIU T. 2005. Effects of neem-based insecticides on beet armyworm (Lepidoptera: Noctuidae). *Insect Science*. 12: 17-23.

- GUO M., ZHU D., AND LI L. 1998. Selection of Tichogramma species for controlling the diamondback moth Plutella xylostella (L.). *Insect Science*. 6(2): 187-192.

- HASSAN S.A., HAFES B., DEGRANDE P.E. AND HERAI K. 1998. The side effects of pesticides on the egg parasitoids *Trichogramma caecoeciae* Marchal (Hym., Trichogrammatidae), acute dose-response and persistence tests. *Journal of Applied Entomology-Zeitschrift fur Angewandte Entomologie*. 122: 569-573

- KAZMER D.J. AND LUCK R.F. 1991. Female body size, fitness and biological control quality: field experiments with *Trichogramma pretiosum*. *Les Colloques*. 56:23-27

- LEWIS W.J., NORDLUND D.A., GROSS H.R., PERKINS W.D., KNIPLING E.F. AND VOEGELE J. 1976. Production and performance of *Trichogramma* reared on eggs of *Heliothis zea* and other hosts. *Environ. Entomol*. 5:449-452

- LI, LI-YING. 1994. Worldwide use of Trichogramma for biological control of different crops: A survey. 37-54. *In:* E. Wajnberg and S.A. Hassan (eds.). Biological control with egg parasitoids. CAB International, Wallingford, U.K.

- MANJUNATH T.M. 1988. Mass production and Utilisation of *Trichogramma*. In: Biocontrol Technology for Sugarcane Pest Management. Sugarcane Breeding Institute. Indian Council of Agricultural Research. Editors H. David and S. Easwaramoorthy. Coimbatore 641 007. India.

- MIURA K. AND KOBAYASHI M. 1995. Reproductive properties of *Trichogramma chilonis* females on diamondback moth eggs. *Appl. Entomol. Zool*. 30:393-400

- MOORE A. AND MILLER R.H. 2008. *Daphnis nerii* (Lepidoptera: Sphingidae), a New Pest of Oleander on Guam, Including Notes on Plant Hosts and Egg Parasitism. Proc. Hawaiian Entomol. Soc. 40: 67-70

- MOORE A. AND MILLER R.H. 2008. *Daphnis nerii* (Lepidoptera: Sphingidae), a New Pest of Oleander on Guam, Including Notes on Plant Hosts and Egg Parasitism. Proc. Hawaiian Entomol. Soc. 40: 67-70

- NOLDUS L.P.J.J. 1989. Semiochemicals, foraging behaviour and quality of entomophagous insects for biological control. *J. Appl. Entomol*. 108: 425-451

- REAY-JONES F. 2001. Caractérisation bio-écologique de *Trichogramma chilonis* Ishii (Hym: Trichogrammatidae): Implication pour la lutte biologique sur la cane à sucre contre *Chilo sacchariphagus* Bojer (Lep: Crambidae). Mémoire de DESS Technologies du Végétal de Université d' Angers et de l'Institut

National d'Horticulure. 50 pp.

- REDDY G.V.P., HOLOPAINEN J.K. AND GUERERO A. 2002. Olfactory responses of *Plutella xylostella* natural enemies to host pheromone, larval frass and green leaf cabbage volatile s. *Journal of Chemical Ecology*. 28:131-143

- ROMEIS J., SHANOWER T.G. AND ZEBITZ C.P.W. 1996. Using sticky traps to monitor populations of *Trichogramma* egg parasitoids. International Chickpea and Pigeonpea Newsletter. 3: 102-103

- ROMEIS J., SHANOWER T.G. AND ZEBITZ C.P.W. 1997. Volatile plant info-chemicals mediate plant preference of *Trichogramma chilonis*. *Journal of Chemical Ecology*. 23: 2455-2465

- ROMEIS J., SHANOWER T.G. AND ZEBITZ C.P.W. 1999. *Trichogramma* egg parasitism of *Helicoverpa armigera* on pigeonpea and sorghum in Southern India. *Entomologia Experimentalis et Applicata*. 90: 69-81

- ROMEIS J., SHANOWER T.G. AND ZEBITZ C.P.W. 2004. Volati,e Plant Infochemicals Mediate Plant Preference of *Trichogramma chilonis*. *Journal of Chemical Ecology*. 23(11): 2455-2465

- RUBERSON J.R. AND KRING T.J. 1993. Parasitism of developing eggs by *Trichogramma pretiosum* (Hymenoptera:Trichogrammatidae): Host age preference and suitability. Biological Control. 3: 39-46

- SCHMIDT J.M. 1994. Host recognition and acceptance by *Trichogramma*. Biological Control with Egg Parasitoids (ed. By E. Wajnberg and SA Hassan). 165-200. CAB International, Wallingford, Oxon, UK.

- SOULA B., GOEBEL F.R., CAPLONG P., KARIMJEE H., TIBERE R. AND TABONE E. 2003. *Trichogramma chilonis* (Hymenoptera: Trichogrammatidae) as a biological control agent of

Chilo sacchariphagus (Lepidoptera: Crambidae) in Reunion Island: Initial field trials. Oroc S. Afr. Sug. Technol. Ass. 77: 278-283

- THOMSON L.J., GLENN D.C. AND HOFFMANN A.A. 2000. Effects of sulphur on *Trichogramma* egg parasitoids in vineyards: measuring toxic effects and establishing release windows. *Australian Journal of Experimental Agriculture*. 40: 1165-1171

- ULRICHS CH., MEWIS, I., SCHNITZER, W.H. 2002: Indigenous parasitoids for the control of Maruca vitrata F. In:)(Lep.: Pyralidae) in Southeast Asia. *Parasitic wasps: Evolution, Systematics, Biodiversity and Biological Control.* Ed. by Melika, G.; Thuroczy, C. Budapest: Agroinform. 447-452

- UNMOLE L. 2009. Sustainable approach for the management of the pod borers on bean in Mauritius. Research Week 2008. vol.15. http://vcampus.uom.ac.mu/rci/resjournal/index.htm

- UNMOLE L., 2007. Investigation on the potential of neem against *Maruca vitrata* Fabricius. World Neem Conference (21st -24th November 2007), Coimbatore, India

- VASQUEZ, L.A., SHELTON A.M., HOFFMANN M.P. AND ROUSH R.T. 1997. Laboratory evaluation of commercial Trichogrammatid products for potential use against *Plutella xylostella* (L.) (Lepidoptera: Plutellidae). *Biological Control*. 9:143-148.

- WILLIAMS J.R. 1983. The sugarcane stem borer (*Chilo sacchariphagus*) in Mauritius. *Revue Agricole et Sucrière de l'île Maurice*. 62(1): 5-23

- ZAHID M., FARID A., SATTAR A. AND KHAN I. 2007. Effects of parasitoid and host egg age on parasitism by *Trichogramma chilonis* (Ishii). Suranaree J. Sci. Technol. 14(4):381-384