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Biological Control of the Sugarcane Planthopper by the Moth *Epiricania melanoleuca* (Fletcher) in Sri Lanka

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The sugarcane planthopper (SCPH) *Pyrilla perpusilla* is a serious sap-sucking pest of sugarcane in Sri Lanka. Several outbreaks of the pest have been recorded during the past despite the role of indigenous natural bio-control agents. Several releases of eggs of the parasitoid moth *Epiricania melanoleuca* into two sugarcane plantations showed that the parasitoid established and controlled the SCPH effectively within a period of 1-2 years. Post-release population estimates revealed that the higher levels of SCPH populations (68 individuals per leaf) were brought under control (below one individual per leaf) and maintained by the parasitoid successfully during the subsequent five-year period. The parasitoid naturally dispersed and established within a period of two years in other sugarcane plantations too, located more than 50 km away from the released fields, confirming its efficiency as a bio-control agent on the SCPH.

KEY WORDS : *Pyrilla perpusilla, Epiricania melanoleuca,* bio-control, sugarcane.

INTRODUCTION

The sugarcane planthopper (SCPH), *Pyrilla perpusilla* (Walker) (Homoptera: Lophopidae) is a serious pest of sugarcane in Sri Lanka. Nymphs and adults of SCPH feed on leaf sap resulting in wilting of leaves. The honeydew secreted by the pest induces growth of "sooty mould" fungus on leaves reducing photosynthesis. The SCPH has been reported to cause reduction in sugarcane yield up to 25% and sucrose content in juice up to 34% (Rahman and Nath, 1940; Rajani, 1960; Butani, 1964; Kumarasinghe and Wratten, 1996).

Epidemic proportions of SCPH have been recorded in Sri Lanka since 1968, i.e. after establishment of commercial plantations (Rajendra, 1979). Following the expansion of sugarcane plantations in Uda Walawe and Sevanagala (South-eastern region) in 1987, several outbreaks of SCPH were observed specially, during drought periods in spite of the presence of native egg parasitoid *Parachrysocharis javensis* Girault and the entomogenous fungus *Metarhizium anisopliae* (Metsch).

The ecto-parasitoid *Epiricania melanoleuca* (Fletcher) (Lepidoptera: Epipyropidae) has been reported to use as a successful bio-control agent on *Pyrilla sp.* in many parts of the Indian sub-continent (Kalra, 1973; Sinha *et al.,* 1974; Singh and Dayal, 1975; Mohyuddin *et al.,* 1982; Miah *et al.,* 1986; Rajak *et al.,* 1987). According to Chaudhary and Sharma (1988) the short life cycle, higher reproductive rate and tremendous searching ability of this parasitoid larva for its host increase its effectiveness as an useful bio-control agent. Singh and Dayal (1975) and Garg and Sethi (1982) reported that the waxy covering over the body of *E. melanoleuca* larvae protects it from insecticides allowing chemicals to be used in integrated pest management programmes. Successful control of *Pyrilla* has been reported in India (Misra and Pawar, 1984) where 2,000 - 3,000 cocoons and 400,000 - 500,000 eggs per hectare were released in several provinces including Andhra Pradesh, Gujarat, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Rajasthan and West Bengal.

In this situation, it was decided to use *E. melanoleuca* as a bio-control agent against the SCPH in Sri Lanka. This paper reports the control of SCPH in an area of about 2,500 ha of sugarcane plantations at Sevanagala and Hingurana in the South-Eastern region of Sri Lanka with the establishment of *E. melanoleuca* after systematic release into the severely affected areas of the country.

MATERIALS AND METHODS

After basic quarantine tests on the effect of *E. melanoleuca,* on two most useful insects in Sri Lanka, honey bee, *Apis cerana* Fabricius (Hymenoptera: Apidae) and the silk worm, *Bombyx mori* Linneaus (Lepidoptera:Bombicidae), a batch of 500 cocoons of the parasitoid was imported from the International

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Institute of Biological Control, Pakistan in May 1991 in order to multiply and release in the pest affected sugarcane plantations. The experimentation consisted of five steps i.e. 1. rearing *E. melanoleuca* in the laboratory 2. multiplication in the field 3. release in the plantation 4. evaluation of the establishment of the parasitoid and 5. determination of the natural dispersal.

Laboratory Rearing of *E. melanoleuca*

Adults of *E. melanoleuca* obtained from the cocoons (pupae) brought from Pakistan were held in Petri dishes in pairs to mate and lay eggs on pieces of cardboard (5 × 2 cm) provided. These egg cards were kept in separate glass vials (12 × 4 cm) loosely plugged with cotton swabs. Eggs were kept in the laboratory at room temperature (26-34 °C) until they hatched. Larvae that emerged from eggs were held with third instar field collected SCPH nymphs (1 parasitoid: 2 SCPH nymphs) in the same glass vials for 15-20 minutes for parasitization. The parasitized nymphs were then released onto sugarcane clumps of the variety Co 775. The sugarcane clumphs were separately covered with breeding cages of 1.25x1.25x2.0 m wooden frames and 16x16 plastic mesh to continue their life cycle. In order to provide sufficient hosts for the parasitoid, nymphs and adults of SCPH collected from sugarcane plantations were released into these cages from time to time.

Multiplication of *E. melanoleuca*

In order to obtain sufficient number of eggs of *E. melanoleuca* for field release, about 300 egg masses were removed with pieces of sugarcane leaves from the breeding cages and placed on five separate sugarcane clumps of the variety Co 775 situated 50 m apart in an experimental sugarcane field of the research farm. These plants were also individually covered with meshed cages similar to the breeding cages used for the laboratory rearing of the parasitoid. Sufficient numbers of nymphs and adults of SCPH were also introduced into the same cages from time to time in order to build-up the parasitoid population. After a significant increase of population, the nets of the cages were removed to move the parasitoids to the surrounding pest infested sugarcane fields for further multiplication.

Release of *E. melanoleuca* into Sugarcane Plantations

Release of *E. melanoleu ca* was carried out in two plantations Sevanagala and Hingurana, situated 175 km apart, during the period of August 1992 to August 1993. In Sevanagala plantation, twelve sugarcane fields, each field 0.75 ha in area, heavily infested with SCPH and located 400 m apart were selected for the release of *E. melanoleuca.* These fields were consisted of 5-6 months old plants of the variety, Co 775. In the middle of each field, a plot of 10 m x 10 rows was demarcated before release of the parasitoid. A batch of 1832 egg masses (about 288,300 eggs) of *E. melanoleuca,* was removed from the research farm with the pieces of sugarcane leaves onto which they were attached and stapled on the leaves of the sugarcane in those plots. Thus, in the first week of August 1992, 155 egg masses (24,025 eggs) were initially distributed in each plot at Sevanagala, pending peak population of SCPH in that month, according to the previous observation.

Similarly, in the third week of March 1993, a second batch of 1740 egg masses (about 274,920 eggs) was released in another 12 sugarcane fields of the same size situated near to the previously released fields in order to boost the parasitoid population. These 12 fields were selected for release of the parasitoid as the crop of the previously released fields had been harvested at the time of the second release.

In Hingurana plantation, release of *E. melanoleuca* was conducted in the last week of August 1993, pending the peak population of the SCPH. A total of 4,200 egg masses (about 663,600 eggs) of the parasitoid were distributed in 20 plots (10 m × 10 rows) in 20 selected fields as in the Sevanagala plantation.

Evaluation of Establishment of *E. melanoleuca*

The pre-release and post-release population levels of the SCPH were made separately at the two plantations, in order to determine the establishment of *E. melanoleuca.* During the pre-release monitoring, number of nymphs and adults of SCPH on 50 randomly drawn sugarcane leaves were recorded. This was carried out on 5-12 month old crops in each of five selected fields, situated 400 m apart each other. The population levels were recorded once a month for a period of one year before the first release of the parasitoid both at Sevanagala and Hingurana plantations. Similarly, after the first release of the parasitoid, the number of nymphs and adults of SCPH and number of intact cocoons of *E. melanoleuca* on 50 randomly drawn leaves were recorded for a period of 5 and 4 years in Sevanagala and Hingurana plantations, respectively. In order to compare the population levels of SCPH before and after release of the parasitoid, the monthly mean numbers of nymphs and adults of SCPH per leaf in the year before the release of the parasitoid was compared with the corresponding values of SCPH after release of the parasitoid, using the simple T test at 1% and 5% levels.

Observations on Natural Dispersal of *E. melanoleuca* into Other Sugarcane Plantations

In order to understand the natural dispersal of *E. melanoleuca* into other sugarcane plantations in Sri Lanka, surveys were conducted in three other plantations Pelwatta, Moneragala and Siyambalanduwa situated about 60, 90 and 50 km away from the released fields respectively. The surveys were conducted four times a year during the period 1994-1997, i.e. just before and after the two annual monsoon rains. The number of nymphs and adults of SCPH and the intact cocoons of the parasitoid on randomly drawn 100 leaves were recorded on 5-12 month old crops in the above three plantations. The mean number of cocoons and individuals of SCPH were calculated accordingly for comparisons.

RESULTS AND DISCUSSION

Establishment of *E. melanoleuca* at Sevanagala

The pre-release populations of SCPH at Sevanagala in 1991 indicated two peaks in the months of May (28 individuals per leaf) and August (68 individuals per leaf). The population levels were regularly maintained over 10 individuals per leaf except in the months of January, February and December (Fig. 1).

Similar pattern of SCPH population was observed in 1992 too at Sevanagala before the parasitoid was released. However, the peak population level in May 1992 (63 individuals per leaf) was found to be significantly higher than that of in 1991 (Table 1). The first release of the parasitoid was made in the last week of August 1992 when the SCPH population level was at 47 individuals per leaf. However, the population of the SCPH was decreased (as per pre-release population pattern in 1991) without showing the parasitoid establishment (Fig. 2). Therefore, it can be assumed that the establishment of *E. melanoleuca,* was affected

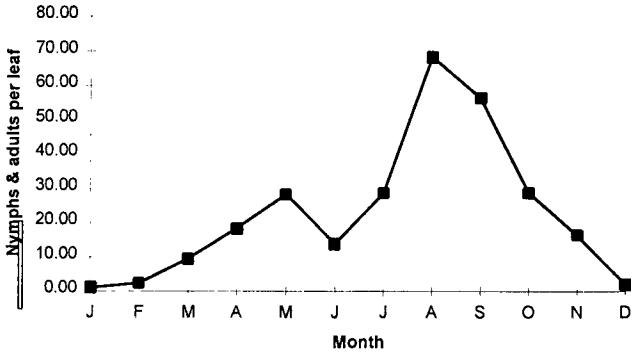

Fig. 1 : Population levels of *P. perpusilla* before introduction of *E. melanoleuca* at Sevanagala in 1991.

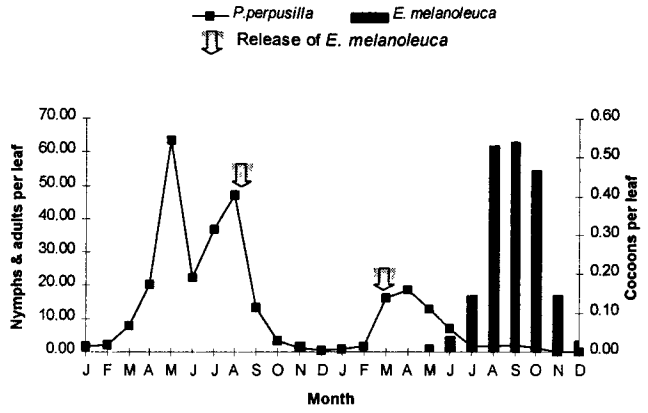

Fig. 2 : Population levels of *P. perpusilla* and *E. melanoleuca* at Sevanagala during 1992-1993 showing the parasitoid establishment

at this stage possibly due to the effect of prevailing climatic factors. However, only a few of cocoons were appeared in November 1992, i.e. 3 months after the first release. This led the release of a second batch of the parasitoid in March 1993 before the anticipated first peak of SCPH population in May 1993. After release of the second batch, a gradual increase of the number of parasitoid cocoons was observed during the period from May to September 1993 indicating higher levels of parasitization by *E. melanoleuca.* Simultaneously, a gradual decrease of SCPH population was also recorded during the same period avoiding the usual annual population build-up of SCPH in May and August. After this trend, the populations of SCPH were maintained at remarkably low levels (below 1 individual per leaf) during the period of five subsequent years. Regular occurrence of higher number of parasitoid cocoons were also observed during the same period indicating the successful establishment of the parasitoid at the plantation of Sevanagala (Figure 3).

Comparison of pre-release mean monthly SCPH

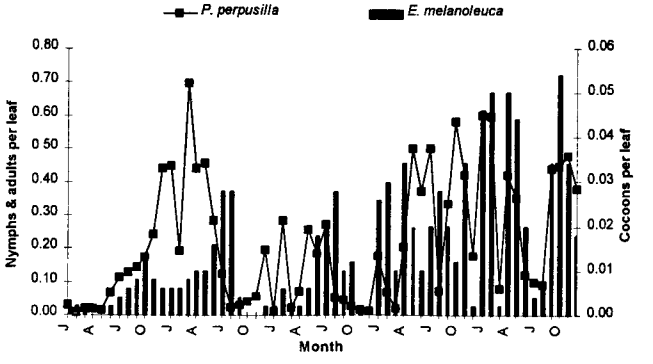

Fig. 3 : Population levels of *P. perpusilla* and *E. melanoleuca* at Sevanagala during 1994-1998.

Table 1 : Mean monthly population levels of *P. perpusilla* before and after release of *E. melanoleuca* at Sevanagala

Month	Mean no. of nymphs and adults of *P. perpusilla* per leaf							
	1991	1992	1993	1994	1995	1996	1997	1998
Jan	0.87	1.70**	0.80	0.03**	0.45*	0.01**	0.18**	0.60
	(0.26)	(0.26)	(0.17)	(0.05)	(0.19)	(0.02)	(0.04)	(0.07)
Feb	2.35	2.00	1.80	0.01	0.19	0.28	0.07	0.60
	(2.06)	(0.46)	(0.28)	(0.02)	(0.06)	(0.1)	(0.02)	(0.09)
Mar	9.50	7.70	15.90*	0.02**	0.69**	0.02**	0.02**	0.08**
	(3.90)	(1.84)	(2.16)	(0.02)	(0.10)	(0.02)	(0.01)	(0.02)
Apr	18.30	20.10	18.50	0.02**	0.44**	0.07**	0.20**	0.42**
	(5.05)	(5.25)	(2.63)	(0.02)	(0.19)	(0.03)	(0.03)	(0.05)
May	28.26	63.30**	12.90**	0.02**	0.46**	0.26**	0.50**	0.35**
	(2.81)	(7.56)	(4.80)	(0.02)	(0.10)	(0.09)	(0.13)	(0.09)
Jun	13.72	22.30**	7.10*	0.07**	0.28**	0.18**	0.37**	0.12**
	(3.89)	(3.66)	(1.0)	(0.04)	(0.10)	(0.05)	(0.14)	(0.04)
Jul	28.54	36.70**	1.70**	0.11**	0.12**	0.27**	0.50**	0.10**
	(3.91)	(2.68)	(0.29)	(0.07)	(0.05)	(0.12)	(0.27)	(0.02)
Aug	68.20	46.85*	1.60**	0.13**	0.02**	0.05**	0.07**	0.09**
	(14.67)	(6.35)	(0.49)	(0.10)	(0.03)	(0.05)	(0.02)	(0.03)
Sep	56.41	13.00**	2.02**	0.14**	0.03**	0.04**	0.33**	0.44**
	(16.77)	(1.58)	(0.26)	(0.09)	(0.02)	(0.04)	(0.11)	(0.19)
Oct	28.76	3.50**	1.10**	0.18**	0.04**	0.03**	0.58**	0.45**
	(8.41)	(0.64)	(0.32)	(0.13)	(0.02)	(0.03)	(0.08)	(0.09)
Nov	16.89	1.40**	0.09**	0.24**	0.06**	0.02**	0.42**	0.48**
	(3.43)	(0.27)	(0.04)	(0.06)	(0.02)	(0.02)	(0.04)	(0.09)
Dec	2.03	0.50**	0.04**	0.44**	0.20**	0.01**	0.18**	0.38**
	(0.34)	(0.12)	(0.03)	(0.22)	(0.15)	(0.01)	(0.04)	(0.09)

*Significantly different at 5% level against corresponding month of 1991
**Significantly different at 1% level against corresponding month of 1991
Standard deviations are given within parenthesis

population levels in 1991 (before release of the parasitoid) with that of post-release population levels from 1994 to 1998 clearly indicated that monthly SCPH population levels after release were significantly lower than that in the corresponding month of the pre-released year (Table 1).

Establishment of *E. melanoleuca* at Hingurana

Monitoring of SCPH population levels before introduction of *E. melanoleuca* at Hingurana in 1992 indicated that there were two peaks in March and September (2 and 13 individuals per leaf respectively) (Fig. 4). A similar trend in population levels of SCPH was also observed before release of the parasitoid in 1993. The first batch of parasitoid was released in August 1993 before the anticipated second population peak of the SCPH i.e. in September (Fig. 5).

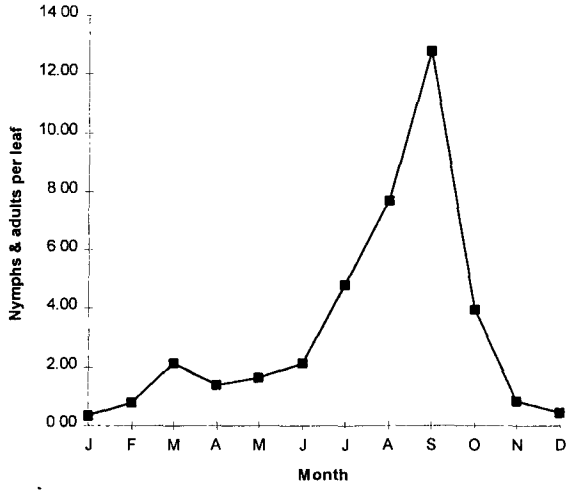

Fig. 4 : Population levels of *P. perpusilla* before introduction of *E. melanoleuca* at Hingurana in 1992

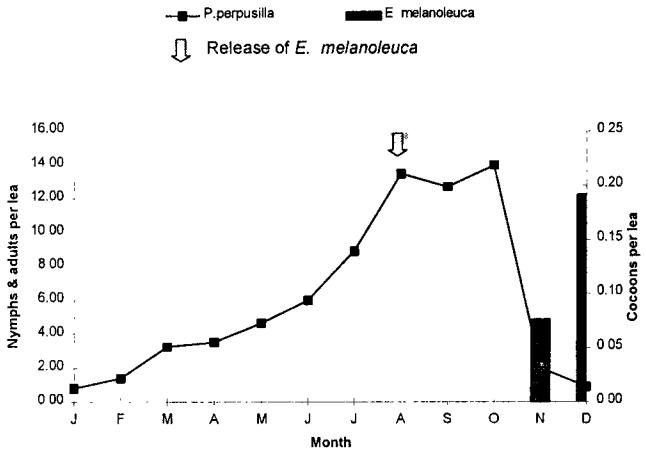

Fig. 5 : Population levels of *P. perpusilla* and *E. melanoleuca* at Hingurana in 1993

The cocoons of *E. melanoleuca* were first observed in November 1993 in Hingurana plantation, about three months after the release of the parasitoid eggs (Fig. 5). Thereafter, the cocoons of the parasitoid regularly appeared in the plantation over a period of four years after the release, maintaining the host population always below one individual per leaf (Fig. 6).

Comparison of mean monthly SCPH population levels before release (1992) and after release (1994 - 1997) in Hingurana plantation also clearly indicated that the monthly SCPH population levels after release were significantly lower than that in the corresponding before release months showing the efficiency of *E. melanoleuca* as a bio-control agent over the SCPH populations (Table 2).

Natural Dispersal into Other Sugarcane Plantations

Cocoons of *E.melanoleuca* were recorded from the three sugarcane plantations surveyed; Pelwatta, Moneragala and Siyambalanduwa from the latter part of 1995 (Table 3). Further, continuation of low levels

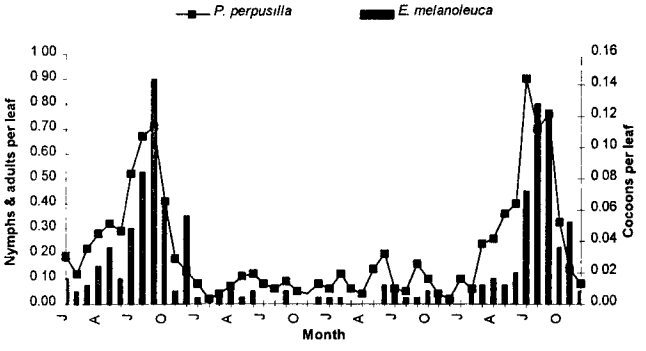

Fig. 6 : Population levels of *P. perpusilla* and *E. melanoleuca* at Hingurana during 1994-1997

of SCPH population and the regular occurrence of the parasitoid cocoons observed during the period of survey indicated that *E. melanoleuca* has successfully dispersed and established in all three plantations Pelwatta, Moneragala and Siyambalanduwa situated at least 50 km away from the released fields.

CONCLUSION

Experimental results indicated that *E.melanoleuca* could be successfully released into commercial plantation after breeding in the laboratory and multiplication in field cages. The parasitoid had adapted to the local field conditions during the multiplication stage occurred inside field cages. This adaptation has

Table 2 : Mean monthly population levels of *P. perpusilla* before and after release of *E. melanoleuca* at Hingurana

Month	Mean no. of nymphs and adults of *P. perpusilla* per leaf					
	1992	1993	1994	1995	1996	1997
Jan	0.33 (0.25)	0.78* (0.36)	0.19 (0.20)	0.08 (0.08)	0.06 0.04	0.10 0.07
Feb	0.81 (0.60)	1.38 (0.53)	0.12 (0.13)	0.02* (0.02)	0.12 0.05	0.06* 0.04
Mar	2.13 (1.41)	3.25 (1.21)	0.22* (0.14)	0.04* (0.05)	0.06* (0.04)	0.24* 0.11
Apr	1.38 (0.74)	3.50 (1.82)	0.28* (0.27)	0.07* (0.08)	0.04* (0.03)	0.26* (0.15)
May	1.66 (0.86)	4.65* (2.52)	0.32* (0.10)	0.11* (0.04)	0.14* (0.09)	0.36* (0.29)
Jun	2.12 (0.94)	6.00** (2.26)	0.29** (0.28)	0.12** (0.07)	0.20** (0.13)	0.40* (0.14)
Jul	4.84 (2.62)	0.40* (3.39)	0.52* (0.26)	0.08* (0.02)	0.06* (0.07)	0.90* (0.26)
Aug	7.70 (3.58)	13.50* (4.38)	0.67* (0.20)	0.06** (0.04)	0.05** (0.03)	0.70* (0.28)
Sep	12.80 (3.58)	12.70 (4.20)	0.71** (0.27)	0.09** (0.06)	0.16** (0.15)	0.76** (0.19)
Oct	3.97 (2.19)	14.00** (3.78)	0.41* (0.11)	0.05* (0.04)	0.10* (0.06)	0.32* (0.13)
Nov	0.84 (0.42)	2.00* (0.78)	0.18* (0.11)	0.04* (0.03)	0.04* (0.05)	0.14* (0.10)
Dec	0.45 (0.28)	0.88 (0.39)	0.13 (0.06)	0.08* (0.06)	0.02* (0.03)	0.08* (0.03)

*Significantly different at 5% level against corresponding month of 1992

**Significantly different at 1% level against corresponding month of 1992

Standard deviations are given within parenthesis

Table 3 : Natural dispersal of *E. melanoleuca* in the sugarcane plantations at Pelwatta, Moneragala and Siyambalanduwa

year	Month of Observation	Pelwatta		Moneragala		Siyambalanduwa	
		SCPH*	*E. melanoleuca***	SCPH*	*E. melanoleuca***	SCPH*	*E. melanoleuca***
1994	Feb.	0.76 (0.32)	0.00 (0.00)	1.02 (0.29)	0.00 (0.00)	0.98 (0.19)	0.00 (0.00)
	May	7.00 (1.83)	0.00 (0.00)	9.00 (5.60)	0.00 (0.00)	6.70 (3.65)	0.00 (0.00)
	Jul.	2.04 (1.12)	0.00 (0.00)	2.44 (0.70)	0.00 (0.00)	1.96 (0.58)	0.00 (0.00)
	Oct.	0.10 (0.07)	0.00 (0.00)	0.05 (0.02)	0.00 (0.00)	0.16 (0.07)	0.00 (0.00)
1995	Feb.	0.72 (0.34)	0.00 (0.00)	0.64 (0.14)	0.00 (0.00)	0.70 (0.14)	0.00 (0.00)
	May	0.42 (0.15)	0.02 (0.01)	0.28 (0.09)	0.00 (0.00)	0.32 (0.19)	0.00 (0.00)
	Jul.	0.32 (0.14)	0.00 (0.00)	0.36 (0.16)	0.01 (0.01)	0.24 (0.12)	0.01 (0.00)
	Nov.	0.04 (0.05)	0.00 (0.00)	0.08 (0.03)	0.02 (0.02)	0.06 (0.02)	0.00 (0.00)
1996	Feb.	0.17 (0.08)	0.01 (0.01)	0.16 (0.13)	0.00 (0.00)	0.10 (0.04)	0.00 (0.00)
	May	0.15 (0.05)	0.02 (0.01)	0.14 (0.05)	0.01 (0.01)	0.28 (0.11)	0.01 (0.01)
	Jul.	0.30 (0.10)	0.01 (0.01)	0.26 (0.12)	0.01 (0.01)	0.32 (0.12)	0.02 (0.01)
	Oct.	0.10 (0.08)	0.01 (0.01)	0.16 (0.07)	0.01 (0.01)	0.24 (0.14)	0.02 (0.01)
1997	Mar.	0.16 (0.13)	0.04 (0.02)	0.20 (0.06)	0.00 (0.00)	0.24 (0.09)	0.02 (0.01)
	Jun.	0.66 (0.18)	0.01 (0.00)	0.50 (0.17)	0.00 (0.00)	0.70 (0.12)	0.01 (0.01)
	Sep.	0.91 (0.18)	0.04 (0.02)	0.66 (0.11)	0.01 (0.01)	0.66 (0.24)	0.04 (0.02)
	Dec.	0.16 (0.10)	0.01 (0.01)	0.20 (0.07)	0.01 (0.01)	0.24 (0.07)	0.02 (0.01)

*Mean number of nymphs and adults per leaf
**Mean number of cocoons per leaf
Standard deviations are given within parenthesis

helped the parasitoid to establish in the commercial plantations after release.

It has been observed that the *E. melanoleuca* was established on SCPH populations in Sevanagala plantations within a period of three months after the second release. It was confirmed that the activity of the parasitoid was further continued throughout the evaluation period of five years, lowering the host population from 68 individuals per leaf to below one individual per leaf. This was repeatedly confirmed at Hingurana plantation as *E. melanoleuca* established within a period of four months on SCPH populations lowering the host population from 14 individuals per leaf to below one individual per leaf. The establishment and activity of the parasitoid was further continued for the subsequent period of four years too. These observations confirmed that the parasitoid was able to establish on SCPH within a period of three to four months. The two annual peak populations of SCPH did not occur in those two released plantations after establishment of *E.melanoleuca* indicating the higher level of efficiency of the parasitoid, confirming the populations of both host and its parasitoid are in equilibrium levels after establishment. It was also observed (during the six year experimental period) that the parasitoid had not been affected by the local adverse weather conditions such as monsoonal rains and the maximum temperatures (30- 36 °C) confirming that the parasitoid has well adapted to the local weather conditions.

The establishment of *E.melanoleuca* in other three plantations Pelwatta, Moneragala and Siyambalanduwa situated at least 50 km away from the released fields within a period of two years showed the higher efficiency of natural dispersal of the parasitoid under favourable conditions of Sri Lanka. The higher fecundity (200- 550 eggs per female) and good searching ability of the first instar larvae of this lepidopteran parasitoid may also have contributed for the natural dispersal and establishment in other plantations within a shorter period of time.

The sugar industry in Sri Lanka has remarkably been benefited by reducing the losses to the sugar yield and the quality with the control of SCPH by introduction of *E.melanoleuca*. This introduction has indirect benefit to the other crops such as rice and maize grown in the same region, as SCPH is a sap-sucking insect on these crops too.

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