J. Biol. Control, 22(1): 91-97, 2008

Efficacy of *Beauveria bassiana* (Balsamo) Vuill. and an exotic parasitoid, *Cephalonomia stephanoderis* (Betrem) (Hymenoptera: Bethylidae) for the management of coffee berry borer, *Hypothenemus hampei* (Ferrari) (Coleoptera: Scolytidae)

S. IRULANDI[1], R. RAJENDRAN[2], STEPHEN D. SAMUEL[1], C. CHINNIAH[2], P. K. VINOD KUMAR[1] and K. SREEDHARAN[3]

[1]Regional Coffee Research Station, Kodaikanal TK, Thandigudi – 624216, Dindigul District, Tamil Nadu, India.

[2]Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai – 625104, Tamil Nadu, India.

[3]Central Coffee Research Institute, Coffee Research Station, Chikmagalur – 577117, Karnataka, India.

E-mail: ksirulandi@gmail.com

ABSTRACT: **Laboratory and field experiments were carried out to evaluate the bio-efficacy of the white muscardine fungus, *Beauveria bassiana* (Balsamo) Vuill. and the exotic parasitoid *Cephalonomia stephanoderis* (Betrem) on coffee berry borer, *Hypothenemus hampei* (Ferrari) (Coleoptera: Scolytidae) at Pulney hills, Tamil Nadu, India, during the year 2004-05. Laboratory studies showed that *B. bassiana* at the dose of $1x10^9$ spores ml^{-1} registered the highest per cent mycosis (65.09%), followed by $1x10^8$ spores ml^{-1} (61.52%) and $1x10^7$ spores ml^{-1} (56.39%) as against zero per cent mycosis in untreated check. The results from the field studies indicated that the cumulative mean per cent mycosis of *B. bassiana* on coffee berry borer recorded throughout the period of observations was highest at the dosage of $1x10^9$ spores ml^{-1} (58.49%), followed by $1x10^8$ spores ml^{-1} (48.76%) and $1x10^7$ spores ml^{-1} (39.27%). The results of the present study on *C. stephanoderis* revealed that among the 17 locations surveyed, the highest level of parasitism was observed in Nallurkadu (36.25%), followed by Solaikadu (34.45%) and Adalur (32.44%).**

KEY WORDS: *Beauveria bassiana*, biological control, *Cephalonomia stephanoderis*, Coffee berry borer, *Hypothenemus hampei*, IPM for coffee

INTRODUCTION

Coffee is a widely consumed beverage and the second largest commercial commodity in the world, next to petroleum. It is cultivated in more than 80 developing countries across the globe, of which 51 are considered to be major coffee producers (Naidu, 2000). In India, coffee is one of the major plantation crops earning valuable foreign exchange, cultivated in an area of 3.8 lakh hectares, mainly in the Southern States of Karnataka (57.6%), Kerala (23.9%) and Tamil Nadu (8.6%), the traditional coffee growing tracts and also in non-traditional areas (9.9%), *viz.*, Andhra Pradesh, Orissa

and North Eastern States (Anonymous, 2005). Coffee, being a perennial crop, is subject to attack by many insect pests. Among them, the coffee berry borer, *Hypothenemus hampei* (Coleoptera : Scolytidae), a native of Central Africa, is the most serious pest in many coffee growing countries, and causes great losses (Le-Pelley, 1968). In case of severe infestation, it can cause up to 80 per cent of damage to berries resulting in heavy crop loss. In India, it was first noticed during February 1990 in a few plantations in Gudalur in the Nilgiris district of Tamil Nadu (Kumar *et al.*, 1990).

Though insecticidal interventions are reported to check this pest effectively (Sreedharan *et al.*, 1994), growing concern for environmental pollution and residue problems in the bean necessitate the search for alternative means of control. Hence, an attempt to tackle the pest through the bethylid parasitoid, *Cephalonomia stephanoderis* (Betrem), introduced from Mexico during 1995, was attempted. This wasp has been reared in large numbers and released on several infested estates (Balakrishnan *et al.*, 2000). The establishment of the parasitoid was recorded on many farms. The parasitoid is reported to have established in most of the recipient countries. The efficacy of the parasitoid against berry borer was 75 and 48 per cent in 1994 and 1995, respectively, in Mexico (Garcia and Barrios, 1996). White muscardine fungus, *Beauveria bassiana,* is found to be very potential and widely used in the biocontrol of coffee berry borer. The fungus was found to occur in nature and under favorable conditions of temperature (23 to 28°C) and humidity (> 90%), causes mortality to the beetles (Alves, 1986). In this direction, the present investigation was carried out to study the efficacy of *B. bassiana* and also evaluate the exotic parasitoid *C. stephanoderis* through large scale releases at different locations on Pulney hills, Tamil Nadu.

MATERIALS AND METHODS

Efficacy of *B. bassiana* on berry borer

Laboratory studies

B. bassiana collected from coffee field infested with berry borer was mass cultured utilizing rice bran as medium. Serial dilutions of *B. bassiana* with the spore concentrations of $1x10^5$, $1x10^6$, $1x10^7$, $1x10^8$ and $1x10^9$ spores ml^{-1} were prepared and bioassayed on the beetle in comparison with chlorpyriphos 20EC (0.06%) and untreated check. Teepol (0.1%) was added as wetting agent in all treatments. Chorpyriphos (0.06%) was used for comparison as it is one of the recommended insecticides for the control of coffee berry borer. The treatments were replicated four times. The beetles were dipped in the suspension for a minute and kept in separate plastic containers in a room maintained at 90 per cent relative humidity and 25 $\pm$ 1°C. The beetles were examined on 5, 7, 10, 15 and 20 days after treatment for mortality/infection.

Field study

A field experiment was conducted at N.T. Neelamegam estate, a private plantation adjacent to Regional Coffee Research Station, Thandigudi, during 2004-05 (Average temperature 25.5°C and relative humidity 79.85%). To test the field efficacy of *B. bassiana* on *C. canephora* (25 years old) the fungus was serially diluted to spore concentrations of $1x10^5$, $1x10^6$, $1x\ 10^7$, $1x10^8$ and $1x10^9$ spores ml^{-1} and compared with chlorpyriphos 20EC (0.06%) and untreated check. The treatments were replicated four times. In each replication, five plants were selected randomly and in each plant, five branches were selected. Plants and branches with sufficient berry borer infestations were selected and the infested berries counted. The conidial suspensions of *B. bassiana* were sprayed onto the berry clusters. Observations on mortality (mycosis) of coffee berry borer due to *B. bassiana* infection were recorded prior to and at weekly interval of 7, 14, 21 and 28 days after treatment and percentage infection was worked out.

Field efficacy of *C. stephanoderis* on coffee berry borer

C. stephanoderis obtained from laboratory culture were released at 17 locations on lower Pulney hills during 2004-2005, to manage the population of

coffee berry borer. At each location, about 20,000 adult parasitoids were released/hectare selecting five coffee plantations. A total of 250 fruits were collected at random from each released site and examined in the laboratory for the presence of various stages of the parasitoid and the per cent parasitism worked out.

Statistical analyses

Data collected from various field and laboratory experiments were statistically analysed using randomized and completely randomized block designs. The percentage values were subjected to *arcsine* transformation. Square root transformation was followed for converting the population data. The treatment means were compared by Duncan's multiple range test (DMRT) for their significance (Gomez and Gomez, 1985).

RESULTS AND DISCUSSION

Bio-efficacy of *B. bassiana* on coffee berry borer

Laboratory studies

The observations on mean per cent mycosis due to *B. bassiana* on berry borer worked out at four intervals of observations after treatment indicated that all the treatments were significantly superior to untreated check. *B. bassiana* at the dose of $1x10^9$ spores ml^{-1} registered the highest per cent mycosis (65.09%), followed by $1x10^8$ spores ml^{-1} (61.52 %), and $1x10^7$ spores ml^{-1} (56.39%) as against zero per cent in untreated check (Table 1). The present finding is supported by Rosa *et al.* (1997) who reported that three most virulent strains of *B. bassiana* such as Bb14 (Ecuador) @ $2.2x10^6$, Bb25 (Mexico) @ $4.1x10^6$ and Bb26 (Mexico) @ $5.9x10^6$

Table 1. Bio-efficacy of *B. bassiana* against coffee berry borer under laboratory condition

Treatment	Mean per cent mycosis (Days after treatment) *					Cumulative
	5	7	10	15	20	Mean
B. bassiana ($1x10^5$ spores ml^{-1})	3.75 (11.16)^e	9.63 (18.07)^e	19.30 (26.06)^e	33.52 (35.37)^e	52.15 (46.23)^c	23.67 (27.37)^e
B. bassiana ($1x10^6$ spores ml^{-1})	8.22 (16.66)^d	21.12 (27.35)^d	32.17 (34.88)^d	52.46 (46.41)^d	81.43 (64.74)^b	39.08 (38.01)^d
B. bassiana ($1x10^7$ spores ml^{-1})	12.36 (20.58)^c	28.31 (32.14)^c	59.91 (50.17)^c	82.74 (65.45)^c	98.66 (83.35)^a	56.39 (50.34)^c
B. bassiana ($1x10^8$ spores ml^{-1})	16.60 24.04)^b	35.82 (36.76)^b	69.52 (56.49)^b	85.65 (67.74)^b	100.00 (89.71)^a	61.52 (54.95)^b
B. bassiana ($1x10^9$ spores ml^{-1})	19.44 (26.16)^a	42.15 (40.48)^a	75.13 (60.08)^a	88.71 (70.36)^a	100.00 (89.71)^a	65.09 (57.37)^a
Chlorpyriphos 20EC @ 0.06%	0.00 (0.57)^f	0.00 (0.57)^g	0.00 (0.57)^g	0.00 (0.57)^g	0.00 (0.57)^e	0.00 (0.57)^g
Untreated check	0.00 (0.57)^f	0.00 (0.57)^g	0.00 (0.57)^g	0.00 (0.57)^g	0.00 (0.57)^e	0.00 (0.57)^g

* Each value is the mean of four replications; figures in parentheses are arcsine transformed values; in a column, means followed by common letter(s) are not significantly different by DMRT (P = 0.05)

conidia ml^{-1} registered a sporulation of 90, 81.9 and 62 per cent, respectively, within LT_{50} range of 4.3 and 7.5 days.

Field study

Among the various concentrations tested, the application of *B. bassiana* at $1x10^9$ spores ml^{-1} was found superior in all the periods of observations and recorded from 15.73 to 86.62 per cent mycosis. Next to this in descending order of efficacy were the treatments with $1x10^8$ spores ml^{-1} (12.43 to 73.55%) and $1x10^7$ spores ml^{-1} (9.36 to 66.46%) and untreated check (1.21 to 2.47%) (Table 2). This trend has also been recorded by earlier workers (Rosa *et al.*, 1997; Samuels *et al.*, 2002).

Field evaluation of parasitisation by *C. stephanoderis* on coffee berry borer

The results on the parasitic potential of *C. stephanoderis* on coffee berry borer revealed that the mean per cent parasitism recorded ranged from 11.37 to 34.72 and from 12.36 to 37.79 during 2004 and 2005, respectively (Table 3 and 4). Of the 17 locations evaluated during 2004, the mean parasitic potential (rate of parasitism) observed in Nallurkadu (34.72%) was highest, followed by Solaikadu (33.12%), which were statistically on par with each other and the lowest mean per cent parasitism was recorded in Pallathukalvai (11.37%) and Manalur (11.62%).

In 2005, Nallurkadu registered highest per cent parasitism of 37.79, followed by 35.84, 32.44 and 30.42 per cent in Solaikadu, Adalur and Nerimalai, respectively. The least (12.36 per cent), parasitism was recorded in Pallathukalvai, followed by 14.66 per cent in Manalur.

The above study indicated high mortality of coffee berry borer stages in the areas with increased parasitoid activity and also possible predation by the female wasp, in conformity with the findings of Balakrishnan and Sreedharan (2002) in Karnataka,

Table 2. Bio-efficacy of *B. bassiana* against coffee berry borer under field condition

Treatment	Mean per cent mycosis (Days after treatment) *					Cumulative Mean
	Before application	7	14	21	28	
B. bassiana ($1x10^5$ spores ml^{-1})	1.02	2.92 (9.83)^e	14.86 (22.67)^e	23.23 (28.81)^e	37.25 (37.61)^e	19.56 (24.73)^e
B. bassiana ($1x10^6$ spores ml^{-1})	1.52	6.89 (15.21)^d	21.76 (27.80)^d	38.64 (38.43)^d	51.33 (45.76)^d	29.65 (31.80)^d
B. bassiana ($1x10^7$ spores ml^{-1})	1.07	9.36 (17.81)^c	31.55 (34.17)^c	49.71 (44.83)^c	66.46 (54.61)^c	39.27 (37.85)^c
B. bassiana ($1x10^8$ spores ml^{-1})	1.21	12.43 (20.64)^b	47.82 (43.75)^b	61.25 (51.50)^b	73.55 (59.05)^b	48.76 (43.73)^b
B. bassiana ($1x10^9$ spores ml^{-1})	1.11	15.73 (23.36)^a	58.91 (50.13)^a	72.71 (58.50)^a	86.62 (68.54)^a	58.49 (50.13)^a
Chlorpyriphos 20EC @ 0.06%	1.32	1.36 (5.86)^e	1.46 (6.13)^f	2.25 (8.79)^f	2.37 (8.98)^f	1.86 (7.14)^f
Untreated check	1.12	1.21 (5.57)^f	1.69 (6.76)^e	1.83 (6.96)^e	2.47 (9.04)^h	1.09 (5.18)^g

* Each value is the mean of four replications; figures in parentheses are arcsine transformed values; in a column, means followed by common letter(s) are not significantly different by DMRT (P = 0.05)

where the parasitism ranged between 1.00 and 55 per cent. Baker (1999) reported that high levels of death and absence of coffee berry borer beetles were found in the *C. stephanoderis* released sites in Colombia. He concluded that the effect of the wasp is almost 100 per cent as predator, when mass released. On Pulney hills of Tamil Nadu, Robusta plants having more left over berries

Table 3. Parasitization by *C. stephanoderis* on coffee berry borer (Season 2004-05)

Location	Mean per cent parasitism at bimonthly interval *						Pooled mean
	Jan. ' 04	March '04	May '04	July '04	Sep. '04	Nov. '04	
Adalur	9.00 (17.45)^{e}	11.00 (19.37)^{ij}	25.00 (30.00)^{e}	38.11 (38.12)^{e}	39.11 (38.71)^{g}	38.67 (38.45)^{abc}	30.39 (30.39)^{b}
Kanalkadu	16.00 (23.00)^{a}	17.36 (24.62)^{d}	20.00 (26.56)^{g}	22.31 (28.18)^{i}	38.00 (35.05)^{h}	29.92 (33.16) ^{def}	23.93 (28.42)^{d}
K.C.Patty	12.10 (20.27)^{bc}	20.00 (26.56)^{e}	20.10 (26.63)^{fg}	24.00 (29.33)^{f}	40.32 (39.41)^{f}	31.61 (34.21) ^{ef}	24.69 (29.40)^{cd}
Kamanur	6.13 (14.33)^{h}	15.23 (22.97)^{ef}	16.72 (24.13)^{j}	22.52 (28.38)^{gh}	31.63 (34.22)^{jk}	25.44 (30.29) ^{f}	19.61 (25.72)^{f}
Mangalam kombu	8.17 (16.60)^{fg}	13.82 (21.92)^{h}	20.00 (26.56)^{g}	24.31 (29.54)^{e}	43.00 (40.97)^{d}	32.33 (34.65)^{cde}	23.60 (28.37)^{f}
Manjalpa rappu	12.30 (20.53)^{bc}	15.41 (23.11)^{e}	21.00 (27.27)^{e}	22.60 (28.38)^{g}	44.00 (41..55)^{c}	36.60 (37.22) ^{bc}	25.31 (29.71)^{c}
Manalur	6.00 (14.71)^{h}	8.25 (16.69)^{l}	9.50 (17.95)^{n}	13.00 (21.13)^{m}	17.00 (24.35)^{m}	16.00 (23.57) ^{g}	11.62(19.73)^{j}
Nallurkadu	12.00 (20.26)^{e}	24.16 (29.44)^{b}	37.42 (37.71)^{a}	40.11 (39.29)^{a}	50.66 (45.37)^{a}	44.00 (41.55)^{a}	34.72 (35.60)^{a}
Nerimalai	8.66 (17.11)^{ef}	14.00 (21.97)^{gh}	21.55 (27.66)^{d}	33.41 (35.31)^{d}	36.33 (37.06)^{i}	35.55 (36.60)^{bcd}	24.90 (29.28)^{e}
Periyamalai	13.00 (21.13)^{b}	17.42 (24.64)^{d}	20.22 (26.72)^{fg}	24.30 (29.53)^{e}	32.00 (34.45)^{jk}	29.00 (32.52) ^{ef}	22.65 (28.16)^{f}
Perumparai	12.12 (14.47)^{bc}	14.00 (21.97)^{h}	19.25 (26.02)^{h}	22.32 (28.19)^{i}	41.60 (40.16)^{e}	26.00 (30.65) ^{f}	22.54 (26.91)^{g}
Pillaveli	6.25 (14.47)^{h}	15.00 (22.78)^{f}	16.38 (23.87)^{k}	22.50 (28.31)^{hi}	31.27 (34.00)^{k}	25.79 (30.52) ^{f}	19.53 (25.65)^{f}
Pachalur	8.15 (16.58)^{fg}	13.17 (21.27)^{j}	19.00 (25.84)^{i}	20.25 (26.74)^{l}	32.00 (34.45)^{jk}	27.50 (31.62)^{f}	20.01 (26.08)^{f}
Pallathu kalvai	4.00 (11.53)^{i}	8.00 (16.43)^{m}	10.27 (18.69)^{m}	10.71 (19.10)^{n}	20.09 (26.63)^{l}	15.19 (23.41)^{g}	11.37 (19.29)^{j}
Solaikadu	11.00 (19.37)^{d}	30.00 (33.21)^{a}	31.33 (34.03)^{b}	40.00 (39.27)^{b}	46.25 (42.85)^{b}	40.15 (39.32)^{ab}	33.12 (34.67)^{a}
Thandigudi	8.13 (16.56)^{g}	10.00 (18.43)^{k}	12.50 (20.70)^{j}	21.00 (27.27)^{l}	32.17 (34.55)^{j}	25.00 (30.00)^{f}	18.31 (32.91)^{f}
Thadiyanku disai	11.00 (19.37)^{d}	14.25 (22.17)^{g}	20.25 (26.74)^{f}	21.00 (27.27)^{k}	32.00 (34.45)^{k}	26.30 (30.89)^{f}	20.80 (26.81)^{b}
Mean	9.64 (17.51)^{f}	15.35 (22.79)^{f}	20.02 (26.29)^{D}	24.85 (29.60)^{C}	35.73 (33.92)^{A}	29.70 (32.86)^{B}	22.77 (28.06)^{CD}

* Each value is the mean of five estates per location; figures in parentheses are arcsine transformed values; in a column, means followed by the same letter(s) are not significantly different by DMRT (P = 0.05)

Table 4. Parasitization by *C. stephanoderis* on coffee berry borer (Season 2005 - 06

Location	Mean per cent parasitism at bimonthly interval *						Pooled mean
	Jan. '05	March 05	May 05	July 05	Sep. ' 05	Nov. ' 05	
Adalur	31.56 (34.18)^{b}	25.46 (30.30)^{c}	26.71 (31.11)^{c}	31.55 (34.17)^{d}	41.25 (39.96)^{d}	38.11 (37.53)^{d}	32.44 (34.54)^{b}
Kanalkadu	24.31 (29.54)^{g}	19.40 (26.13)^{g}	21.66 (27.73)^{efg}	25.22 (30.14)^{k}	35.36 (36.48)^{i}	30.00 (32.21)^{i}	25.99 (30.37)^{e}
K.C.Patty	26.65 (31.08)^{f}	23.72 (29.14)^{d}	20.00 (26.56)^{egh}	26.00 (30.65)^{j}	38.17 (38.15)^{g}	36.13 (36.94)^{e}	28.44 (32.88)^{d}
Kamanur	21.30 (27.48)^{i}	18.41 (25.40)^{h}	13.35 (21.43)^{ij}	23.20 (28.79)^{l}	29.26 (32.74)^{k}	26.15 (30.98)^{n}	21.94 (27.80)^{i}
Mangalam kombu	26.71 (31.11)^{f}	20.62 (27.00)^{f}	18.46 (25.44)^{h}	26.32 (30.86)^{i}	42.47 (39.67)^{c}	35.31 (36.45)^{f}	28.31 (31.92)^{d}
Manjal parappu	13.60 (23.58)^{d}	25.25 (30.16)^{c}	23.13 (28.74)^{def}	29.91 (33.15)^{f}	45.67 (42.51)^{b}	37.39 (37.69)^{c}	29.15 (34.30)^{c}
Manalur	15.25 (22.98)^{n}	10.36 (18.77)^{k}	8.19 (16.62)^{j}	11.58 (19.89)^{m}	22.33 (28.20)^{m}	20.26 (26.75)^{o}	14.66 (22.20)^{j}
Nellurkadu	33.15 (35.15)^{a}	27.36 (31.53)^{b}	36.25 (37.02)^{a}	42.50 (40.68)^{a}	48.30 (44.02)^{a}	39.21 (38.76)^{b}	37.79 (31.86)^{a}
Nerimalai	27.17 (31.41)^{e}	25.23 (30.15)^{c}	25.19 (30.12)^{cd}	30.17 (33.31)^{e}	41.50 (39.10)^{d}	33.30 (35.24)^{g}	30.42 (33.38)^{b}
Periyamalai	23.19 (28.78)^{h}	18.76 (25.66)^{h}	19.75 (26.38)^{gh}	26.25 (30.82)^{i}	35.32 (36.40)^{i}	28.15 (32.04)^{l}	25.23 (30.01)^{f}
Perumparai	21.00 (27.27)^{j}	22.25 (28.14)^{e}	24.13 (29.42)^{cde}	32.15 (34.54)^{e}	40.16 (39.32)^{e}	33.19 (35.17)^{g}	28.81 (32.31)^{d}
Pillaveli	17.25 (24.54)^{l}	19.65 (26.31)^{g}	21.00 (27.27)^{fgh}	28.30 (32.14)^{g}	36.40 (37.10)^{h}	30.32 (33.41)^{h}	25.48 (30.29)^{f}
Pachalur	20.25 (26.74)^{k}	16.75 (24.15)^{i}	12.50 (20.70)^{j}	23.05 (28.69)^{l}	35.35 (36.48)^{i}	27.17 (31.41)^{m}	22.51 (28.02)^{h}
Pallathu kalvai	10.11 (18.54)^{o}	6.82 (15.13)^{l}	6.32 (14.55)^{k}	8.13 (16.56)^{n}	25.33 (30.21)^{l}	17.50 (24.72)^{p}	12.36 (20.01)^{k}
Solaikadu	31.25 (33.98)^{c}	29.00 (32.58)^{a}	30.00 (33.21)^{b}	39.26 (38.79)^{b}	45.75 (42.56)^{b}	39.81 (39.12)^{a}	35.84 (36.7)^{a}
Thandigudi	17.12 (24.44)^{m}	14.11 (22.06)^{j}	15.11 (22.87)^{i}	25.16 (30.10)^{k}	38.80 (38.52)^{f}	29.31 (37.77)^{j}	23.26 (29.29)^{g}
Thadiyan kudisai	24.36 (29.57)^{g}	22.52 (28.33)^{e}	23.66 (29.10)^{def}	26.75 (31.14)^{h}	32.55 (34.18)^{j}	28.61 (37.32)^{k}	26.40 (28.27)^{e}
Mean	22.60 (28.25)^{D}	20.33 (26.52)^{E}	20.31 (26.36)^{E}	26.79 (30.84)^{C}	37.29 (37.38)^{A}	31.17 (34.32)^{B}	26.41 (30.24)^{C}

* Each value is the mean of five estates per location; figures in parentheses are arcsine transformed values; in a column, means followed by the same letter(s) are not significantly different by DMRT (P = 0.05)

and off-season crops throughout the year are highly favorable for coffee berry borer infestation and build up of populations, which provide an ideal condition for parasitoid development.

ACKNOWLEDGMENTS

The authors are thankful to Mr. Antony Raj, Mr. S. Kariamal and Mr. N.T.N. Maruthakumar for their unstinted support in carrying out this work in various coffee estates in Pulney hills.

REFERENCES

Alves, S. B. 1986. Fungus entomopatogenicos. pp.73-126. In: Alves, S. B. (Ed.) Controle microbiano de insectos. Sao Paulo, Editora Mande.

Anonymous. 2005. Data base on coffee (July 2005) Coffee Board, Bangalore. 69p.

Baker, P. S. 1999. The Coffee Berry Borer in Colombia: Final report of the DFID- Cenicafe-CABI Bioscience IPM for the coffee Project (CNTR 93 / 1536 A). CABI Bioscience, Silwood Park, Ascot SL5 7TA, UK, 144pp.

Balakrishnan, M. M. and Sreedharan, K. 2002. Establishment of *Cephalonomia stephanoderis*, the introduced parasitoid of coffee berry borer in Coorg district, Karnataka. pp.504-508. Proceeding of the 15th Plantation Crops Symposium (PLACROSYM XV), Mysore, 10-13 December, 2002.

Balakrishnan, M. M., Prakasam, C. B. and Sreedharan, K. 2000. *Biocontrol of coffee berry borer in India.* Paper presented at the International Scientific Symposium on Coffee held at Bangalore on 4th December 2000. 111pp.

Garcia, A. and Barrios, L. 1996. Efectivda del parastoide *Cephalonomia stephanoderis* en el control de la broca del Caf 'e. Bolletin de Promocafe. 69-70: 16-17.

Gomez, K. A. and Gomez, A. A. 1985. *Statistical procedures for agricultural research.* John Wiley and Sons. New York. 650pp.

Kumar, P. K. V., Prakasam, C. B. and Vijayalakshmi, C. K. 1990. Coffee berry borer, *Hypothenemus hampei* (Coleoptera: Scolytidae): first record from India. *Journal of Coffee Research,* **20**: 160-164.

Le Pelley, R. H. 1968. *Pests of Coffee.* Longman Green and Co Ltd, London, 590p.

Naidu, R. 2000. Present performance and future outlook of coffee industry in India. Souvenir, International Conference on Plantation crops 12 – 15 December 2000. PLACROSYM XIV, organized by National Research Centre for oil palm, Pedavegi – 534 450, A. D., India. 70pp.

Rosa, W., Alatorre, R., Trujillo, J. and Barrera, J. F. 1997. Virulence of *Beauveria bassiana* (Deuteromycetes) strain against the coffee berry borer (Coleoptera: Scolytidae). *Journal of Economic Entomology,* **90**: 1534-1538.

Samuels, R. I., Pereira, R. C. and Gava, C. A. T. 2002. Infection of the coffee berry borer, *Hypothenemus hampei* (Coleoptera: Scolytidae) by Brazilian isolates of the entomopathogenic fungi *Beauveria bassiana* and *Metarhizium anisopliae* (Deuteromycotina: Hyphomycetes). *Biocontrol Science and Technology,* **12**: 631-635.

Sreedharan, K., Balakrishnan, M. M., Prakasam, C.B., Krishnamoorthy Bhat, P. and Naidu, R. 1994. Bioecology and management of coffee berry borer. *Indian Coffee*, **58**: 5-13.

(Received: 28.12.2006; Revised: 09.07.2007; Accepted: 14.08.2007)