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Influence of weather factors on the incidence of coffee berry borer, *Hypothenemus hampei* (Ferrari) (Scolytidae: Coleoptera) in Pulney hills, Tamil Nadu

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Abstract : Studies were carried out to assess the influence of weather parameters on the incidence of coffee berry borer, *Hypothenemus hampei* (F.) at three locations in lower Pulney hills of Tamil Nadu during 2004 - 05 and 2005 - 06. In all the three locations, the infestation was higher (19.71%) in *robusta* than in *arabica* coffee varieties. In both the varieties, the peak period of infestation occurred between November and December. Correlation between weather parameters and infestation of coffee berry borer revealed a negative association with maximum temperature and rainfall at all the three locations while a positive relationship with maximum and minimum relative humidity with reference to the infestation of berry borer. Irrespective of the locations surveyed the population build-up of coffee berry borer in left over berries had served as a main source of inoculum for their carryover to the next season. The mean number of borer adults emerged from gleaning was high (21.72) due to rain followed by 12.93 and 12.52 recorded in mere water spray and surface temperature, respectively.

Key words: Abiotic factors, coffee berry borer, Hypothenemus hampei.

Introduction

The coffee berry borer, *Hypothenemus hampei* (Ferrari) (Scolytidae: Coleoptera) is one the most serious pests of coffee in many of the worlds chief coffee producing countries, which has caused great losses to the yield (Le-Pelley, 1968). Though, it gained entry in to India in 1990 *via.* Gudalur in Tamil Nadu it made its first appearance on Pulney Hills at Pethuparai village, an isolated pocket in Perumalmalai liaison zone (Anonymous, 1996). It invaded in to the main coffee growing areas of Pulneys during 1997 and by 2000 spread to entire coffee areas in Pulneys. The coffee berry borer is known to feed and reproduce only in the seeds of coffee species. The female beetle enters into the coffee berry by cutting a circular hole, generally at the tip of the berry. Occasional attempts made by the coffee berry borer to penetrate into the immature endosperm cause decaying of endosperm by secondary infection resulting in premature fruit drop. Any delay in harvesting will aggravate the damage as rate of reproduction is faster near to harvest (Baker, 1999; Sreedharan *et al.,* 2001). In the recent years, the berry borer menace has been felt as a major limiting factor for quality coffee production by the coffee growers of lower Pulney hills. Information on the seasonal trends in population development of coffee berry borer is essential for timely implementation of cultural and chemical control methods.

Table 1. Infestation of coffee berry borer in three coffee estates of lower Pulney hills, 2004 - 2005

Standard week	Mean per cent infestation (RCRS, Thandigudi) *						Mean per cent infestation (Periyamalai VKV, hill garden estate) *					
	2004		2005		Mean+		2004		2005		Mean+	
	Arabica	Robusta	Arabica	Robusta	Arabica	Robusta	Arabica	Robusta	Arabica	Robusta	Arabica	Robusta
Jan 1 - Jan 15	0.56	4.92	1.51	2.47	1.03(5.82)^{ab}	3.69(11.07)^{a}	0.66	6.67	1.86	5.97	1.26(6.44)^{d}	6.32(14.56)^{cd}
Jan 16-Jan31	0.61	4.82	0.91	2.52	0.76(5.00)^{a}	3.67(11.04)^{a}	0.73	4.08	1.12	4.38	0.92(5.50)^{bc}	4.23(11.86)^{a}
Feb 1 - Feb 15	0.26	4.36	0.18	3.88	0.22(2.68)^{a}	4.12(11.71)^{ab}	0.34	4.92	0.61	4.09	0.47(3.93)^{ab}	4.50(12.24)^{a}
Feb 16-Feb 29	0.10	5.43	0.06	2.71	0.08(1.62)^{a}	4.07(11.63)^{ab}	0.17	6.74	0.09	5.69	0.13(2.06)^{a}	6.21(14.43)^{cd}
March 1 - Mar. 15	0.05	4.38	0	3.62	0.02(0.81)^{a}	4.0(11.53)^{ab}	0.02	5.86	0.01	6.71	0.01(0.57)^{a}	6.28(14.51)^{cd}
Mar. 16-Mar 31	0.09	3.59	0	2.76	0.04(1.14)^{a}	3.17(10.25)^{a}	0.03	7.16	0.02	5.82	0.02(0.81)^{a}	6.49(14.75)^{cd}
April 1 -Apr. 15	8.12	3.89	0.09	4.07	4.10(11.68)^{d}	3.98(11.50)^{a}	0.19	4.63	0.11	7.42	0.15(2.21)^{a}	6.02c 14.20)^{c}
April 16 -Apr.30	0.22	4.11	0.17	4.98	2.16(8.45)^{c}	4.54(12.30)^{ab}	0.31	6.66	0.19	6.37	0.25(2.86)^{a}	6.51(14.78)^{cd}
May 1 - May 15	0.36	4.36	0.27	5.11	0.31(3.19)^{a}	4.73(12.56)^{ab}	0.49	7.13	0.38	4.56	3.81(11.25)^{f}	5.84(13.98)^{bc}
May 16 - May 3 1	0.96	5.76	0.56	4.78	0.76(5.00)^{a}	5.27(13.27)^{bc}	1.12	8.19	0.89	5.39	1.00(5.73)^{cd}	6.79(15.10)^{cd}
June 1 - June 15	1.76	5.89	0.99	5.47	1.37(6.72)^{b}	5.68(13.78)^{c}	2.11	6.33	1.31	6.94	1.71(7.51)^{e}	6.63(14.92)^{cd}
June 16 -June 30	2.11	4.66	1.15	4.96	3.38(10.59)^{c}	4.81(12.66)^{b}	3.61	5.17	2.62	4.39	3.11(10.15)^{f}	4.78(12.62)^{ab}
July 1 -July 15	2.91	6.17	2.98	5.91	2.94(9.87)^{c}	6.04(14.22)^{c}	4.92	8.66	1.98	5.17	3.45(10.70)^{f}	6.91(15.24)^{cd}
July 16-July 31	4.01	7.86	2.38	6.12	3.19(10.28)^{a}	6.99(15.3 3)^{ca}	6.31	10.14	3.1.3	7.19	4.72(12.54)^{g}	8.66(17.11)^{f}
Aug 1 - Aug 15	5.32	8.39	4.13	6.46	6.85(15.17)^{a}	6.26(14.48)^{c}	5.26	11.16	4.94	7.92	5.10(13.05)^{gh}	9.54C 17.99)^{g}
Aug 16-Aug 30	6.41	10.28	3.98	5.33	5.19(13.16)^{de}	7.80(16.21)^{de}	7.32	13.66	5.18	6.03	6.25(14.47)^{hi}	9.84C 18.28)^{g}
Sep 1 - Sep 15	5.73	12.67	5.66	7.19	5.65(13.75)^{e}	9.93(18.36)^{gh}	6.16	16.32	4.67	8.14	5.41(13.45)^{hi}	12.23(20.47)^{h}
Sep 16-Sep 30	7.46	13.88	6.12	8.27	6.79(15.10)^{f}	11.07(19.43)^{l}	9.13	13.41	6.17	9.66	7.65(14.05)^{j}	11.53(19.85)^{gh}
Oct 1 -Oct 15	6.68	10.71	5.09	6.91	5.88(14.03)^{e}	8.81(17.26)^{ef}	7.88	12.39	8.69	10.71	8.28(16.72)^{jk}	11.55C 19.86)^{gh}
Oct 16-Oct 31	9.43	14.91	7.27	9.36	8.35(16.79)^{g}	12.13(20.38)^{j}	12.16	16.47	6.88	8.96	9.52(17.97)^{kl}	12.71(20.88)^{h}
Nov 1 - Nov 15	11.37	16.79	9.18	11.12	10.2708.69)^{h}	13.95(21.93)^{k}	13.17	16.55	9.17	12.76	11.17(19.52)^{m}	14.65(22.50)^{ij}
Nov 16-Nov 30	7.56	11.54	8.75	10.13	8.15(16.58)^{g}	10.83(19.21)^{h}	11.92	17.11	7.36	13.36	9.64(18.08)^{kl}	15.23(22.97)^{j}
Dec 1 -Dec 15	6.34	10.48	7.36	8.26	6.85(15.17)^{f}	9.37(17.82)^{fg}	9.71	14.86	10.44	14.17	10.07(18.50)^{l}	14.48(22.36)^{ij}
Dec 16-Dec 31	4.18	8.38	5.16	9.19	4.67(12.48)^{d}	8.78(17.23)^{ef}	6.66	11.91	7.17	13.36	6.91(15.24)^{j}	12.63(20.81)^{h}

* Each value is the mean of five plants

\+ Figures in parentheses are square root transformed values In a column, means followed by a common letter (s) are not significantly different by DMRT (P=0.05)

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Table 1. Infestation of coffee berry borer in three coffee estates of lower Pulney hills, 2004 - 2005

Standard week	Mean per cent infestation (Pillaveli estate) *					
	2004		2005		Mean+	
	Arabica	Robusta	Arabica	Robusta	Arabica	Robusta
Jan 1 - Jan 15	0.81	5.51	3.71	5.67	2.26(8.64)^{f}	5.59(13.67)^{ab}
Jan 16 - Jan 31	0.96	4.96	2.66	5.42	1.81(7.73)^{e}	5.19(13.16)^{a}
Feb 1 - Feb 15	0.76	6.76	1.26	6.48	1.01(5.76)^{d}	6.62(14.90)^{b}
Feb 16 - Feb 29	0.55	7.81	0.48	5.61	0.51(4.09)^{bc}	6.71(15.01)^{b}
March 1-Mar. 15	.0.06	6.95	0	4.71	O.O3(O.99)^{a}	5.83(13.97)^{ab}
Mar. 16 - Mar 31	0	8.12	0	6.12	0.0(0.57)^{a}	7.12(15.47)^{cd}
April 1 - Apr. 15	0	12.12	0.08	7.46	0.04(1.14)^{a}	9.79(18.23)^{et}
April 16 - Apr.30	0.27	13.14	0.26	8.12	0.26(2.92)^{ab}	10.63(19.()2)^{lg}
May 1 - May 15	0.67	10.14	0.52	6.86	0.59(4.40)^{c}	8.50(16.95)^{d}
May 16-May 31	1.76	6.17	1.17	7.19	1.46(6.94)^{de}	6.68(14.97)^{bc}
June 1 - June 15	3.17	7.26	2.46	9.46	2.81(9.65)^{fg}	8.36(16.80)^{d}
June 16 - June 30	3.96	2.64	3.48	10.47	3.72(11.12)^{ghi}	6.55(14.82)^{b}
July 1 -July 15	5.89	4.72	3.96	8.67	4.92(12.81)^{hi}	6.69(14.99)^{bc}
July 16-July 31	7.79	6.17	3.14	7.17	5.46(13.51)^{i}	6.67(14.96)^{bc}
Aug 1 - Aug 15	6.12	8.39	4.27	8.94	5.19(13.16)^{l}	8.66(17.11)^{d}
Aug 16 - Aug 30	8.46	12.06	6.46	10.66	7.46(15.85)^{j}	11.36(19.69)^{gh}
Sep 1 -Sep 15	9.56	14.71	6.98	11.17	8.27(16.71)^{k}	12.94(21.08)^{hi}
Sep 16 - Sep 30	7.66	17.13	8.55	9.14	8.10(16.53)^{k}	13.13(21.24)^{i}
Oct 1-Oct l5	10.71	15.26	9.26	10.36	9.98(18.41)^{lm}	12.81(20.97)^{hi}
Oct 16-Oct 31	9.13	16.81	8.17	13.96	8.65(17.10)^{k}	15.38(23.09)^{jk}
Nov 1 - Nov 15	15.99	18.16	10.17	16.58	13.08(21.20)^{o}	17.37(24.63)^{l}
Nov 16 - Nov 30	17.15	19.71	8.46	15.36	12.80(20.96)^{no}	17.53(24.75)^{l}
Dec 1 -Dec 15	13.91	16.63	8.26	17.17	11.08(19.44)^{mn}	16.90(24.27)^{kl}
Dec 16-Dec 31	8.76	12.46	6.86	14.20	7.81(16.22)^{jk}	13.33(21.41)^{l}

* Each value is the mean of five plants

\+ Figures in parentheses are square root transformed values In a column, means followed by a common letter (s) are not significantly different by DMRT (P=0.05)

Hence, the present study was taken up on the influence of weather factors on the incidence of berry borer, *H. hampei* at three locations in Pulney hills, Tamil Nadu and results are presented here.

Materials and Methods

Seasonal infestation of coffee berry borer

A study was conducted in lower Pulney hills, to assess the seasonal incidence and influence of coffee berry borer, *H. hampei* at fortnightly interval from January 2004 to December 2005 in the coffee plantations (*C. arabica and C. canephora)* maintained at Regional Coffee Research Station, Thandigudi (4300 feet MSL), VKV hill garden estate, Periyamalai (3600 feet MSL) and Pillaveli estate (2900 feet MSL). In each plantation, observations were made from 10 randomly selected coffee plants and in each plant, three branches were chosen. The damaged berries by berry borer was worked out based on number of infested and uninfested berries. The data were corrected by using Abbot's formula. The mean were compared using Duncan's multiple range test (DMRT) (Erwin *et al.,* 1962). The data on weather parameters, maximum and minimum temperature (°C), relative humidity (%) and rainfall (mm) were recorded during study period.

Source of inoculum of coffee berry borer in left-over berries

The left-over berries were collected from 17 locations on lower Pulney hills during May and June of 2004 and 2005. One hundred left-over berries were collected randomly in five places in each location and they were sliced and recorded for the total number of beetles per berry.

Adult emergence pattern of coffee berry borer from gleanings

The infested gleanings were collected from the field in six treatments and five replications after the main harvest. Fifty fruits were collected and maintained uniformly in each replication. The treatments were imposed with (1) water spray, (2) water soaking for 2 min., (3) exposure for natural rain, (4) exposure to surface temperature (25 °C), (5) impact of relative humidity (90%) and (6) untreated check. The above treated gleanings were kept in a plastic container covered with brass wire mesh on top to allow the aeration. The emerging adults were counted periodically up to 5 days.

Statistical analyses

The fortnightly means were calculated from the data on the incidence of coffee berry borer and this was correlated with the weather parameters. Data collected in various field and laboratory experiments were statistically analysed. The percentage values were subjected to *arc sine* transformation. Square root transformation was followed for converting the population / numbers. The treatment means were compared with Duncan's multiple range test (DMRT) for their significance (Gomez and Gomez, 1985).

Results and Discussion

Seasonal infestation of coffee berry borer

Seasonal occurrence and influence of weather parameters on the infestation of coffee berry borer, *H. hampei* in coffee plantation *(C. arabica and C. canephora)* during the period from January 2004 to December 2005 at RCRS (Farm), NTN estate (Thandigudi), VKV hill garden estate (Periyamalai) and Pillaveli estate (Pillaveli) of lower Pulney hills revealed the following.

Table 2. Correlation between weather parameter and the infestation of coffee berry borer (Thandigudi)

Location	Genotypes	Season	Weather parameters				
			Temperature (°C)		Relative humidity (%)		Rain fall (mm)
			Maximum	Minimum	Maximum	Minimum	
Thandigudi (RCRS, Farm)	C. *arabica*	Year 2004					
		R	-0.411	0.322	0.506	0.629	-0.507
		R^2	0.17	0.10	0.26	0.39	0.26
		Y = a+bx	15.99 - 0.54 x	-4.20 + 0.55 x	-22.44 + 0.31 x	-6.19+0.17x	2.29-0.36x
		Significance					
		*P = 0.05	*	-	-	-	-
		** P = 0.01	-	-	**	**	**
		NS= Nonsignificant	-	NS	-	-	-
Thandigudi (RCRS, Farm)	C. *arabica*	Year 2005					
		R	-0.537	0.404	0.021	0.619	-0.327
		R^2	0.29	0.16	0.04	0.38	0.11
		Y = a+bx	18.59-0.66x	-4.22+0.51x	5.35+0.02x	-6.38+0.14x	1.85-0.28x
		Significance					
		*P = 0.05	*	-	-	-	-
		**P = 0.01	-	-	-	**	-
		NS= Nonsignificant	-	NS	NS	-	-
Thandigudi (RCRS, Farm)	C. *canephora*	Year 2004					
		R	-0.302	0.253	0.529	0.685	-0.497
		R^2	0.09	0.06	0.28	0.47	0.25
		Y = a+bx	13.59-0.32x	0.74+0.48x	-23.14+0.36x	-4.46+0.22x	6.12-0.40x
		Significance					
		*P = 0,05	*	-	-	-	-
		** p = 0.01	-	-	**	**	**
		NS= Non significant	-	NS	-	-	-
Thandigudi (RCRS, Farm)	C. *canephora*	Year 2005					
		R	-0.526	0.560	0.172	0.717	-0.347
		R^2	0.28	0.31	0.03	0.51	0.12
		Y = a+bx	18.26-0.52x	-2.34+0.58x	-9.52=0.16x	-3.090+0.13x	4.84-0.24x
		Significance					
		*P = 0.05	*	-	-	-	*
		** P = 0.01	-	-	-	**	-
		NS= Non significant	-	NS	NS	-	-

Table 3. Correlation between weather parameter and the infestation of coffee berry borer (Periamalai)

Location	Genotypes	Season	Weather parameters				
			Temperature (°C)		Relative humidity (%)		Rain fall (mm)
			Maximum	Minimum	Maximum	Minimum	
Periamalai (VKV estate)	C. *arabica*	Year 2004					
		R	-0.559	0.116	0.565	0.695	-0.535
		R^2	0.31	0.02	0.32	0.48	0.29
		Y = a+bx	41.86-1.51x	-0.71+0.29x	-32.47+0.44X	-9.38+0.25X	2.67-0.53x
		Significance					
		*P = 0.05	-	-	*	-	*
		** P = 0.01			**	**	**
		NS= Nonsignificant	-	NS	-	-	-
Periamalai (VKV estate)	C. *arabica*	Year 2005					
		R	-0.597	0.075	0.057	0.654	-0.124
		R^2	0.36	0.006	0.03	0.43	0.02
		Y = a+bx	34.04-1.23x	5.73+012X	10.49+0.07x	-7.45+0.17X	3.13-0.11x
		Significance					
		*P = 0.05	-	-	*	-	*
		**P = 0.01	**	-			-
		NS= Nonsignificant	-	NS		-	-
Periamalai (VKV estate)	C. *canephora*	Year 2004					
		R	-0.213	0.07	0.479	0.600	-0.485
		R^2	0.05	0.004	0.23	0.36	0.24
		Y = a+bx	1.33-0.37X	6.93+0.16x	-21.17+0.36X	-2.82+0.21X	8.12-0.47X
		Significance					
		*P = 0.05	-		-	-	-
		** P = 0.01	-	-	**	**	**
		NS= Non significant	NS	NS	-	-	
Periamalai (VKV estate)	C. *canephora*	Year 2005					
		R	-0.634	0.175	0.149	0.639	-0.244
		R^2	0.40	0.03	0/022	0.41	0.06
		Y = a+bx	37.49-1.20x	12.41+0.25X	-8.82+0.17x	-2.16+0.15X	6.97-0.21 x
		Significance					
		*P = 0.05	-	*	-	-	•*k*
		** P = 0.01	**	-	-	**	-
		NS= Non significant	-	-	NS	-	-

Table 4. Correlation between weather parameter and the infestation of coffee berry borer (Pillaveli)

Location	Genotypes	Season	Weather parameters				
			Temperature (°C)		Relative humidity (%)		Rain fall (mm)
			Maximum	Minimum	Maximum	Minimum	
Pillaveli (Pillaveli estate)	C. *arabica*	Year 2004					
		R	-0.205	0.177	0.553	0.268	-0.297
		R^2	0.04	0.03	0.31	0.07	0.09
		Y = a+bx	0.95-0.23x	18.26+0.50x	-20.96+0.31x	-4.28+0.14x	4.42-0.40x
		Significance					
		*P = 0.05	-	-	*	-	*
		** P = 0.01			**	**	**
		NS= Nonsignificant	-	NS	-	-	-
Pillaveli (Pillaveli estate)	C. *arabica*	Year 2005					
		R	-0.579	0.199	0.563	0.604	-0.138
		R^2	0.34	0.04	0.29	0.37	0.02
		Y = a+bx	29.89-1.00X	9.70+0.26X	-25.29+0.35X	-9.89+0.21x	4.48-0.07x
		Significance					
		*P = 0.05	-	-	-	-	*
		**P = 0.01	**	-	**	-	-
		NS= Nonsignificant	-	NS	-	NS	-
Pillaveli (Pillaveli estate)	C. *canephora*	Year 2004					
		R	-0.174	0.047	0.298	0.201	-0.476
		R^2	0.03	0.002	0.09	0.04	0.23
		Y = a+bx	6.93-018x	13.73+0.13x	-2.69+0.16x	3.72+0.09x	8.84-0.59x
		Significance					
		*P = 0.05	*	-	-	-	-
		** P = 0.01	-	-	-	-	**
		NS= Non significant	-	NS	NS	NS	-
Pillaveli (Pillaveli estate)	C. *canephora*	Year 2005					
		R	-0.542	0.139	0.546	0.776	-0.176
		R^2	0.29	0.02	09.29	0.60	0.03
		Y = a+bx	34.99-0.99x	13.54+0.19x	-21.46+0.36x	-9.79+0.28x	9.85-0.09x
		Significance					
		*P = 0.05	-	*	-	-	*k*
		** P = 0.01	**	-	-	-	-
		NS= Non significant	-	-	NS	NS	-

Thandigudi

In Thandigudi, in *arabica* coffee the mean per cent berry damage by the berry borer was registered high (11.37 and 9.18 %) in the first fortnight of November during 2004 and 2005 respectively, and in *robusta* coffee it was maximum (16.79 and 11.12%) in November 2004 and 2005, where as it was less in first fortnight of March 2004 (0.05%) and March 2005 (0%) in *arabica.* In *robusta,* it was the least (3.59 and 2.71 per cent) in March 2004 and 2005, respectively (Table 1).

Correlations between the weather parameters and the coffee berry borer infestation in *C. arabica* during 2004 and 2005 showed that maximum temperature (r = - 0.411 and r = - 0.537) and rainfall (r = - 0.507 and r = - 0.327) exhibited significant negative association with berry borer infestation while maximum relative humidity (r = 0.506 and r = 0.021) and minimum relative humidity (r = 0.629 and r = 0.619) had a positive association, (Table 2) respectively.

The correlation studies made between weather parameters and berry borer infestation in *C. canephora* during 2004 and 2005 revealed that maximum temperature and rainfall had significant negative association recording the r values of- 0.302 and - 0.497 in 2004 and - 0.526 and - 0.347 in 2005, respectively. Where as maximum and minimum relative humidity had a positive association with berry borer infestation (r = 0.529 and 0.172; r = 0.685 and 0.717 respectively.

Periyamalai

In Periyamalai, VKV estate, the peak per cent berry damage by berry borer in *arabica* was 13.17 and 9.17 per cent in first fortnight of November 2004 and 2005, while the least damage was recorded during March 2004 (0.02%) and 2005 (0.01%) respectively (Table 1). As far as *robusta* was concerned the highest infestation was recorded (17.11 and 14.17%) during second fortnight of November 2004 and first fortnight of December 2005 and it was the least (4.08 and 4.09%) during 2004 and 2005 respectively.

The simple correlations worked out between weather parameters and berry borer infestation in *C. arabica* during 2004 and 2005 indicated significant negative association of the maximum temperature and rainfall with berry borer infestation, recording the 'r' values of - 0.559 and - 0.535 during 2004 and - 0.597 and - 0.124 during 2005 respectively, and the maximum (r = 0.565 and r = 0.057) and minimum relative humidity (r = 0.695 and r = 0.654) exhibited positive associations with berry borer infestation during 2004 and 2005 (Table 3). The results also predicted that an increase in maximum temperature by 1 °C and rainfall by 1 mm would decrease the berry borer infestation by 1.51 and 0.53 per cent in 2004, and 1.23 and 0.11 per cent in 2005 respectively. But an increase of one per cent in case of maximum and minimum relative humidity increased the berry borer infestation by 0.44 and 0.25 per cent during 2004 and 0.07 and 0.17 per cent during 2005 in *C. arabica.* Minimum temperature had no significant correlation with the level of berry borer infestation during 2004 mand 2005.

During 2004, the maximum and minimum temperatures exhibited no significant association with berry borer damage in *C. canephora.* However, maximum (r = 0.479) and minimum (r = 0.600) relative humidity recorded significant positive association while the rainfall

(r = - 0.485) had a negative association with berry borer infestation. With reference to maximum temperature and rainfall during 2005, *C. canephora* showed significant negative correlation with berry borer infestation, with the 'r' values of- 0.634 and - 0.244 respectively, and minimum temperature (r = 0.175) and minimum relative humidity (r = 0.639) had positive influence on berry borer infestation (Table 3).

Pillaveli

In Pillaveli, in the different periods of observations, the per cent berry borer damage in *arabica* ranged from 0 to 17.15 per cent during 2004 and 0 to 10.17 per cent during 2005 (Table 1). The peak per cent damage by berry borer was 17.15 in second fortnight of November 2004, while it was 10.17 per cent in first fortnight of November 2005. In *robusta*, the per cent berry borer damage was maximum in second fortnight of November 2004 (19.71%) and first fortnight of December 2005 (17.17%). In above locations the infestation of berry borer was more in *robusta* than *arabica.*

The correlation co-efficient worked out between the berry borer infestation and weather factors in *C. arabica* during 2004 and 2005 indicated that maximum temperature (r = - 0.205 and r = -0.579) and rainfall (r = - 0.297 and r = - 0.138) had negative correlation while maximum relative humidity exhibited positive correlation with the r values of 0.553 and 0.563 during 2004 and 2005, respectively (Table 4).

Simple correlation worked out between minimum temperature, maximum and minimum relative humidity and berry borer infestation in *C. canephora* during 2004 had shown no significant associations between them. However, maximum temperature and rainfall recorded negative associations with the berry borer infestation recording the 'r' values of- 0.174 and - 0.476 respectively. During 2005 in *C. canephora*, the maximum temperature and rainfall exhibited its negative associations with berry borer infestation recording the r values of- 0.542 and - 0.176 and also predicted that an increase in maximum temperature by 1°C and one mm of rainfall would decrease the berry borer infestation by 0.99 and 0.09 per cent (Table 4).

Coffee berry borer was found to be the major pest of coffee at all the three locations surveyed in lower Pulney hills, Dindigul District, Tamil Nadu. Though its distribution had already been reported in coffee growing areas of Nilgris district, lower Pulney hills of Dindigul district, Wayanad district of Kerala and Kodagu district of Karanataka (Kumar *et al.*, 1990 and Sreedharan *et al.*, 1994), the present investigation further quantified its occurrence in three major coffee growing locations on Pulney hills *viz.*, Thandigudi, Periyamalai, and Pillaveli. During the fixed plot survey, observations were made on each plant from waist high plagiotropic branch and the number of infested and uninfested berries were recorded as stated by Baker *et al.* (1989). In all the three locations, the infestation was high (19.71%) in *robusta* than in *arabica* variety which is in conformation with the findings of Campos and Garcia (1997) who observed high percentage of infestation in *robusta* coffee (45 to 60%) than *catimore*, an *arabica* variety (32 to 41%) and it might be due to relative feeding preference to berries in *robusta* with prolonged fruiting season that favoured the infestation to a considerable level as reported by Baker *et al.*, (1989).

Fig.1. Seasonal infestation of coffee berry borer at three different locations

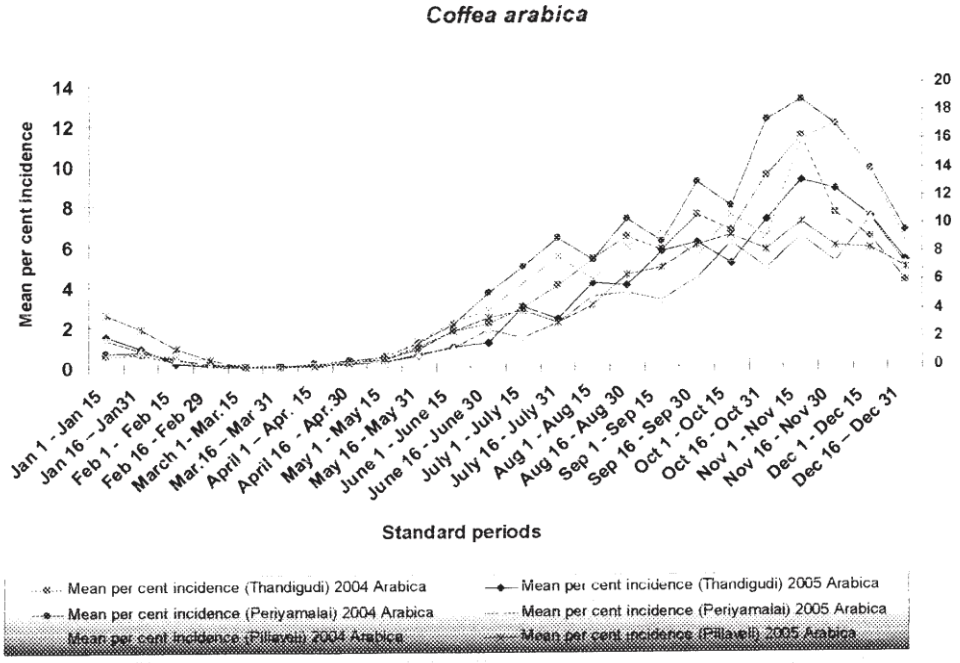

Fig.2. Seasonal infestation of coffee berry borer at three different locations

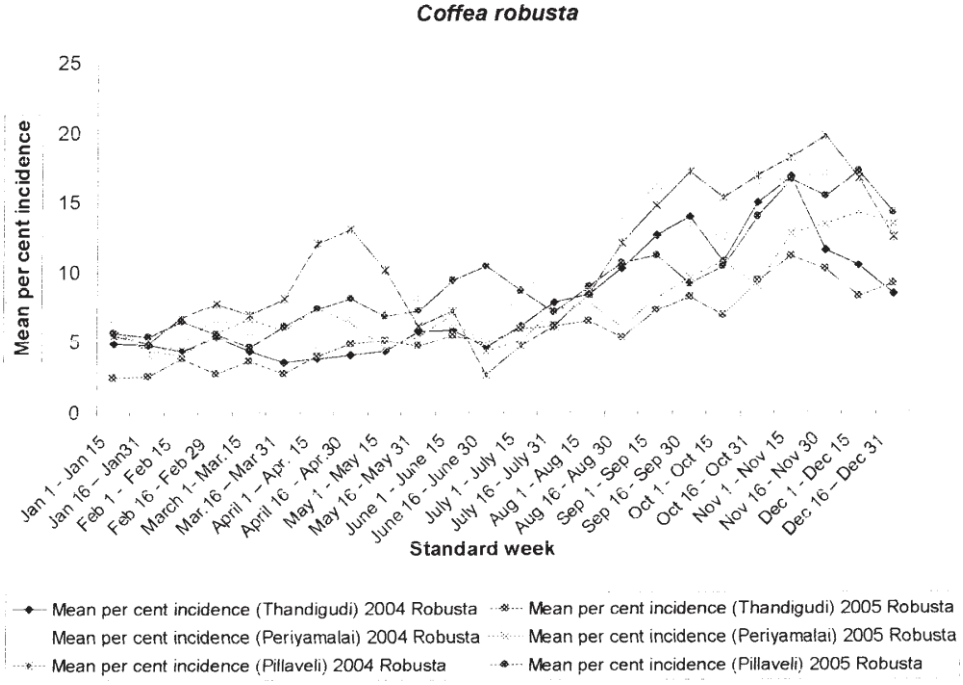

Table 5. Coffee berry borer population in left-over berries

S. No.	Sampling Location	Mean number of beetles / gleaning*										Overall Mean+
		May 2004		June 2004			May 2005		June 2005			
		Mean + SD	Range	Mean + SD	Range	Mean (2004)+	Mean + SD	Range	Mean + SD	Range	Mean (2005)+	
1.	Adalur	48.53±41.39	5-144	33.75±24.37	3-92	41.14(6.41)^{a}	39.09±33.71	4-135	31.36±23.08	2-76	35.23(5.93)^{c}	38.16(6.17)^{a}
2.	Kanalkadu	34.13+32.70	4-131	29.05±23.47	2-86	31.59(5.62)^{fg}	30.67±26.33	4-126	26.12±20.32	2-81	28.40(5.32)^{d}	29.99(5.47)^{d}
3.	K.C.Patty	27.96±30.95	3-121	29.48±20.97	4-81	28.72(5.35)^{jk}	29.2±26.45	2-115	20.71±19.48	3-69	24.96(4.99)^{gh}	26.70(5.16)^{g}
4.	kamanur	33.83±28.59	2-120	29.78±20.25	3-77	31.81(5.64)^{efg}	28.40±25.45	3-99	19.92±16.70	2-62	24.16(4.91)^{hi}	27.98(5.28)^{ef}
5.	Mangalamkombu	26.1±22.61	3-89	28.18±19.73	1-71	27.18(5.21)^{k}	22.39±19.07	2-83	20.64±17.21	1-79	21.52(4.63)^{j}	24.83(4.98)^{hi}
6.	Manjalparappu	31.24±26.03	2-91	26.12±19.73	1-82	28.68(5.35)^{ij}	23.60±21.90	1-78	21.39±19.76	1-72	25.50(5.04)^{g}	25.09(5.00)^{h}
7.	Vlanalur	34.58±30.02	5-123	25.50±17.05	2-87	30.04(5.48)^{ghi}	29.64±25.13	3-98	23.71±19.51	2-77	26.68(5.16)^{f}	28.35(5.32)^{ef}
8.	Nallurkadu	42.80±33.89	7-131	35.00±22.55	3-99	38.90(6.23)^{b}	33.06±28.82	4-127	32.11±21.36	2-91	32.59(5.70)^{b}	35.74(5.97)^{b}
9.	Ncrimalai	35.19±30.15	4-113	30.76±21.03	2-89	32.98(5.74)^{def}	25.07±27.58	3-112	24.12±19.76	1-86	24.60(4.95)^{i}	28.78(5.36)^{ef}
10.	Periyamalai	33.50±27.51	3-117	24.63±21.63	2-88	29.07(5.39)^{hij}	29.84±28.92	2-105	23.66±21.32	1-79	26.75(5.17)^{f}	27.90(5.28)^{f}
11.	Perumparai	29.20±25.97	2-94	22.13±18.71	1-74	25.67(5.06)^{hl}	25.03±22.68	3-87	20.71±16.17	2-71	22.81(4.77)^{j}	24.26(4.92)^{i}
12.	Pillaveli	38.49±34.16	4-137	34.03±16.60	2-99	36.26(5.02)^{c}	32.13±26.74	3-107	26.11±19.21	1-83	29.12(5.39)^{c}	31.94(5,65)^{c}
13.	Pachalur	31.26±129.17	3-123	26.98±23.10	2-91	29.12(5.39)^{hij}	31.16±25.59	2-115	23.11±119.91	1-88	27.14(5.20)^{e}	28.12(5.30)^{ef}
14.	Pallathukalvai	37.36±32.08	5-121	30.33±21.71	3-97	33.85(5.81)^{d}	27.38±21.76	3-117	25.31±21.72	1-92	26.35(5.13)^{f}	30.09(5.48)^{d}
15.	Solaikadu	45.50±43.63	4-131	32.15±24.16	2-98	38.83(6.23)^{b}	35.66±28.71	3-131	31.36±25.38	2-95	33.51(5.78)^{b}	36.16(6.01)^{b}
16.	Thandigudi	33.43±24.05	1-91	23.50±17.10	1-71	28.47(5.33)^{jk}	20.53±18.88	1-88	19.46±16.72	0-76	20.00(4.47)^{k}	24.23(4.92)^{i}
17.	Thadiyankudisai	27.81±25.38	2-98	22.12±19.73	1-66	24.97(4.99)^{l}	24.43±22.37	1-87	20.11±18.66	1-71	22.27(4.71)^{j}	23.62(4.86)^{l}
	Mean±S.D	34.76±30.48		28.44±20.69			28.48±25.25		24.11±19.78			

* Mean of five estates sampling per location

\+ Figures in parentheses are square root transformed values

In a column, means followed by a common letter (s) are not significantly different by DMRT (P=0.05)

In both the varieties the peak period of infestation was noticed between November and December during which most of the berries were in ripening stage that preferred by coffee berry borer than earlier stages (Fig, 1 & 2). This finding gains support from the report of lboekwe (1984) who stated that coffee berry borer adults significantly preferred red coffee berries than green ones and Gaviria *et al.* (1995) reported that highest level of infestation occurred between 133 - 220 days after flowering. In Pillaveli, the infestation was slightly higher than Periyamalai and Thandigudi, and this might be due to fluctuations in weather factors, shade effect, indiscriminate use of insecticides and by accumulation of left over berries infected with berry borer.

In all the three locations, infestation of coffee berry borer was gradually declined from January because most of the ripened berries were harvested during this period and thus the borers might be moved to over ripened and left over berries or dry berries (gleanings) for both shelter and further breeding and multiplication. This is in consonance with the earlier findings of ManSingh (1991) and Baker and Barrera (1993) who stated that prevalence of immature stages throughout the year and large number of females accumulated in the fallen berries during dry season.

The present investigation quantified its occurrence in three major locations *viz.*, Thandigudi, Periyamalai and Pillaveli, during 2004 and 2005, and revealed that the coffee berry borer infestation in *C. arabica* and *C. canephora* had significant negative correlations with maximum temperature and rainfall while as positive relationship with maximum and minimum relative humidity. Similar results were obtained by Baker *et al.* (1992a) where increase in emergence of coffee berry borer at 90 - 100 % RH in 20 - 25°C temperature regime which is in consonance with the present finding that a range of relative humidity ranged from 55.25 to 99.00 per cent and temperature regimes ranged between 10.25 and 32.75°C. Rainfall was possibly the factor that attributed to the low berry borer population (Ferreira *et al.*, 2000). Further, Vijayalakshmi (2000) reported that the coffee berry borer infestation had a significant negative correlation with rainfall and found that only a thin population of the borer prevalent during the rainy months. This may be due to the mortality caused by the heavy rains. Earlier, Rehiman and Vijayalakshmi (1998) have also reported that rains cause mortality of the beetle.

Source of inoculum of coffee berry borer in left-over berries

The mean populations of coffee berry borer in different locations are presented in Table 5. The over all mean population of borer per gleaning recorded in Adalur, Solaikadu, Nallurkadu and Pillaveli was high as 38.16 ± 30.63, 36.16 ± 30.47, 35.74 ± 26.65 and 31.94 + 24.17 as against the less borer population recorded in Thadiyankudisai (23.62 + 21.54), Thandigudi (24.23 ± 19.19), Perumparai (24.26 ± 20.88) and Managalamkombu (24.83 + 21.00). Thus, irrespective of the locations surveyed the population build up of coffee berry borer in left over berries had become a main source of inoculum for their carryover to next season crops.

Adult emergence pattern of coffee berry borer from gleanings

Emergence of coffee berry borer from gleanings exposed to different treatments up to 5 days after collection and their results

Table 6. Effect of moisture and temperature on coffee berry borer beetle emergence from gleanings.

Treatment No.	Treatments	Mean number of beetles emerged * (Days after exposed)					
		1	2	3	4	5	Mean
T_1	Impact of water spray	24.13 (4.12)d	26.12s (5.10)b	8.09 (2.84)c	4.16 (2.03)c	2.17 (1.47)b	12.93 (3.59)b
T_2	Impact of water soaking	26.31 (5.12)c	22.41 (4.73)c	5.32 (2.30)d	3.12 (1.76)cd	1.20 (1.09)c	11.67 (3.41)c
T_3	Impact of natural rain	46.16 (6.83)a	32.11 (5.66)a	22.09 (4.70)a	6.14 (2.47)b	2.12 (1.45)b	21.72 (4.66)a
T_4	Impact of surface temperature	28.13 (5.30)b	19.07 (4.36)d	12.12 (3.48)b	2.10 (1.47)cd	1.22 (1.10)c	12.52 (3.53)b
T_5	Impact of relative humidity (90% RH)	10.19 (3.19)e	12.12 (3.48)e	6.30 (2.50)d	8.21 (2.86)a	7.16 (2.67)a	8.79 (2.96)d
T_6	Untreated check	3.40 (1.84)f	4.36 (2.08)f	2.11 (1.45)e	1.30 (1.14)a	1.20 (1.09)c	2.47 (1.57)e

* Each value is the mean of five replications
Figures in Parentheses are square root transformed values
In a column, means followed by a common letter (s) are not significantly different by DMRT (P=0.05)

are presented in Table 6. The mean number of borer adults emerged from gleaning was high (21.72) due to rain followed by 12.93 and 12.52 recorded in mere water spray and surface temperature, respectively. Atwal and Balraj Singh (1990) reported that berry borer when exposed to extreme temperature might become dormant and resume activity on being exposed to favourable range.

Emergence of coffee berry borer from gleanings showed that maximum emergence of borer when the samples were exposed under natural shower and minimum emergence at 90% relative humidity. This is in confirmation with the earlier results that heavy rain also triggered the emergence of the beetles (Sreedharan *et al.,* 1994) and low humidity (< 60% RH, 25 °C) provoked rapid evacuation of adults and while it was minimum at 90% RH (Baker *et al.,* 1992a)

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