Introduction of Parasitoids of Hypothenemus hampei (Coleoptera: Curculionidae: Scolytinae) on Small Coffee Plantations in Colombia Through Farmer Participatory Methods Development

Authors: Aristizábal, Luis F., Jiménez, Mauricio, Bustillo, Alex E., and Arthurs, Steven P.

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INTRODUCTION OF PARASITOIDS OF *HYPOTHENEMUS HAMPEI* (COLEOPTERA: CURCULIONIDAE: SCOLYTINAE) ON SMALL COFFEE PLANTATIONS IN COLOMBIA THROUGH FARMER PARTICIPATORY METHODS DEVELOPMENT

LUIS F. ARISTIZÁBAL[1,*], MAURICIO JIMÉNEZ[2], ALEX E. BUSTILLO[3] AND STEVEN P. ARTHURS[1]
[1]Mid Florida Research and Education Center, Apopka, FL, 32703, USA

[2]Cenicafé, (Centro Nacional de Investigaciones de Café), Manizales, Colombia

[3]Cenicaña, (Centro Nacional de Investigaciones en Caña de Azúcar), Cali, Colombia

*Corresponding author; E-mail: larist@ufl.edu

During 2003 and 2004, the National Coffee Research Center, in Colombia (Cenicafé) included this methods development project as a component of the project, 'Integrated Pest Management of the Coffee Berry Borer through Participatory Research with Small Coffee Growers'. This was done in order to establish and increase the adoption of integrated pest management of the coffee berry borer (CBB), *Hypothenemus hampei* (Ferrari). Participatory research and methods development is a strategy to involve farmers in site decision making and documentation in order to improve their acceptance of new pest management practices (Bentley et al. 2002). The CBB is considered one of the most serious insect pests in almost all coffee producing countries (Vega et al. 2009). CBB damages developing coffee berries, and thereby reduces yield, quality, and the price of coffee (Baker, 1999). In September 2010, the Hawaii Department of Agriculture reported CBB present in Hawaii, Kona region (HDOA 2010).

Cenicafé developed an integrated pest management program for CBB involving cultural, biological and chemical controls, and monitoring (Bustillo et al. 1998). Cultural control methods focus on effective harvesting to remove CBB-infested berries while biological control may include use of *Beauveria bassiana* (Balsamo) Vuillemin and parasitoids (Bustillo et al. 1998, 1999). Three African parasitoids were introduced into Colombia between 1989 and 1996 as classical biological agents of CBB, i.e., 2 ectoparasitoids of immature stages, *Cephalonomia stephanoderis* (Betrem) and *Prorops nasuta* (Waterston) (Hymenoptera: Bethylidae), and an adult endoparasitoid, *Phymastichus coffea* (La Salle) (Hymenoptera: Eulophidae). As part of this initiative, a range of studies was conducted on aspects of the biology, mass rearing, and establishment of these parasitoids under the agro-ecological conditions of coffee plantations in Colombia (Aristizábal et al. 1997, 1998, 2004; Quintero et al. 1998; Baker 1999; Portilla 1999; Jaramillo et al. 2005; Maldonado & Benavides 2007). By 2005, more that 1500 million *C. stephanoderis*, 500 million *P. nasuta* and 300 million *P. coffea* had been released in commercial coffee plantations throughout Colombia (Bustillo 2005).

In this paper we documented changes in the adoption of integrated management of CBB before and 2 years after the training of growers. Through a participatory methods development program, 57 coffee growers from the central region learned how to use biological control agents, improved cultural control (frequent and thorough harvesting of ripe and overripe berries, which are a source of new infestations), monitoring the frequency of CBB, and postharvest control of the CBB through the capture of CBB adults in a layer of mechanical grease applied on the underside of a transparent plastic lid on the top of the hopper in which mature berries are placed for processing (Salazar et al. 2003).

A hands-on training methodology termed 'learning by doing' was used to educate farmers about alternative management approaches for CBB (Aristizábal et al. 2002; Bentley et al 2002).

In addition, we documented efforts to introduce 2 parasitoid species and improve cultural control in selected locations. Twelve farmers, who had expressed interest in biological control, volunteered to help with additional evaluations. In each of 12 farms, 2 coffee lots, each 0.4-0.8 ha, were selected for implementing cultural CBB management (i.e., efficient collection of mature berries 1 or 2 times every single month) and the release of parasitoids. The number of coffee trees ranged from 2000 to 4000 per lot, and harvest age from 2 to 5 years. Releases of *P. nasuta* and *P. coffea* were conducted in separate lots (separated at least by 100m). Three releases were made between May 2003 and Aug 2004, summing approximately 250,000 and 340,000 *P. nasuta* and *P. coffea* per farm, respectively. Because the continuous harvesting schedule might also remove parasitoid larvae before they completed development (Jaramillo et al. 2009), in each of 4 farms a screened enclosure that allowed wasps, but not CBB, to escape was installed (*P. nasuta* lots only). Workers placed approximately 1 kg CBB infested berries on trays inside each enclosure during several harvests periods following *P. nasuta* releases. Populations of CBB were monitored for 15 months (*P. nasuta* lots only) in accordance with Cenicafé's recommendations (Bustillo et al. 1998). Monthly, 200 CBB-infested berries were collected per lot and taken to the laboratory to evaluate parasitism by *P. nasuta* and *P. coffea*. Each farm was considered a case study because of different agro-ecological conditions. Due to the high pest mobility and CBB pressure when the study was conducted, it was not feasible to incorporate control plots for our observations. The inclusion of randomized control fields, although very important in making "iron-clad" conclusions, would have required a large fund to reimburse growers for pest losses.

We noted changes in the use of integrated pest management components for CBB among the 57 coffee farmers between the start and end of the project (Fig. 1). While cultural control remained the main component, we observed increases in the reported use of pest monitoring, use of biological control agents (*B. bassiana* and/or parasitoids) and post harvest tactics. A large decrease in the number of farmers using chemical insecticides was reported over the same period. In the additional field survey, we found circumstantial evidence that the IPM program was effective, i.e., CBB infestation rates declined significantly, i.e., from 2.5 to 10.2% (mean = 4.6%, n = 12) at the start of the study to 1.8 to 3.4% (average = 2.5%, n = 162) over the following 15 months (Table 1) (t = 3.1, df = 11, $P < 0.05$, paired samples t-test). The presence of *P. nasuta* and *P. coffea* was detected on all 12 farms (Table 1). Average *P. nasuta* parasitism rates (monitored over 15 months) ranged from 4 to 13% (mean = 5.5%) with maximum parasitism levels ranging from 6 to 44% (mean = 11.8%, n = 117) (Table 1). Overall, parasitism rates for *P. coffea* were slightly lower, ranging from 2 to 20% (mean = 3.5%, n = 117). The percentages of parasitism by the 2 parasitoid species were not equivalent among the different farms.

On the 4 farms where screened enclosures were installed to prevent decimation of *P. nasuta*, parasitism rates were higher compared with the other farms. Average monthly parasitism on the farms with screened enclosures ranged from 5 to 13% (mean = 8.3%, n = 44), compared with a range of 4 to 5% (mean = 4.1%, n = 73) (t = 3.4, df = 10, $P < 0.01$, unpaired t-test) on the remaining 8 farms. Maximum observed parasitism rates were also comparatively higher in the plots using screened enclosures for releasing *P. nasuta*, i.e., averaging 20.5% compared 8.3% (t = 2.3, df = 10,

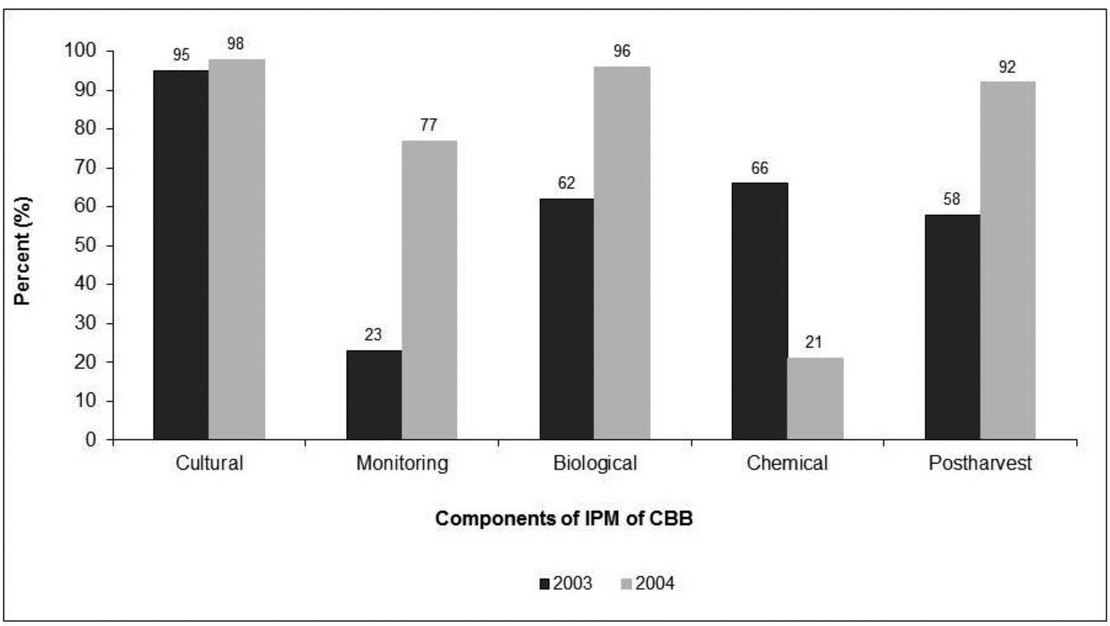

Fig. 1. Changes in components of IPM of the coffee berry borer (CBB) ascertained in a survey of 57 coffee growers before Jan 2003 and after Nov, 2004 in a participatory methods development project conducted by Cenicafé on coffee farms from the central coffee region in Colombia. The IPM components consisted of the following measures: cultural control (frequent and thorough harvesting of ripe and overripe berries); biological control (release of parasitoids); monitoring the frequency of CBB, and postharvest control (capture of CBB adults in a layer of mechanical grease applied to the underside of a transparent plastic lid on the top of the hopper in which mature berries were placed for processing (Salazar et al. 2003).

TABLE 1. LEVELS OF COFFEE BERRY BORER (CBB) INFESTATION AT INITIATION AND DURING AN IPM PROGRAM INVOLVING CULTURAL HARVESTING PRACTICES AND RELEASE OF 2 PARASITOID SPECIES. AVERAGE % BERRY INFESTATION AND PARASITISM WERE MONITORED MONTHLY BETWEEN MAY 2003 AND AUG 2004.

		CBB infestation (%)		*P. nasuta* (%)[2]		*P. coffea* (%)[2]	
Farm	Municipality[1]	Initial	Average	Average	Max.	Average	Max.
El Futuro	Balboa	8	2.8	4	8	4	18
Portugal	Balboa	3.1	2.4	5	8	3	6
Purace	Balboa	10.2	3.3	4	10	5	20
La Palestina	Balboa	3.2	2.4	4	6	5	18
La Rivera[3]	Viterbo	9.1	3.4	9*	20*	3	10
El Palmar[3]	Viterbo	3.1	2.3	5*	8*	3	4
Buenos Aires[3]	Quimbaya	2.5	1.8	13*	44*	4	6
La Suiza[3]	Quimbaya	3.2	2.3	6*	10*	3	8
La Graciela	Quimbaya	3.7	2.4	4	8	2	4
El Tachuelo	Quimbaya	3.1	2.4	4	6	3	4
Rosenvalles	Quimbaya	3.4	2.6	4	8	3	8
Guamalito	Quimbaya	2.5	1.9	4	6	4	12
Average		4.6	2.5	5.5	11.8	3.5	9.8

[1]Balboa, Risaralda; Viterbo, Caldas; Quimbaya, Quindio from the central coffee region, in Colombia.
[2]An average of 250,000 *Prorops nasuta* (240,000-265,000) and 340,000 *Phymastichus coffea* (210,000-481,000) were released per farm.
[3]Farms where screened enclosures for emergence from berries of *P. nasuta* (*) were placed.

$p < 0.05$, unpaired *t*-test). The results suggested that using screened enclosures might facilitate the establishment of *P. nasuta* and increase CBB parasitism. These results also indicate that parasitoids are (at least to some extent) compatible with cultural control methods for CBB.

SUMMARY

On 57 small coffee farms in Colombia, an IPM program for CBB through participatory methods development was conducted during 2003 and 2004. As a result, increased adoption of several IPM components by coffee growers was observed. We also observed decreases in the average infestation of CBB and evidence for the establishment of 2 parasitoid species, *P. nasuta* and *P. coffea* on 12 farms employing cultural control practices for berry harvesting.

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