Biology, ecology and biological control of the cassava hornworm (*Erinnyis ello*)

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Abstract

The hornworm, one of the most important pests of cassava in the Americas, can defoliate plantations rapidly. More than 90 larvae/plant have been observed in Colombia. When populations reach this magnitude they can consume up to 100% of the foliage; they also attack tender stem parts and lateral buds, killing young plants. Yield losses after a single attack can reach 20%; starch content can also be reduced. The 5 larval instars are described as well as the ecological factors that influence population fluctuations. Biological control is preferable to chemical control because pesticide application is costly and affects the equilibrium between parasites and pests. CIAT is conducting a biological control program to evaluate parasitism of eggs by *Trichogramma minutum* and *Telenomus dilophonotae*, parasitism of larvae by *Apanteles congregatus* and *A. americanus*, larval predation by *Polistes canadensis* and *P. erythrocephalus*, and a bacterial disease of larvae caused by *Bacillus thuringiensis*. Data related to these experiments are presented in tables.

The cassava hornworm *Erinnyis ello* is generally considered to be one of the most important pests of cassava in the Americas; its ability to defoliate cassava plantation rapidly has caused serious alarm among cassava growers. This pest is not found in Asia or Africa. The hornworm has been previously recorded as *Sphinx ello*, *Dilophonota ello* (2, 10) and *Anceryx ello* (1). *E. alope*, a less important species, has been reported from Brazil. Cassava and rubber are the principal hosts of *E. ello*, which appears to be confined mainly to the Euphorbiaceae (15).

Yield reductions in cassava of 10 to 50 percent have been estimated (13), depending upon plant age and intensity of attack; a decrease in starch content has also been suggested (9). Yield losses in farmers' fields in Colombia have been measured at 20 percent after a single attack. Undoubtedly repeated attacks would cause greater yield reductions.

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Type of damage caused

The cassava hornworm is a voracious foliage consumer Hornworm outbreaks with populations of more than 90 larvae per plant have been observed in Colombia (6) When populations reach this magnitude 100 percent of the foliage is consumed and larvae will also feed on the tender parts of the stem often consuming the upper 20 to 30 cm of stem tissue Lateral buds may also be consumed and young plants may be killed Damage simulation studies indicate that defoliation of young plants (2 5 months) reduces yields more than that of older plants (6-10 months) Laboratory and screenhouse studies at CIAT (3) show that a larva can consume 1 107 cm² of leaf area during its life cycle 75 percent of which is consumed during the last (5th) instar High larval mortality results when larvae are restricted to the basal leaves only and no larva reaches the pupal stage There is no indication that high or low cyanide content influences larval development greatly (4) Some cassava varieties can tolerate high larval populations since under favorable environmental conditions there can be up to 80 percent defoliation with no reduction in root yield (4)

Biology and ecology

The generally gray nocturnal adult moth has five to six black bands across the abdomen with gray forewings and reddish hind wings The male forewing is a darker gray and brown with a black band from the base to the apex and is smaller than the female Females live 5 to 7 days n the males new days less Winder and Abreu (16) found that the nocturnal flight periodicity for both sexes was bimodal for females from 2300 to 2400 hours and 0200 to 0300 hours and for males from 2400 to 0100 hours and from 0200 to 0300 hours Oviposition occurs 2 to 3 days after emergence usually on the leaf uppersurface but also on the petiole stems and leaf undersurface (10) A female may deposit from 30 to 50 eggs which hatch in 3 to 7 days (6 8)

There are five larval instars with a total duration of 12 to 15 days (may be slightly longer in some areas) The first instar larvae consume the egg shell before moving to the leaf undersurface to begin feeding Larvae prefer feeding on the upper leaves All instars show color polymorphism but it is more common during the third instar Larval colors including green greenish blue greenish gray tan bluish gray brown red black and yellow have been reported (15)

The fifth instar larvae may reach 10 to 12 cm in length they migrate to the soil where they form chestnut brown black lined pupae under plant debris Larvae may crawl considerable distances prior to pupation which lasts 2 to 4 weeks Pupal diapause of several months has been reported (14)

Population fluctuations of the hornworm are reported as occurring during different months of the year depending upon locality It is possible that these fluctuations are triggered by climatic or seasonal change as well as being cyclic In Colombia hornworm outbreaks generally occur at the onset of either rainy or dry periods but attacks are sporadic and the insect can be virtually absent for several years In Brazil they are found all year but are most abundant from January to March several generations may occur

Control

A biological control program that utilizes several of the natural enemies of the cassava hornworm appears to be the most effective method of controlling the pest economically Several insecticides will reduce hornworm populations trichlorphon (Dipterex) being especially effective However chemical control should be avoided as pesticide applications are costly for a long season crop and also affect the equilibrium between parasites and pests (5 10)

Many cassava growers do not notice a hornworm attack until considerable foliage has been consumed and most of the larvae are in the 4th and 5th instar Pesticide application is not as effective against these instars as it is against the earlier ones It has been observed that pesticide application will often induce 5th instar larvae into pupation In addition insecticides also reduce natural enemies Egg parasitism by *Trichogramma* sp has been lessened in fields where insecticides have been applied (5) Hornworm outbreaks in certain cassava growing areas of Colombia have increased in recent years In these areas there has been an increase in cassava acreage as well as in the use of insecticides especially to control thrips and fruit flies

Biological control

A biological control program that combines parasitism of eggs and larvae larval predation and the larval disease *Bacillus thuringiensis* is being studied at CIAT

Egg parasitism

Natural hornworm egg parasitism by *Trichogramma minutum* (12) *T fasciatum* (3) and *Telenomus dilophonotae* (10) has been reported to be as high as 94 to 99 percent (13) An average of 23 *Trichogramma* adults emerge per egg (4)

Two experiments were conducted at CIAT to evaluate the effectiveness of liberating *Trichogramma* in cassava fields to parasitize hornworm eggs During a period of considerable hornworm oviposition approximately 100 000 *Trichogramma* were released into a one hectare field A nearby field where there was no release of parasities was used as a control Egg parasitism was measured prior to release and periodically afterwards Results showed 22 1 percent more parasitism after four days in the field where *Trichogramma* had been released in the first experiment in the second there was a 23 2 percent increase during a similar period and a 32 6 percent increase after five days as compared to the field where *Trichogramma* had not been released (Table 1)

Larval parasitism

Apanteles congregatus and *A americanus* are important larval parasites in Colombia These braconid wasps oviposit in the hornworm larvae where the parasite larvae develop Mature larvae migrate from the host and pupate on the outer skin forming a white cottonlike mass These cocoons are approximately 3 8 cm wide by 4 1 cm long Each cocoon will contain an average of 257 *Apanteles* pupae about 80 percent of which will emerge (unpublished data)

In studies at CIAT we have twice released *Apanteles* adults into hornworm infested fields to

Table 1 Percentage of cassava hornworm eggs parasitized in fields where *Trichogramma* sp had been released as compared to control (no *Trichogramma* released).

Days after release	% of eggs parasitized by liberated *Trichogramma*	Increase in parasitism %	% of eggs parasitized in control fields	Increase in parasitism (%)	Difference in parasitism between fields with liberated *Trichogramma* vs. control
Experiment no 1					
0	48 3		52 6		
4	73 1	24 8	55 3	2 7	22 1
7	67 9	19 6	67 3	14 7	4 9
10	91 0	42.7	95 7	43 1	0 4
Experiment no 2					
1	30 8		45 0		
2	54 2	23 4	61 0	16 0	7 4
3	80 0	49 2	73 8	28 8	20 4
4	76 0	45 2	67 0	22 0	23 2
5	92 7	61 9	74 3	29 3	32 6

Trichogramma released t rate f 100 000/ha
Sample f 50 plants/plot, f 36.6 eggs/pla t
Sample f 150 plants/plot

evaluate larval parasitism Eleven cocoons were released in the first trial and 408 cocoons were collected after three weeks At the same time 382 unparasitized larvae and 633 pupae were collected in the field resulting in about a 35 percent parasitism of the larvae present In the second trial 7 cocoons were released and 49 were collected 17 days later No count was made of larvae or pupae

A drawback in the use of *Apanteles* as a hornworm larval parasite is the high percentage of hyperparasitism observed Seven hyperparasites have been collected from *Apanteles* pupae at CIAT A study of 112 *Apanteles* cocoons collected on three separate occasions resulted in an average of 56 percent hyperparasitism (Table 2) An additional difficulty in the use of *Apanteles* for parasitizing hornworm larvae has been our inability to mass rear the parasite in the laboratory

Larval predation

The paper wasps *Polistes canadiensis* L and *P erythocephalus* appear to be the most effective larval predators Each wasp requires several larvae per day for its own consumption as well as for its brood Control is most effective when tentlike protective shelters are provided for the wasps in the center of cassava fields A program using natural *Trichogramma* egg parasitism plus the *Polistes* wasp has been in operation at CIAT (50-60 ha cassava) since 1973 and there has been no major hornworm outbreak during this period The *Polistes* wasp has been introduced onto several farms in a cassava growing region of Colombia and biweekly evaluations are being made of hornworm oviposition egg parasitism larval and wasp populations

Larval disease

The adult hornworm moth is capable of lengthy flight and large populations of adults may migrate into an area and oviposit numerous eggs upsetting the equilibrium existing between biological control agents and the hornworm population In addition the somewhat cyclic occurrence of the hornworm often causes populations to increase rapidly and dramatically also upsetting the equilibrium

Bacillus thuringiensis a commercially available bacterial disease of many lepidopterous larvae was studied at CIAT for cassava hornworm control In a cassava field with heavy hornworm attack 50 plants/plot were sprayed with a suspension of *B thuringiensis* the larval population was measured before application and three days afterwards Results showed that the larval population was reduced by 68 percent (Table 3) *B thuringiensis* was more effective against the first three larval instars than the fourth and fifth

In a second experiment one half of a 5 hectare field was sprayed with *B thuringiensis* and 50 plants were sampled at random before application and at three and six days afterwards The larval population in the treated field was reduced from more than six larvae per plant to one whereas in the untreated field the larval population increased to more than 13 larvae per plant (Table 4)

A third experiment was designed to test the effectiveness of *B thuringiensis* in controlling each hornworm instar under field conditions Applications were made when there were high populations of the desired instar Results indicated that *B thuringiensis* is effective against the first four instars (the 5th was not tested) but most effective against the first (Fig 1)

Table 2. Percentage of hyperparasites emerging from *Apanteles* sp pupa parasitizing cassava hornworm larvae

Sample no	Date of collection	No of cocoons	*Apanteles* emerged	Hyper parasites	% *Apanteles*	% Hyper parasites
1	Aug. 1977	14	1034	1777	37	63
2	Sept 1977	49	5543	2482	69	31
3	Oct 1977	49	1190	5506	17 8	82 2
Totals		112	7767	9765	44	56

Table 3 Number of cassava hornworm larvae before and three days after application of *Bacillus thuringiensis* on two month-old cassava plants (var Chiroza gallinaza).

	No larvae/instar*	
Developmental stage	Before application	3 days after application
First Instar	1 520	114
Second Instar	4 449	982
Third Instar	3 375	1 207
Fourth Instar	1 192	850
Fifth Instar	320	298
Total	10 856	3 451

Eight plo of 50 plant with ce t 15 pl ts fea h pl t sampled (t tal of 120 pla t sampled)

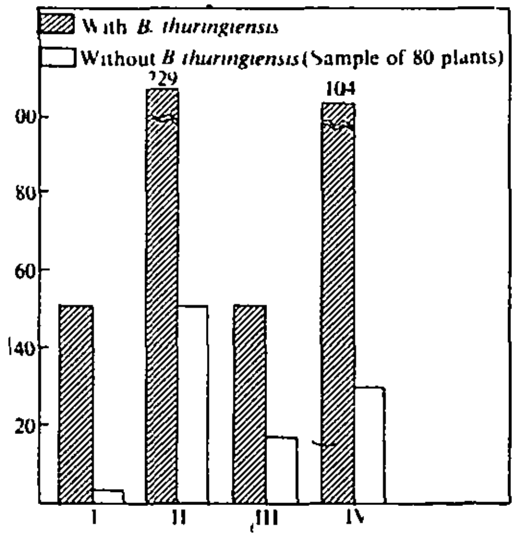

Figure 1 Effect of applications of *Bacillus thuringiensis* on hornworm population when in the 1st 2nd 3rd and 4th larval instars under field conditions

Additional studies have shown that applications of *B. thuringiensis* will not affect *Trichogramma* egg parasitism adversely (6) Laboratory studies were conducted to measure the foliage consumed after leaves had been sprayed with *B thuringiensis* as compared to consumption of untreated leaves Results showed that larvae can survive for 1 to 4 days after they begin to consume treated foliage however the leaf tissue that they are able to consume is reduced by 86% for the 3rd instar 93% for the 4th instar and 98% for the 5th instar larvae (6)

Conclusions

A biological control program for the cassava hornworm appears to be a feasible control method Several biological control agents were studied and found to be effective in reducing hornworm populations These include the *Trichogramma* egg parasite the *Apanteles* larvae parasite the *Polistes* larval predator and *B thuringiensis* a larval disease

Table 4 Effects of *Bacillus thuringiensis* on a cassava hornworm population three and six days after application

	Days after application	No of larvae Instar I	II	III	IV	VI	Total larvae	Larvae/plant
With	0	159	97	56			312	6 24
B thuringiensis	3	84	80	39	1		204	4 08
	6	7	19	21	3	4	54	1 08
Without	0	311	160	63			534	10 68
B thuringiensis	3	141	287	100	1	0	529	10 58
	6	127	254	227	51	20	679	13 58

Based 50-pla t rand m sample

There are several other natural enemies of the hornworm that could be employed effectively in a biological control program but that need to be studied in more detail. A viral disease of the hornworm has been identified but no studies have been carried out. Larval predators that have also been identified are a pentatomid *Alcaeorrhynchus grandis* and a carabid *Calosoma retosum* (7, 9). Numerous other predators and parasites have been recorded as attacking *E. ello* (15). Larval parasitism by several tachinid flies is also reported (11, 16) and occasional tachinid parasitism has also been observed at CIAT. Studies with these parasites should be initiated.

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