Major studies were directed to accumulating information on the complex of insects that attack the cassava crop Emphasis was on biological control studies of important pests especially the cassava hornworm and mealybugs Basic studies of the stemborer were conducted and reported for the first time A new pest a subterranean Hemiptera which causes considerable damage to cassava roots is described

Cassava Hornworm

The effectiveness of natural populations of the egg parasites *Trichogramma* sp and *Telenomus* sp were studied during two natural outbreaks (about one month apart) of the cassava hornworm *Erinnyis ello* These two parasites are an integral part of a pest management program being developed to combine utilization of natural enemies with chemical products to reduce and control hornworm populations

During the first outbreak egg parasitism increased from an initial 2% to 63% In the second attack initial parasitism was 35% and increased to 90% Plant defoliation was heavy during the first outbreak but was only minimal in the second one *Trichogramma* parasitized a greater percentage of eggs than did *Telenomus* These findings indicate that damage currently may be reduced or repeated attacks averted when natural enemies increase during an initial attack

A granulosis virus was discovered infecting natural populations of the hornworm Virus infected larvae were ground and diluted in water to a 30% concentration rates of 5 cc and 10 cc of the viral solution per liter of water were applied to cassava foliage in the laboratory and in the field In the laboratory the 10-cc rate killed all larvae after 72 hours and the 5-cc rate gave 96% mortality after 96 hours Three days after the field application larvae were collected and observed Complete mortality was noted 120 hours after application for both rates

Difluron an insect growth regulator that inhibits synthesis of chitin was tested on first instar larvae and on hornworm eggs Complete mortality was observed for emerging larvae feeding on cassava foliage treated at three rates 2 4 and 6 g/liter of water Death occurred during the first larval molt between the first and second instars Difluron was also effective when applied to hornworm eggs with mortality of emerging larvae observed during the first molt This product appears promising and will receive further study

Mealybug

The cassava mealybug *Phenacoccus* sp (identified as near *P manihoti)* was first identified in Colombia in 1978 *P manihoti* causes considerable losses in Africa and has not been studied previously in the Americas

Male and female life cycles of *Phenacoccus* sp were studied in the laboratory on cassava leaf disks (Table 1) The female passes through four instars before reaching the adult stage whereas the male has five instars The average life cycle of females was longer than that of males — 39 versus 23 days Females began ovipositing seven days (range of 5 8) after fertilization Parthenogenesis was not observed in isolated females which lived for up to 23 days When males were placed with unfertilized 15 23 day old females the ovisac formed in 2 3 days An average of 200 eggs per ovisac was produced and the resulting sex ratio was three females to one male

Biological control High populations of the dipteran predator *Kalodiplosis coccidarum* were observed in populations of *Phenacoccus* sp and *Phenacoccus gossypii* in the greenhouse and in the field *K coccidarum* was initially observed predating on eggs within the ovisac but larvae have also been found predating on nymphs — especially adult females — when ovisacs were unavailable

This predator remains in the ectoparasitic stage and seldom causes nymphal mortality until the ovisac is formed when it then predates on eggs until completing its life cycle Its ectoparasitic stage is important for survival when host populations are low A female male ratio of 2 1 was observed

The average number of *K coccidarum* per ovisac varied depending on host availability when ovisacs were numerous an average of three predator larvae were found per ovisac (from 1 5) and higher predator populations resulted in five larvae per ovisac (range of 2 8) Initial studies of *K coccidarum* indicated a life cycle of 12 days (at 28 C) to 16 days (at 22 C)

The effectiveness of several enemies on controlling *P gossypii* was studied on cassava plants growing in field cages When mealybugs became very numerous (about 26 000 nymphs and adults per cage) natural enemies were allowed entry Predator and parasite populations were recorded for six weeks by which time mealybug pop ulations were almost zero

In general there was a higher percentage of predation than parasitism with the latter never averaging over 10% Predation of ovisacs principally by *K coccidarum* reached 100% after five weeks and predation of nymphs and adults reached 96% primarily due to *Chrysopa* and Reduviids Major predators were *Chrysopa K coc cidarum* several Coccinellids and Reduviids *Anagyrus* spp were the predominant parasites (Table 2) In cages where mealybugs were most numerous *K coccidarum* was the heaviest predator while *Chrysopa* the Reduviids and some Coccinellids predominated in cages with lower mealybug populations *K coccidarum* is host specific for *P gossypii* while *Chrysopa* and the Reduviids are general predators

T bl 1 D t f l f y l f **Ph na occ p ea P m nihoti** ca sa le de lab rat ry o d t o (26 28 C RH 60%)

I t	F m le			M le		
	N f b t	M a d t (d y)	R g (days)	N f ob rv t o s	Mea du at (d y)	Rang (d y)
I	31	9	8 11	30	0 9	8 11
II	35	5	4 6	18	6 2	6 7
III	40	5	4 6	20	2 2	1 3
IV	25	20	18 25	18	2 5	1 4
V				23	2 0	1 4
Γ t l		39	34 48		21 9	17 29

V y M C 1 1 1 3

Table 2 N mbers f t l m e bserved to atta k mealybug (**Ph nacoccus gossypi**) populat f secut e w ks th f ld in xp sed cag

W k ft p re t nat ral e m	A g umbe f t al m pe cage				
	P ed t rs				Pa a t
	K lod pl is d rum	*Chry op* sp	Cocc n ll d	R du da	*Anagy us* p
1	492 0	33 3	61 0		17 5
2	40 5	27 8	20 7	35 7	8 3
3	50 0	30 0	28 3	10 0	2 3
4	11 7	23 8	2 3	12 0	0 2
5	1 3	18 7	3 2	7 0	0 2

A g p g l g
F ld g 3 3 2 m

Stemborers

The lepidopteran stemborer *Chilomina clarkei* (Amsel) attacks cassava throughout the year in the Colombian Llanos and has been found in other areas as well Studies were initiated to determine its economic importance as well as its biology and ecology

Attacks begin around lateral buds where leaves have already fallen During the first four instars it feeds under a fine web around these buds after the fifth instar it penetrates the stem completing its life cycle in galleries within the stem These galleries weaken the plant often cause stem breakage and provide entrance points for plant pathogens

Life cycle duration (larval prepupal and pupal stages) of *C clarkei* was studied on six cassava varieties Cycles varied depending on varieties and ranged from 62 2 days (on M Ven 77) to 68 4 days (on HMC 2) Differences were observed only during the larval stages with the greatest fluctuation occurring during the eighth instar Generally eight instars occurred but the number varied between six and eight even within varieties Durations of the prepupal and pupal stages were constant in all varieties

In a field planting at Carimagua damage from stemborer infestations was estimated for the treatments shown in Table 3 Actual and induced damage affected all yield variables except root starch content which was slightly higher in Treatment 3 than in the others About two thirds of the weakened stems were broken in Treatment 1 and 2 due to natural causes such as winds Stemborer infestations in Treatment 4 (control) was 1 06 perforations per plant

Whiteflies

Previous studies have shown that high infestations of the whitefly *Aleurotrachelus socialis* cause considerable yield losses in cassava (CIAT Ann Rept 1978 and CIAT Cassava Prog 1979 Ann Rept) Three trials were conducted at the Nataima station of the Instituto Colombiano Agropecuario (ICA) Tolima to study cassava losses from whitefly attacks

In one trial one month attacks by whiteflies were permitted over a 10 month growing cycle of the plant with plants protected by applications of dimethoate at 15-day intervals during all other times A single one month attack at any stage of plant growth did not reduce yields significantly However when whiteflies were not con trolled average yields decreased from 26 t/ha to only 9 7 t/ha Likewise production of planting stakes decreased sharply in uncontrolled plots from 4 8 to 2 9 stakes per plant Starch content did not differ significantly between controlled and noncontrol plots

In a second trial whiteflies were permitted to attack cassava for increasingly longer periods up to 11 months of age Results of this experiment are shown in Table 4 A significant correlation (r=0 9) was observed between attack duration and yield reduction and the duration of attack and stakes produced per plant were negatively correlated (r 0 8) The effect of the duration of attack was significant after the third month of plant growth indicating that spray applications (of in this case dimethoate) every three months may be sufficient to reduce whitefly attacks below the economic injury level

T bl 3 E m d mag ca sed to ca sa by th temb re **Chilomim larke** (Amsel) at diff re t le els of atta k C m g a

T atm t	F l age w ght (kg/plant)	N oot pe pl t	Weight of oot (kg/plant)	Comm al ts (%)	Sta ch c te t (%)	No stakes p pla t	H lthy tak (%)	B k t m (%)
1	1 0 b	4 4 b	0 48 b	7 5 b	26 6 b	3 1 b	43 8	65 6 b
2	1 1 b	7 4	0 70 b	10 1 b	26 0 b	3 1 b	58 1 b	66 6 b
3	0 9 b	6 5	0 68 b	12 1 b	28 9	1 6 b	38 6	100
4	1 7	7 8 a	1 26 a	33 9	26 8 b	7 1	85 0	11 1

Trea m 1 8 12 p rf ns pe pla t d nf ed wi h th ee larv p pl 4 6 8 d 10 m h
2 16 20 pe f pe pla t and nfes ed with f larv p pla b
3 1 f d w h w larv pe plant f m th d all m p po ly b k t f m ths
4 C l pl t rtif ial f tat d mag

V l f ll wed by th sam l wi h l mns gnif ca tly d ff re th 95% l l

A third trial was planted to evaluate hybrids CM 489 1 CM 440-5 and CM 91 3 and the high yielding widely adapted variety CMC 40 for their resistance to whitefly attack CMC 489 1 showed the least yield reduction from whitefly attack but it also had the lowest starch content While the yield of CMC 40 decreased 46 5% due to whiteflies it still had the highest yield and highest starch content (Table 5)

Tabl 4 R l t h p b tw th du t of wh t fly Al **otr chelus socıali** atta ks and y ld l se f th l CMC 350 122

D at f wh t fly att k (m th)	No f n t d ppl cat s	Fre h oot y ld (t/h)	Y eld ed t on (%)	Root t h co t t (%)	N st k p pl t
0	22	42 1 a		29 6 a	7 6
1	20	40 1 b	4 8	29 5	7 5
2	18	36 1 abcd	14 3	28 7	5 4 bc
3	16	37 8 ab	10 2	29 4	6 3 ab
4	14	30 6 bcde	27 3	30 7 a	5 7 abc
5	12	29 8 cd	29 2	28 7	4 6 bcd
6	10	24 5 f	41 8	27 2 a	4 7 bcd
7	8	26 7 d	36 6	29 4	4 1 cd
8	6	16 4 fg	61 0	27 8 a	4 1 cd
9	4	14 3 g	66 0	27 9	3 0 d
10	2	11 5 g	72 7	28 3 a	3 0 d
11	0	8 6 g	79 6	27 6	3 0 d

D m h ppl d t th f 0 8 g /l f
\ l w h h m l m f ll d by h sam l t g f ca ly d ff t th 95% l l

T bl 5 Elf t f wh t fly **Aleur tra helus socialis,** tt k y ld f three hyb d d ety of ca sa l l m C l mb

I tm t	C a lin	Wh t fly p pulat g d	Wh t fly p pal g de	Comm rc al t (kg/pla t)	F h t y ld (t/h)	Y ld d ff ( )	Pl t g t k p pl t	R t t h (%)
P t t d	CMC 40	0 8	0 3	6 2	31 2		6 0	25 4
	hyb CMC 489 1	0 6	0 2	2 0	20 7		4 0	21 1
	hyb CM 440 5	0 7	0 2	0 4	3 5		4 0	20 3
	hyb CM 91 3	0 9	0 3	1 7	14 0		2 7	24 7
N p t t d	CMC 40	4 6	4 8	4 1	16 7	46 5	4 3	25 2
	hyb 489 1	4 5	4 1	1 8	15 4	25 6	3 9	18 6
	hyb 440 5	4 1	3 5	0 3	2 4	31 4	2 8	21 1
	hyb 91 3	4 8	4 8	0 1	3 7	73 6	1 4	22 2

Ba d scal 1 0 5
D m h ppl d f 0 8 g p l f

Mites

Several species of mites all previously unreported in Colombia have been identified during recent surveys of cassava They are *Allonychus brazıliensis* (McGregor) *Atrichoproctus uncinatus* Flechtmann *Aponychus schultzi* (Blanchard) *Eutetranychus banksi* (McGregor) *Oligonychus gossypii* (Zacher) and *Brebipalpus phoenecis*

(Geiysker) *Mononychellus caribbeanae* (McGregor) was found along the Atlantic Coast and in the Guajira region High populations of a mite of the Eriophyidae family was also found the first time mites of this family have been reported to attack cassava Visual symptoms of high populations of this latter mite are a white to grey powdery effect caused by the mites exudate

Preference studies Leaf preference studies were carried out with *Mononychellus tanajoa* and *Tetranychus urticae* in the laboratory Field observations show that *M tanajoa* prefers to feed on the upper or apical leaves while *T urticae* prefers the lower leaves Mites of both species were given a choice of feeding on leaf discs from the upper or lower areas of the plant for a three day period Results with *M tanajoa* show that 64% preferred feeding on the apical leaf discs and 36% on lower leaves of the variety M Col 113 The *T urticae* mite preferred the lower leaf discs 78% vs 22% on the variety M Col 22 and 73% vs 27% on M Col 1434 These results indicate strong preference for mite feeding and leaf location

Biology studies Life cycle studies were realized with the mite *Oligonychus peruvianus* an important species in many areas of Colombia Laboratory leaf discs studies with this species have proven unsuccessful due to its behavior of forming a small web on the underside of the leaf under which the developing stages feed Studies were carried out in the greenhouse on growing potted plants adults were allowed to form the protective web and oviposit before being removed The developing life stages were studied The egg stage is 4 5 days the larvae protonymph and deutonymph are 2 7 and 1 5 and 2 5 days respectively The average adult duration is 12 5 days and the preoviposition period is 1 7 days Daily observations indicate that these mites spend their life cycle below the web and it is the female that has the capacity to form this web which it begins doing in the deutonymphal stage

The life cycle of *T urticae* was studied on three cassava varieties M Col 22 M Bra 12 and M Col 1434 M Col 22 is susceptible to *M tanajoa* and M Col 1434 and Bra 12 are resistant (CIAT Cassava Prog 1979 Ann Rept) Studies were carried out in the laboratory at 30 C day temperature and 28 C night with 40 70% RH using leaf discs on moist cotton in petri dishes

Results show that the mites developed slower on the resistant cultivars M Col 1434 and M Bra 12 than on the susceptible cultivar M Col 22 (Table 6) The longevity of the adult stage was shorter and fewer eggs were oviposited on the resistant cultivars These studies indicate that there are resistance mechanisms in cultivars M Bra 12 and M Col 1434 that adversely affect the development of *T urticae* In addition these results coincide with results on resistance studies done with *M tanajoa*

Biological control *Oligota minuta* and *Stethorus* sp are active predators of mites on cassava Preferences of these predators for *M tanajoa* and *T urticae* mites were studied in the field by surveying predator numbers during periods of high populations of mites *T urticae* was predated mainly (98%) by *Stethorus* sp while *M tanajoa* pop ulations were predated by *O minuta* (88%)

Tabl 6 De l pm t f th **T tranyhus urticae** mit n l af d f three cas va ri t d g owth hambe d t n

L fe t g	Durat o of l fe tage (d y)					
	M C l 22		M B 12		M C l 1434	
	F males	M l	Females	M l	F males	Male
Egg	3 50	3 50	3 50	3 50	3 50	3 50
L rva	1 14 d	0 88	1 31 d	0 75 d	1 01 d	1 53 cd
P ot cry l s	0 47 b	0 38 b	0 41 b	0 50 b	0 54 b	0 63 b
P t ymph	1 02 b	0 86 b	2 20	1 00 b	0 84 b	2 18
D t rysal	0 61 a	0 61	0 61	0 50	0 69	0 60
De t ymph	0 91 b	0 72 b	0 99 b	1 50 b	1 65	0 90 b
T l ocrysal	0 78 b	0 88 b	0 85 b	0 50 b	0 78 b	0 80 b
T tal f d l pm tal tag	8 43 b	7 83 b	9 87	8 25 b	9 01 b	10 14 a
Ad lt	17 52	5 00	14 17 ab	2 50	12 78 b	3 60

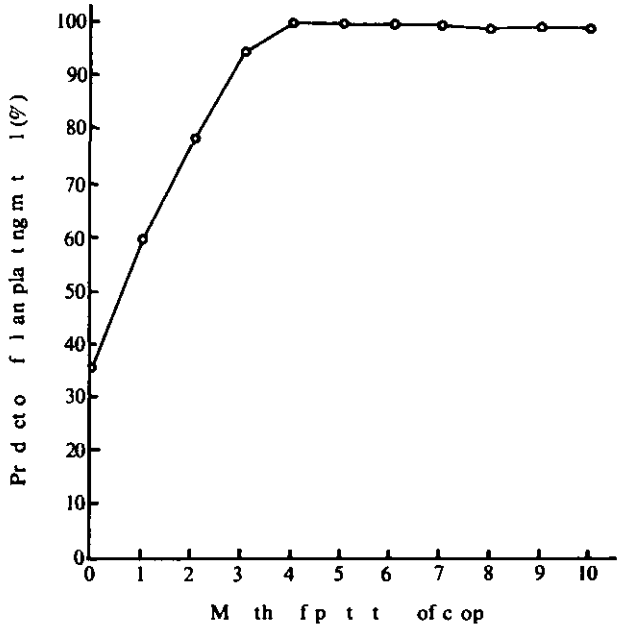
T mpe 28 C gh 30 C d y R l u h mid y 40-70%
F g w th h m w f ll wed by th sam l t t gn f ca ly d ff re h 0 05 l l

Several predatory mites were found attacking *M tanajoa* on cassava for the first time Predators included mites of the Phytoseidae and Blattisocidae families and of family Tydeidae *(Tydeus* prob ne *Californicus)* and *Typhlodromalus limonicus Neoseiulu anonymus Typhlodromina* sp *Iphiseiodes zuluagai Galendromus annectens* and *Proctolaelaps bickleji*

Fruitflies

Cassava fruitflies *(Anastrepha manihoti* and *A pickeli)* reduce the quality of planting material by boring throughout the pith of the stem and by transmitting the bacterial disease *Erwina caratovora* (CIAT Ann Rept 1977 and CIAT Cassava Prog 1979 Ann Rept) Studies were done to determine the critical period of plant growth when fruitfly attacks cause heaviest damage to planting material Bimonthly applications of dimethoate were used to protect plants from planting to 10 months

Protecting plants during the first three months of growth produced 94% healthy planting material while unprotected plots produced only 35% healthy material (Fig 1) There were no significant differences in root yield between treatments corroborating previous studies which showed that fruitfly attacks did not directly affect yield but that eventual yield losses are due to reduced quality of planting



F gu 1 *P d t f pl t ng m t l f f fru tly* (**Anastrepha manihoti**) *d m g by pe d ppl t ns f th ns t id d m th t*

stakes (CIAT Ann Rept 1977) Where high populations of fruitflies are present high-quality planting material can be produced by protecting the crop for the first three months of growth

Cassava Lacebug

The CIAT cassava germplasm bank was evaluated for resistance to the cassava lacebug *(Vatiga manihotae)* for the second time during 1980 Of 1865 lines screened 527 (28%) were scored at 1 or lower on a 0-5 damage scale Although the infestation this year was light and further screening will be done under heavier pressure 131 lines among the 527 had received similar ratings in the first evaluation

While no parasite of the lacebug has been observed a hemipteran of the family Reduviidae has been identified predating lacebug nymphs and adults During the predator s approximate 40-day nymphal cycle it will consume about 280 lacebug nymphs and adults

Cydnidae

Nymphs and adults of a subterranean Cydnidae *Cyrtomenus bergi* Froeschner feed on the swollen roots of cassava by injecting their strong thin stylets through the root peel into the parenchyma This feeding habit causes small brown to black spots at the penetration sites Several fungal pathogens are transmitted in this manner and their development causes a smallpox effect on the edible portion of the root Commercial value of roots is reduced considerably especially in those destined for human consumption

Adult Cydnidae are black while nymphs have white to creme-colored abdomens Their legs are short with numerous small spines which facilitate insects movement through the soil When disturbed the insects become immobile and appear dead making them difficult to find At harvest they occasionally are found adherring to roots by their stylets

Severe attacks have been observed in plantations next to or on fields planted previously to sugarcane or pasture An average of 32 nymphs per plant were counted during a harvest of the cassava variety Chiroza In a preliminary laboratory study 80% of a population of last instar nymphs preferred to feed on a sweet cassava variety instead of a bitter variety Additional discussion of root damage is found in the Pathology section of this report

Termites

Previous studies showed that control of termite damage was most effective if both a fungicide and a chlorinated hydrocarbon insecticide (aldrin) were applied to planting stakes (CIAT Ann Rept 1978) This year additional insecticides were evaluated and methomil (0 5 g commercial product of Lannate 90% per liter of water) and carbaryl (2 0 g commercial product of Sevin 80 OM per liter of water) were equally effective as aldrin Vertically planted stakes also had better germination and less termite attacks than did stakes planted horizontally

Errata

Page	Columm	Element	I rinted	Should bc
6	1	Figure 2	M C I 59	M M x 59
6	2	Figure 3	M C I 59	M M 59
6	2	Figure 3	I SD (I <0 05)	LSD (I <0 05)
7	1	Figure 4	M C I 59	M M x 59
60	2	Second para line 8	more to growth	more *top growth*
61	2	Line 1	and K contents	and K concentrations
20	1	Figure 1	I T I ra t III T le t V Iol t	I I t rm d at re t nt III I t m d t t t V I te m d t t t
62	1	Figure 3	St m □	Stem △
64	1	Figure 5	5 0 4 0 c N	5 0 4 0 ♂ N 3 0
66	1	Figure 8	F g e 44	F g 8
93	2	Footnote	Left d g 1979	L ft d g 1980