DK 554342

CD-RP17869

SUPPORT MISSION TO MANAGEMENT OF COCOA MIRIDS *HELOPELTIS* SPP. IN VIETNAM

21/09/09 – 5/10/09

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Mission schedule

21/09/2009:	Departure from Yaoundé (Cameroon) via Paris, flying on to Ho Chi Minh City.
23/09/2009:	Arrival at Ho Chi Minh City. Meeting with Lê Thị Tuyết and Juan Carlos Motamayor. Visit to the clonal trial and cocoa farm in the Dong Nai province.
24/09/2009:	Meeting with Dr. Pham Hong Duc Phuoc and visit to the cocoa garden of Nong Lam University. Discussion for the working program of the mission. Departure for the Dak Lak province.
25/09/2009:	Visit to private cocoa plantations and farms in the Dak Lak province. Visit to a pod breaking site.
26/09/2009:	Visit to private cocoa plantations and farms in the Dak Lak province. Meeting with WASI and Cargill partners. Visit to WASI cocoa garden (cancelled due to bad weather). Flight back to Ho Chi Minh City.
28/09/2009:	Departure for the Ben Tre province in the Mekong delta. Visit to a black ant trial with Dr. Phuoc. Visit to cocoa farms and a pod collection site.
29/09 to 2/10/09:	Workshop on cocoa mirids *Helopeltis* spp. at Nong Lam University.
2/10/09:	Visit to the Laboratory of Entomology of the Plant Protection Department of NLU. Meeting with Luong Lê Cao (entomologist).
4/10/09:	Departure for Paris via Hanoï.
5/10/09:	Arrival at Yaoundé.

Acknowledgements

We are particularly grateful to Dr. Pham Hong Duc Phuoc and Lê Thị Tuyết, who perfectly organized all our travel and accommodation.
This mission has been funded by Mars Inc..

Contents

Abstract

Vietnam is considered as a good candidate for supplying the deficit of the world market in cocoa beans. Fertile soils in the South East and Central Highlands regions and western part of the southern region are particularly suitable for cocoa growing and enable yield between 1.5 and 2.0 tons. Yet, cocoa production is reduced by emerging pests like plant bugs, also called mirids, of the genus *Helopeltis*. For the moment, these pests are not well known on cocoa in Vietnam and pest management recommendations do not exist.

We were contacted by Mars Inc. to conduct a support mission, with the global objectives to evaluate the situation in terms of species involved, damage, farmer practices, and to consider the possibility of conducting projects on cocoa mirids in Vietnam.

The mission consisted of (i) inspecting cocoa plantations in three regions of Vietnam: the Dong Nai province, near Ho Chi Minh City, the Dak Lak province, in the highlands, and the Ben Tre province, in the Mekong Delta; (ii) running a workshop in order to train Vietnamese students, agronomists and entomologists in experimentation with cocoa mirids and to develop project proposals on IPM for cocoa mirids in Vietnam.

Our investigation showed that *Helopeltis* spp. was present in all inspected farms, yet damaging cocoa with very variable levels. Damage was much more severe in the Dak Lak province, despite the fact that farms were usually regularly sprayed with insecticides. In the more diversified cocoa farms of the Mekong Delta, lower mirid damage was noticed, in spite of the absence of chemical control. Natural enemies, especially ants, were usually numerous in farms of this region. Farmer's spraying practices were very heterogeneous, regarding chemicals and spraying calendars and evidence has been given that recommendations for chemical control of cocoa mirids do not exist in Vietnam.

Twenty participants belonging to seven organizations took part of the workshop on cocoa mirids in Vietnam, in Nong Lam University. PowerPoint presentations dealing with activities conducted on cocoa mirids in Cameroon were read. Demonstration was given for the rearing of cocoa mirids and for the assessment of cocoa resistance to mirids. Training was given on identification of the different development stages of *Helopeltis sp.* collected on cocoa. Finally, a brainstorming session gave the basis for a project proposal, involved organizations, expected funding and main components of which are briefly presented in this report.

1. Purpose of the mission

According to ICCO statistics, world production of cocoa beans was estimated at 3.684 millions tonnes, in the 2007/08 cocoa year. Africa remained by far the largest cocoa producing region, accounting for 72% of world cocoa output in 2007/08. The shares of Asia and Oceania, and of the Americas, were 16% and 12% respectively. Although cocoa is grown in about 50 countries, almost 71% of global output came from three countries: Côte d'Ivoire, Ghana and Indonesia. The next 15% came from a further three countries: Nigeria, Cameroon and Brazil. With a global production deficit of about 80,000 tonnes, world demand of cocoa beans is estimated to have outstripped world supply during the last production seasons (Anon, 2008).

For the present decade, Vietnam is considered as a good candidate for supplying the world market with cocoa beans. Indeed, the country possesses the favourable natural conditions for cocoa development, especially fertile soils in the South East and Central Highlands regions and western part of the southern region. Moreover, Vietnamese coffee and pepper farmers have currently difficulties due to the drop in market price and the lack of high-quality products to sell. Thereby, crop diversification is encouraged by government.

Cocoa tree is grown in Vietnam since many decades but cocoa production really took off since 2003 and the beginning of the Sustainable Cocoa Enterprise Solutions for Smallholders (SUCCESS) Alliance program, a public-private partnership consisting of USAID, USDA, the World Cocoa Foundation (WCF), Mars Inc. and ACDI/VOCA. SUCCESS Alliance increased smallholder farmers' incomes in Vietnam through the introduction of sustainable, diversified cocoa-based agroforestry systems. The program allowed expansion of cocoa growing area from about 1,500 hectares in 2003 to 8,500 hectares of land in 2006, located mainly in the Bên Tre, Tiên Giang (Mekong delta), Ba Ria-Vung Tau, Binh Phuoc (Southeast) and Dak Lak (Highlands) provinces of Vietnam. The country is planning to increase its cacao acreage to some 20,000 hectares by 2010.

The average yield of cocoa growing in these regions is expected to be between 1.5 and 2.0 metric tons per hectare. Yet cocoa production is reduced by emerging pests and diseases, especially the black pod disease, due to *Phytophthora palmivora*, and the plant bugs, also called mirids, of the genus *Helopeltis*. Mirids are known to be the main pests of cocoa in West-Africa, causing 30 to 40 % of crop losses (Babin, 2009). In Asia, *Helopeltis* species are damaging many crops, including a number of major cash crops such as black pepper (*Piper nigrum*), cashew (*Anacardium occidentale*), cinchona (*Cinchona* spp.), cocoa and tea (*Camellia sinensis*) (Stonedahl, 1991). On cocoa, mirids make characteristic necrotic lesions which can kill young pods (cherelles) and young shoots. In Malaysia, maximum damage to pods has been estimated at 85 % during the fruiting months and yield losses around 50 % have been reported (Tong-Kwee *et al.*, 1989). However, due to a lack of in-depth studies, basic knowledge of the biology and ecology of these pests on cocoa is still incomplete. Moreover, in Vietnam, management recommendations do not exist and cocoa farms are consequently highly vulnerable.

Then, the objectives of the mission were to:

- Collect and identify plant bugs in different cocoa growing regions
- Roughly estimate mirid damage under different cocoa growing conditions
- Assess farmer's notion of the pests and their management strategies
- Train personnel of organisms dealing with cocoa to:
    - identification of the pests and their damage

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    - experimentation with the pests (rearing method, cocoa resistance screening, ...)
- Develop project proposals on IPM strategies for cocoa mirids in Vietnam

To reach these objectives, the mission consisted mainly in (i) inspecting cocoa plantations in different cocoa growing regions and (ii) running a workshop on *Helopeltis* spp..

2. Inspection of cocoa plantations

2.1. Dong Nai province

a) Clonal plot in Trang Bom

The plot is located at about 50 km from HCMC.
The plot has been planted in 2005, as part of a Mars Inc./NLU/WCF project. It consists of 62 local clones and 46 imported clones from Reading University notably (annexe 1), planted in randomised blocs of 16 trees following a split plot design with 4 replications (annexe 2). Observations of pests and diseases prevalence were conducted in August 2009. Damage of black pod, vascular-streak dieback, algal rust, mirids (on pods and buds), mealybugs, husk borers and leaf insects, as well as incidence of cankers, was assessed following a notation scale. Data analysis is currently in progress.

At the time of the visit, trees did not bear many pods but *Helopeltis* lesions were observed on pods and shoots and individuals were collected and conserved in alcohol. Some trees of a same clone and next to each over showed very different levels of damage, suggesting that environmental factors as well as behavioural elements interact with genetic factors. The idea of additional laboratory screening tests was discussed.

b) Cocoa farm

The farm was close to the clonal plot and relatively isolated as cocoa farms are not numerous in this area. Cocoa is grown behind the farmer house, with fruit trees, and could be considered as an agroforest garden. The setting up of the plot was stimulated by researchers and the planting material has been supplied by NLU. Trees were well developed but started produce pods recently. Trees showed low level of mirid damage. Some individuals of *Helopeltis sp.* were sampled on pods.

2.2. Dak Lak province

The Dak Lak province is located in the highlands, at about 200 km from Ho Chi Minh City. Two large plantations belonging to private companies were inspected. The first one was 300ha-sized and was partitioned in about 300 small plots rented by smallholders. The plantation was planted in 2002. The yield of the inspected plot was estimated between 2.5 and 3.5 tones/ha. For this plot, large amounts of fertilizer (1 kg of 18-8-16 per tree and per year) were used and insecticide (fenobucarb) was sprayed once a month during the rainy season. Inspected plot showed serious mirid damage, especially on pods, many of them being distorted by attack at young stages (figure 1). Another plot was inspected in the same plantation, which showed similar mirid damage in spite of 8 insecticide sprayings with alpha-cypermethrin per year, 3 times during the dry season and 5 times during the rainy season. In this plot, cashew was associated with cocoa and mirid lesions on cashew shoots were detected (figure 2).

The second plantation was similar: 150 ha divided in small plots rented by farmers (figure 3). A quick inspection of the plantation clearly revealed the high variability of mirid damage between plots, even between neighbouring plots. Thus, for some plots cocoa foliage and branches were particularly damaged, with dried leaves and cankers, while for other plots cocoa canopy was healthy. Although, one spraying with thiamethoxam per month was recommended by the company owning the plantation, farmers had very variable spraying practices, according to their means. Among chemicals, thiametoxam is relatively expensive and is usually replaced by other chemicals like dimethoate for instance. The heterogeneity of farmer's practices leads to high variability of mirid damage. This observation clearly demonstrated that good spraying practices limit mirid damage, especially on branches.

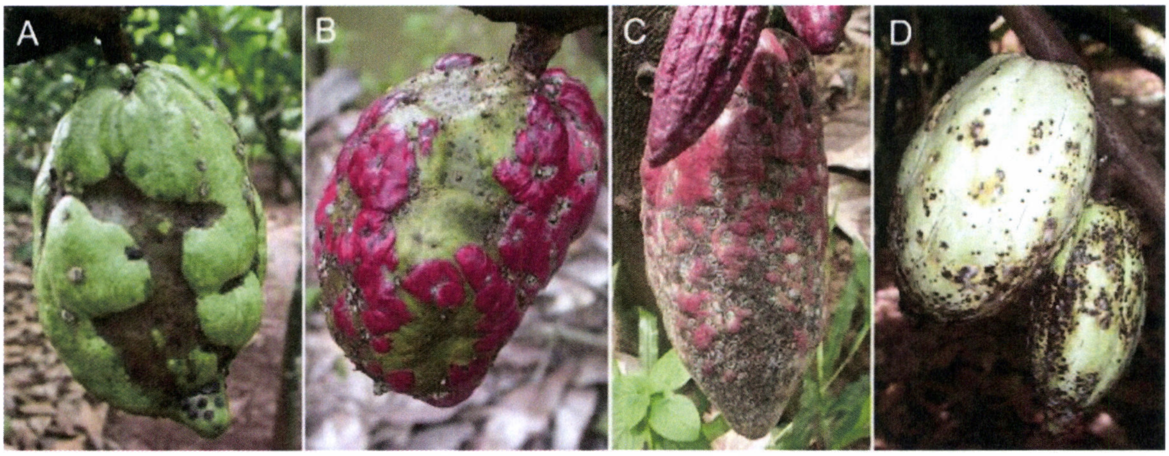

Figure 1: *Helopeltis* spp. damage on pods. A & B: old damage on cherelles involving pod distortion; C: old damage on an adult pod; D: new damage caused by mirid at different development stages.

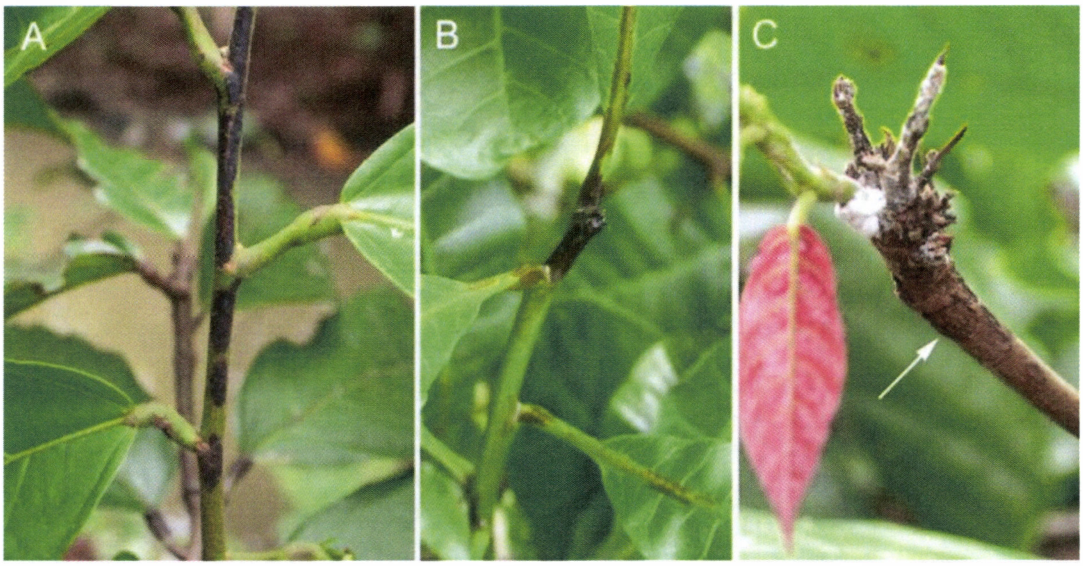

Figure 2: *Helopeltis* spp. damage on shoots. A: new damage on cocoa shoot; B: new damage on cashew shoot; C: old damage (canker) on cocoa branch involving the death of the terminal bud.

We also visited a 3 years-old plantation, measuring about 0.6 ha, where cocoa was associated with cashew following a plantation design in lines (figure 4). Cocoa plants have been supplied as grafted seedlings by a state company. The plot was fertilized with ammonium sulphate, potassium and urea, with about 1 kg of fertilizer per tree, in 3 applications per year. Insecticide (dimethoate) was sprayed with mistblower on cocoa and cashew 3 times per year. We could not collect any *Helopeltis* individual in this plot but we detected mirid lesions on cocoa pods and shoots and on cashew shoots.

Figure 3: Large plantation (150 ha) belonging to private company partitioned in small plots rented by smallholders, in the Dak Lak province. Plots were usually lightly shaded.

Figure 4: Association cocoa/cashew in the Dak Lak province.

The visit of a pod breaking site revealed that (i) despite the fact that they usually showed mirid lesions, pods were generally well developed (figure 5). However, it was more difficult to extract beans from highly damaged pods; (ii) a significant part of harvested pods was affected by black pod disease due to *Phytophthora palmivora*. Yet, affected pods were not moved apart and were processed as healthy ones. The effect of mirid and black pod disease damage on the quality of dry beans was discussed and recommendations for post-harvesting process were formulated.

Figure 5: Pod breaking site, showing well developed pods but highly infested by *Phytophtora* pod rot. Seeds extracted from infected pod were not separated from the others.

2.3. Ben Tre province

The Ben Tre province is located in the Mekong Delta at about 60 km from Ho Chi Minh City. In this region, cocoa is usually cultivated by smallholders in association with coconut palm and fruit trees (longan = *Dimocarpus longan*, *Citrus* spp. ...) (figure 6). The use of pesticides is not in the habit of farmers and cocoa plots are especially suitable for IPM experimentation.

Figure 6: Plantation of the Mekong Delta. Cocoa is grown by smallholders in association with coconut palms and fruit trees (*Citrus* spp., longan, and banana).

We first visited a 5 year-old and 0.3ha-sized cocoa plot where Dr. Phuoc has introduced the black ant *Dolichoderus thoracicus* for biocontrol of cocoa mirids (figure 7). According to Dr. Phuoc, ant, which had been introduced 2 years ago, has considerably reduced *Helopeltis* population in the plot. Indeed, though it was not sprayed with insecticides, plot was particularly clean, with only few mirid lesions on pods and young shoots. Old damage on branches showed evidence of mirid infestation in the past. Efficiency of the black ant as biocontrol agent against mirids seemed to be proved in this plot. However, Dr. Phuoc has conducted this experiment in 2 more plots where introduction of the black ant did not succeed. According to Dr. Phuoc, farmers did not trust and sprayed their farm, destroying ant colonies.

Figure 7: The black ant *Dolichoderus thoracicus* tending mealybugs (*Cataenococcus* spp.). Pods, pod peduncles, bark and green shoots are feeding sites for the mealybugs.

Dr. Phuoc's way of using the black ant: the black ant *D. thoracicus* tends mealybugs (*Cataenococcus* spp.) for their honeydew, a source of sustenance. Then, the mealybug must be introduced in farms at the same time as the black ant. Mealybugs can be reared, carried and introduced in farms on piece of pods or other fruits, as papaya for example, which are finally stapled near pod peduncles for mealybug establishment. Black ant is trapped in pieces of PVC pipes, containing coconut leaflet and molasses (figure 8). Then tubes are fixed on cocoa trees. The newly introduced black ants have to compete with other ant species and a large population has to be introduced in order to overwhelm the antagonistic ants. Thus, Dr. Phuoc fixes 2 to 3 artificial nests per tree to ease black ant establishment. Once a strong population is established, one nest per cocoa tree is sufficient.
Three more farms were inspected in the province. Although none of these plots was regularly treated with insecticides, we did not notice as severe mirid damage as in the Dak Lak province. *Helopeltis sp.* could be found in farms and damage was observed, but at a lower level. The visit of a site of breaking pod revealed very few mirid lesions on mature pods. The presence of natural enemies, and especially the weaver ant *Oecophylla smaragdina* (figure 9), nesting on cocoa and associated fruit trees, could explain this observation.

Figure 8: Technique to introduce and maintain the black ant in cocoa plantation A: old bamboo nest still occupied by an ant colony; B: new PVC nests fixed on cocoa trees; C: Dr. Phuoc controlling pod infestation by mealybugs.

Figure 9: The weaver ant *Oecophylla smaragdina* is a natural enemy of *Helopeltis* spp. and could be involved in the low population levels in farms of the Mekong Delta.

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2.4. Identification of sampled plant bugs

A total of 46 *Helopeltis* spp. specimens were collected from 7 plots and preserved in alcohol (table 1). The collected specimens are suspected to belong to the species *Helopeltis theivora* (= *H. theobromae* Miller). However, as many *Helopeltis* species are morphologically similar and very variable in size and coloration, identification will be confirmed by a morphological study with the help of the Gary M. Stonedahl's identification guide for Oriental species of *Helopeltis* (1991).The use of molecular analysis will be considered afterwards.

Table 1: Collection characteristics of mirid specimens

Date of collection	Place of collection		Plant		Number of specimens	
	Province	Plot	Species	Organ	Nymph	Adult
23/09/09	Dong Nai	Clonal trial	Cocoa	Pods	4	2
23/09/09	Dong Nai	Farm	Cocoa	Pods	2	1
24/09/09	Ho Chi Minh City	Nong Lam Univ.	Cocoa	Pods	5	2
24/09/09	Ho Chi Minh City	Nong Lam Univ.	Cashew	Green shoots	3	-
25/09/09	Dak Lak	Farm1	Cocoa	Pods	2	7
25/09/09	Dak Lak	Farm2	Cocoa	Pods	-	3
28/09/09	Ben tre	Farm1	Cocoa	Pods	5	-
28/09/09	Ben tre	Farm2	Cocoa	Pods	8	2
			Total		29	17

2.5. Discussion and conclusions

All of the inspected plots showed evidence of new and old damage caused by plant bugs. However, damage was much more severe in the Dak Lak province, where plots showed pod distortion and cankers on branches, despite the fact they were usually and regularly sprayed with insecticides.

Farmer's spraying practices were very heterogeneous, regarding chemicals and spraying calendars. Such practises may be harmful in large partitioned plantations, where pests could take shelter in insufficiently protected plots. These plots could be infestation foci for adjacent plots. In such crop systems, pest management has to be organized on the scale of the all plantation.

Evidence has been given that recommendations for chemical control of cocoa mirids do not exist in Vietnam. Research efforts have to be made in order to identify efficient chemicals and to define spraying calendars adapted to the different cocoa growing regions. With this end in view, our knowledge of the pest ecology must be improved first, and especially seasonal variations have to be precisely described.

In the highlands, cocoa is often associated with cashew, which is known to be a host plant of *Helopeltis* spp.. In such crop associations, cashew may be a plant-reservoir and could be largely involved in initial infestation, as it has been suggested for *Cola* spp. in West Africa. Consequently, cashew must be sprayed at the same time as cocoa and the use of mistblowers is recommended for efficient applications.

Moreover, in order to develop alternative options to chemical control and especially strategies linked to farming practices, studies must be conducted on the ecology of the pest in farms.

Relationships between mirid populations and light and microclimatic conditions should be studied with the aim to develop shade management and pruning recommendations.

In the more diversified cocoa farms of the Mekong Delta, lower mirid damage may be linked to the presence of natural enemies. In Asia, ants have been used by farmers for centuries to protect their crops from pests. Introduction of the black ant gave promising results in a farm where cocoa was associated with coconut palms. However, these results have to be confirmed by large-scale trials, including different cropping systems.

3. Workshop on cocoa mirids

3.1. Objectives

The workshop aimed to present what is done on cocoa mirids in Cameroon in order to (i) train Vietnamese students, agronomists and entomologists to identify the pest and its damage and to conduct experimentation with the pest; (ii) develop project proposals on IPM strategies for cocoa mirids in Vietnam.

3.2. List of participants

Annexe 3 shows the list of participants of the workshop. Seven organizations were represented:

- The Plant Protection Department of Agriculture Faculty of the Can Tho University, the biggest university in the Mekong Delta
- The Institute of Agriculture Science (IAS)
- ACDIVOCA Vietnam, a cocoa development organization funded by USDA
- Cargill Vietnam
- The Western Highlands Agro-forestry Scientific and Technical Institute (WASI)
- Helvetas Vietnam (NGO), program Eco-cacao
- The Nong Lam University

3.3. Training on experimentation with cocoa mirids

Two PowerPoint presentations were read, one dealing with activities conducted on cocoa mirids in Cameroon (annexe 4) and one dealing with the different methods used to assess cocoa resistance to mirids in Cameroon (annexe 5).

Demonstration was given in the cocoa garden of NLU for the rearing of cocoa mirids. Mirid pairs were enclosed in sleeve-cages on cocoa pods and cashew shoots. One day after, cages were opened and plant tissues explored in search of mirid eggs.

We also demonstrate the technique currently used in Cameroon to assess cocoa resistance to mirids. The laboratory test of antixenosis assessment on twigs in glass vials was chosen because the technique proved to be less destructive for cocoa collections than the field test on shoots. One mirid nymph is introduced in a vial and allowed to feed on a twig of a known genotype for 24 hours. Twenty to 30 repetitions enable the calculation of a mean number of feeding points for each tested genotype.

A session was finally conducted on identification of the different development stages of *Helopeltis sp.* collected on cocoa. Figures 10, 11 and 12 show pictures taken during this session, which were shown to the participants for the identification of development stages.

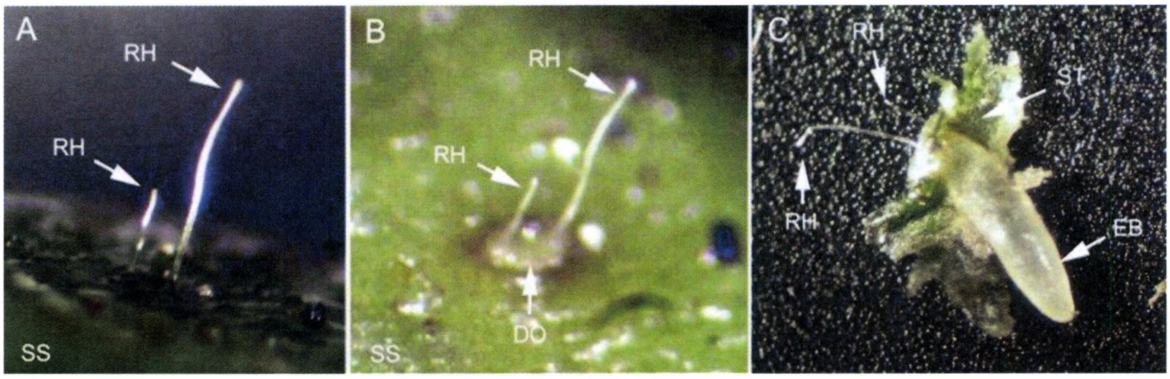

Figure 10: *Helopeltis sp.* egg buried in a cocoa shoot (A and B) and extracted from the shoot (C). SS: shoot surface, ST: shoot tissues, RH: respiratory horns, DO: domed opercule, EB: egg body.

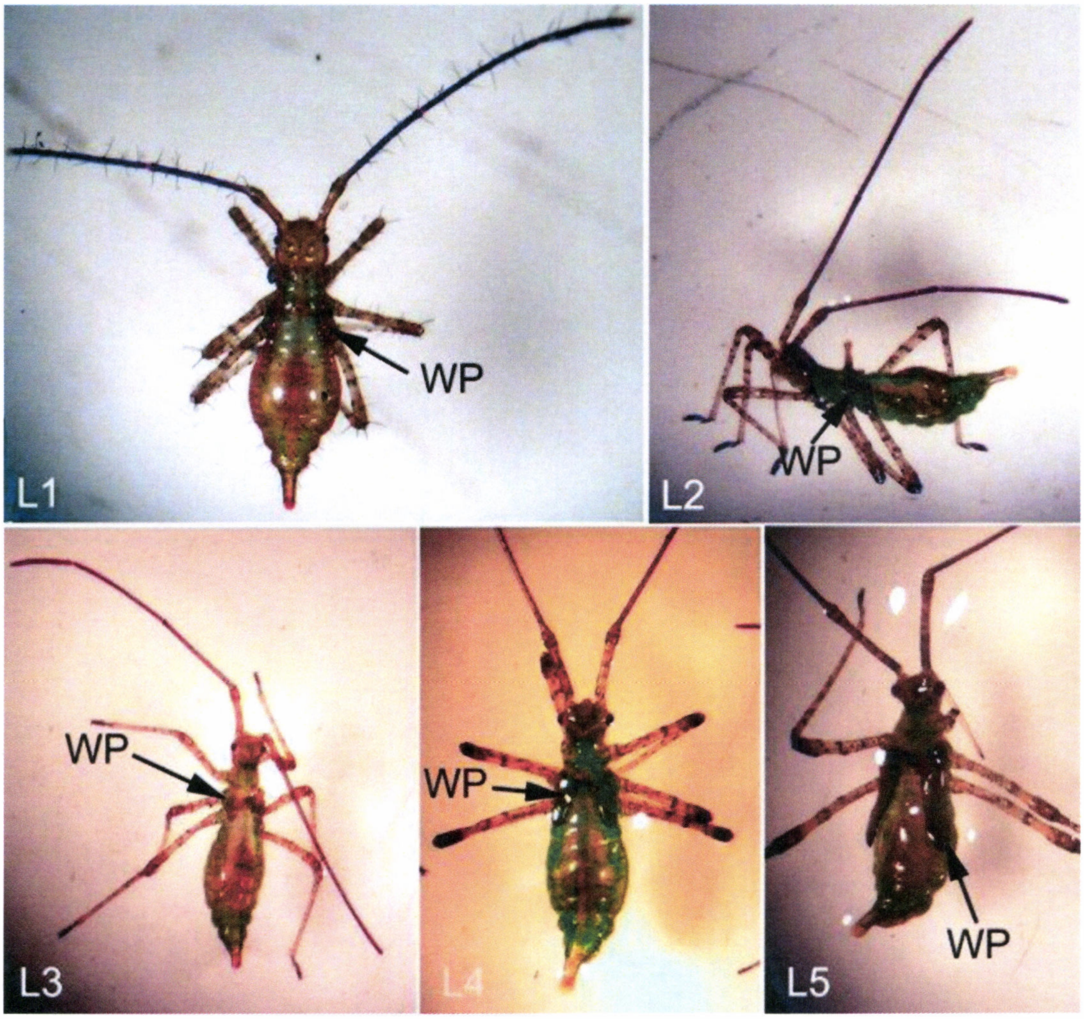

Figure 11: *Helopeltis sp.* nymphal instars. WP: wing pads. The global size of the specimen as well as the size of the wing pads (WP) are the main characteristics used to distinguish the different nymphal instars.

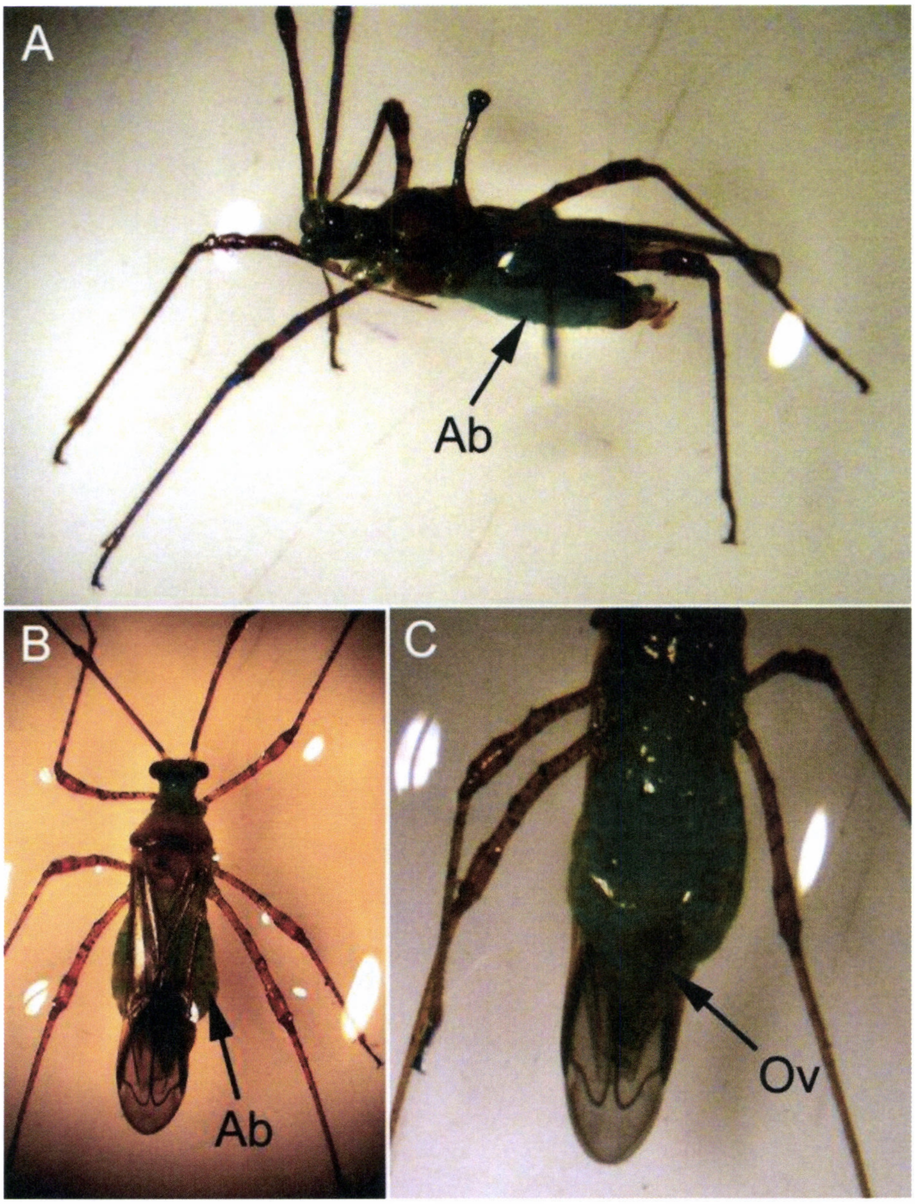

Figure 12: *Helopeltis sp.* adults male (A) and female (B and C). The main distinction criteria are the size of the abdomen (Ab) which is larger for the female, and the presence of an ovipositor (Ov) for the female.

3.4. Project proposal for research activities on cocoa mirids in Vietnam.

This project aims at the development of science-based management strategies for the control of cocoa mirids *Helopeltis* spp. in Vietnam, in order to improve their management and thus reduce pest impacts on cocoa production. The project will obtain the general objective of this proposal through a set of studies on the pest biology and ecology, control measures and impact on production.

The project will consist of 4 components, each with their own specific, yet complementary, scientific objectives:

- Improve chemical control by testing chemicals and method of spraying, assessing economical threshold and proposing spraying calendars.

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Since they are no real alternative, chemical control should remain an important management strategy for *Helopeltis* spp. However, improving application effectiveness with minimum environmental effect is highly desirable.

- Develop pest management strategies based on farming practices in order to limit the use of chemicals. We should be able to provide farmers with resistant/tolerant varieties and IPM recommendations for shade management and pruning for example.

- Develop biological alternative to chemical control involving natural enemies (ants, entomopathogens) and trapping (sex pheromones).

- Increase general knowledge on the diversity, biology and ecology of *Helopeltis* spp. in Vietnam.

Table 2 shows the results of a brainstorming session, aiming to identify organizations which could be involved in the different project activities and expected funding.

The project is currently being drawn up.

Table 2: Proposal for activities to be conducted on *Helopeltis* spp. on cocoa in Vietnam

Component	**Activity**	**Involved institute**	**Expected funding**
Chemical control	Test of chemical products	WASI Nong Lam Univ. (NLU)	Government Chemical firms
	Treatment method	WASI NLU, on farms	Government (2011) Firms
	Treatment calendar	NLU	Mars Government (2011)
	Economic threshold	NLU	Mars
Agronomic control	Screening resistance	NLU	Mars WCF
	Recommendations for pruning	NLU	Eco-cacao
	Recommendations for shade management	NLU	Eco-cacao
	Recommendations for crop associations	NLU	Eco-cacao
Biological control	Pheromone traps*	Can Tho Univ.	Government Mars
	Mycoinsecticides	Can Tho Univ.	Government Mars
	Natural enemies (ants, parasitoids**)	NLU IAS ***	Eco-cacao Mars
Biology	Rearing	NLU	Mars
	Life cycle	NLU	Mars

* Pheromones traps probably available on:
http://www.ecplaza.net/tradeleads/seller/2520163/pheromone_traps_organic.html
** Parasitoid expert: Gérard Delvare (CIRAD Montpellier) gerard.delvare@cirad.fr
*** Institute on Agriculture Science – Activities already conducted on Helopeltis/weaver ants relationships on cashew.

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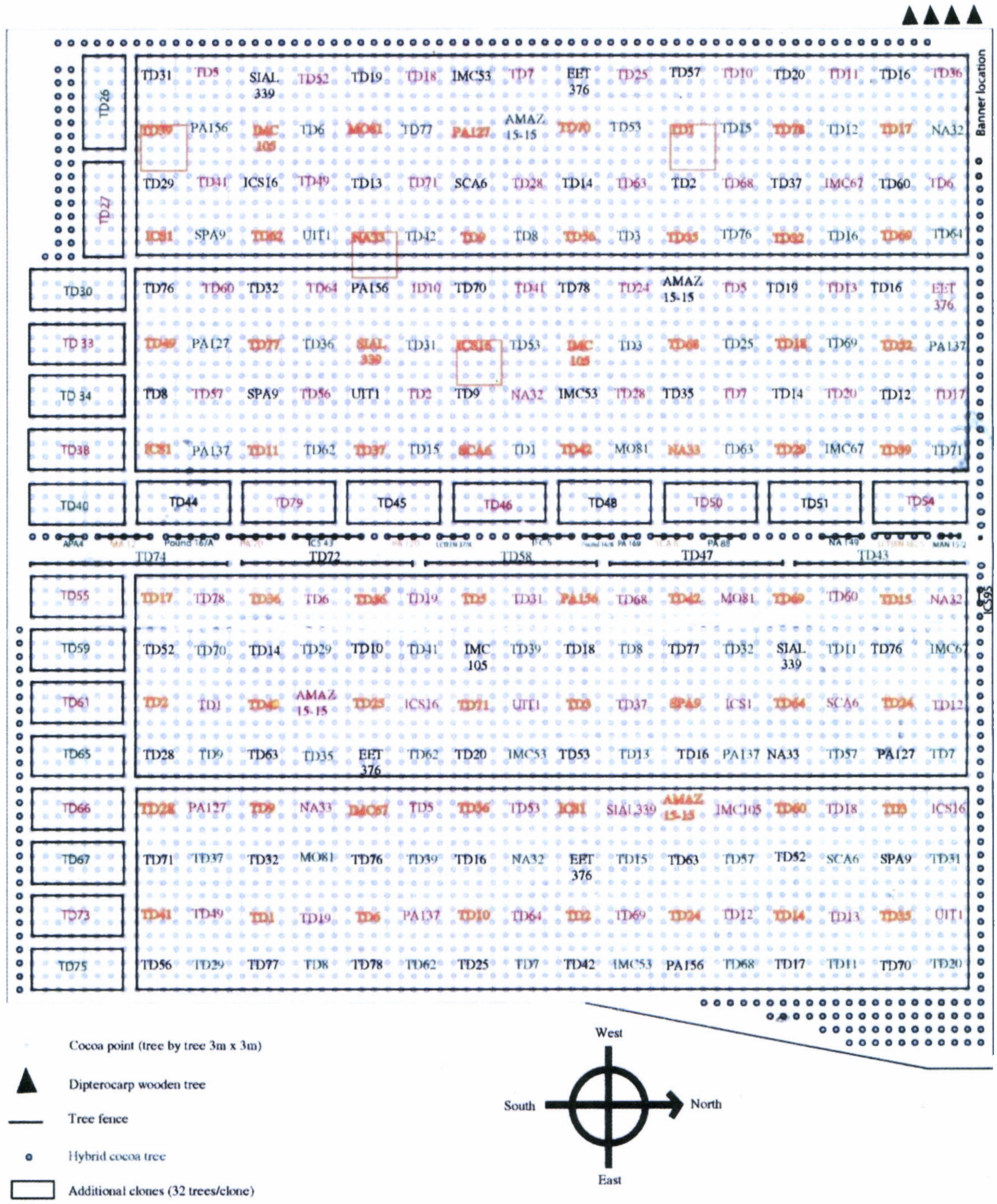
Annexe 1: List of the clones of the clonal trial (Dong Nai province)

64 CLONES - FORMAL EXPERIMENT					
No.	Original clone	Code	No.	Original clone	Code
Local collection			Imported collection		
1	CR1	TD 25	35	BAL 209	TD1
2	CR4	TD 28	36	BAL 244	TD2
3	CR5	TD 29	37	BR 25	TD 3
4	CR7	TD 31	38	KKM 22	TD5
5	CR8	TD 32	39	PBC 123	TD6
6	CR15	TD 15	40	PBC 154	TD7
7	CR16	TD 16	41	PBC 157	TD8
8	CR17	TD 17	42	PBC 159	TD9
9	CR18	TD 18	43	DESA 001	TD10
10	CR19	TD 19	44	PBC 236	TD11
11	CR20	TD 20	45	QH 1213	TD12
12	CR 24	TD 24	46	QH 22	TD13
13	CT 1	TD 35	47	QH 441	TD14
14	CT 2	TD 36	48	AMAZ15-15	Imported clones from Reading University
15	CT 9	TD 37	49	EET376	
16	CT 54	TD 49	50	ICS1	
17	CT16	TD 39	51	ICS16	
18	CT 21	TD 41	52	IMC105	
19	CT22	TD 42	53	IMC53	
20	CT96	TD 52	54	IMC67	
21	CT97	TD 53	55	MO81	
22	CT 123	TD 56	56	NA32	
23	CT 126	TD 57	57	NA33	
24	CT 146	TD 60	58	PA127	
25	CT 157	TD 62	59	PA137	
26	CT 158	TD 63	60	PA156	
27	CT 159	TD 64	61	SCA6	
28	CT194	TD 70	62	SIAL339	
29	CT176	TD 68	63	SPA9	
30	CT179	TD 69	64	UIT1	
31	CT 197	TD 71			
32	CT231	TD 76			
33	CT232	TD 77			
34	CT233	TD 78			

44 CLONES - OBSERVATION EXPERIMENT				
No.	Sub-trial clones	Code	New imported clones from Reading University	
Local collection			Imported clones	
1	CR 2	TD 26	29	APA 4
2	CR3	TD 27	30	ICS 43
3	CR6	TD 30	31	ICS 95
4	CR9	TD 33	32	IFC 5
5	CR10	TD 34	33	LCTEEN 162/5
6	CT11	TD 38	34	LCTEEN 37/A
7	CT17	TD 40	35	MA 12
8	CT31	TD 44	36	MAM 15/2
9	CT41	TD 45	37	NA 149
10	CT44	TD 46	38	PA 120
11	CT49	TD 48	39	PA 169
12	CT71	TD 50	40	PA 70
13	CT78	TD 51	41	PA 88
14	CT118	TD 54	42	POUND 16/A
15	CT119	TD 55	43	POUND 16/B
16	CT137	TD 59	44	SCA 6
17	CT148	TD 61		
18	CT173	TD 65		
19	CT175	TD 66		
20	CT178	TD 67		
21	CT221	TD 73		
22	CT226	TD 75		
23	CT225	TD 74		
24	CT211	TD 72		
25	CT127	TD 58		
26	CT45	TD 47		
27	CT23	TD 43		
28	CT 37	TD 79		

Annexe 2: Plan of the clonal trial (Dong Nai province)



Annexe 3: List of participants and group picture of the workshop on cocoa mirids

No	Name	Organization	E-mail
1	Hùynh Phước Mẫu	Plant Protection Department, Agriculture Faculty, Cần Thơ University (Mekong Delta)	hpmau@ctu.edu.vn
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5	Đãng Thi Thúy Hà		hanet240483@yahoo.com
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15	Nguyễn Văn Hoàng	Nong Lam University (NLU)	
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Annexe 4: PowerPoint presentation on ongoing activities on cocoa mirids in Cameroon

1

Ongoing activities on cocoa mirids in Cameroon, with an emphasis on ecobiology of *Sahlbergella singularis* (Hemiptera: Miridae)

Régis BABIN – CIRAD (thesis)
Luc DIBOG – (Lab leader) IRAD
Joseph AMANG A MBANG - IRAD
Hervé BISSELEUA – IRAD (thesis in Germany)

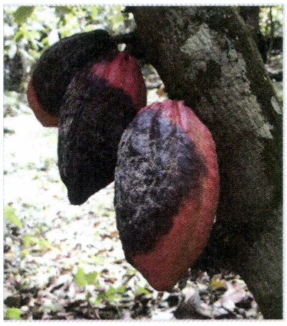
2

Black Pod Disease

Due to *Phytophthora megakaria*

Losses of 50 to 80 % of pods when no spraying

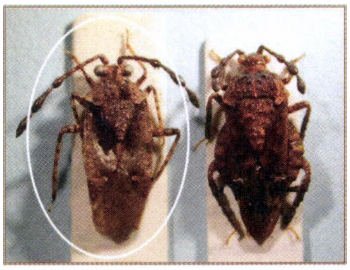
Fongicides very epensive for farmers



3

Cocoa mirids

Cocoa mirids two main species in West Africa:



Sahlbergella singularis **Hagl.** ***Distantiella theobroma*** **Dist.**

In Cameroon, *S. singularis* in the majority in the « Centre-Sud »

4

Mirids damage - description

Drying up of shoots

Canker

Cankers + pathogen fungi = dieback

5

Mirids damage - economic impact

- Crop losses between 25 and 40 % in West Africa
- Loss of 25 % of the trees in Cameroon following the end of the state controlled spraying (early nineties)

6

Management

Control essentially **chemical** today but:

- Economical difficulties
- Environmental preoccupations

IPM, a more sustainable way today

- Reduction of spraying frequency
- Development of cultural methods
- Selection of resistant cocoa varieties
- Use of myco and botanical pesticides
- Exploitation of natural enemies
- Use of attractive traps (pheromones)

7

Ongoing activities in Cameroon (1)

Rearing of *S. singularis* in laboratory

Goals:

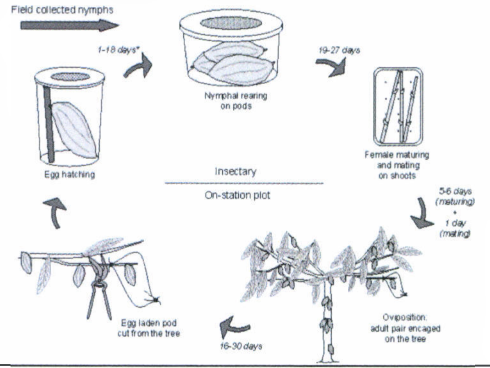
- Produce a large and homogenous population for experimentation
- Improve knowledge on the biology

Convincing results:

- More than 15 generations produced continuously between June 2003 and May 2005
- Thousands nymphs produced since 2003 for experimentation
- Life cycle of *S. singularis*, on cocoa
- Assessment of demographic parameters

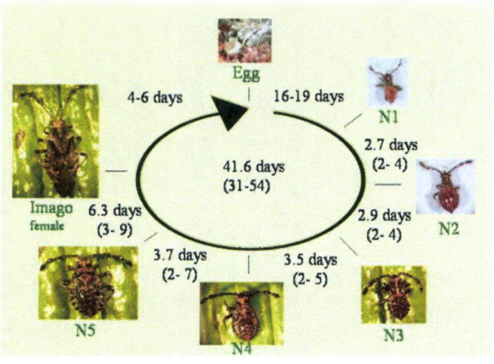
8

Rearing method for *S. singularis* on cocoa



9

S. singularis life cycle on cocoa in Cameroon (rearing conditions)

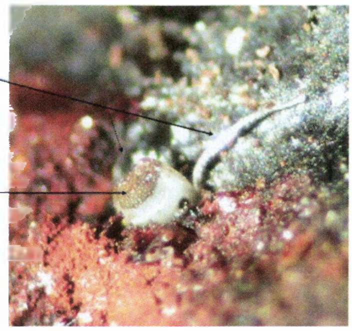


10

S. Singularis egg buried in a rotten pod

Respiratory horns (2)

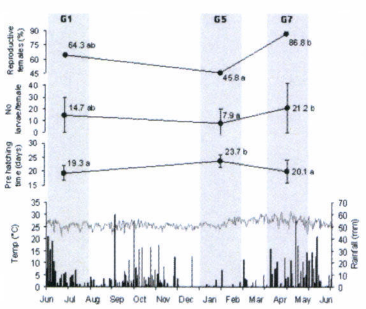
Domed operculum



11

Results: demographic parameters

Impact of climatic conditions on fecundity



Generations

% of productive females

Number of nymphs per female

Length of the embryonic development (in days)

Climatic data

12

Ongoing activities in Cameroon (2)

Cocoa resistance to *S. singularis*

Goals:

- Propose resistant/tolerant varieties for breeding programs
- Improve understanding of the mechanisms involved in the cocoa genetic resistance to mirids

Results:

- Development of a screening test
- Ranking of about 40 local and international clones for attractiveness, antixenosis and tolerance

13

Ongoing activities in Cameroon (3)

Biocontrol of *S. singularis* with mycoinsecticides

Global objective:

- Provide an ecologically sound and sustainable alternative to chemical control

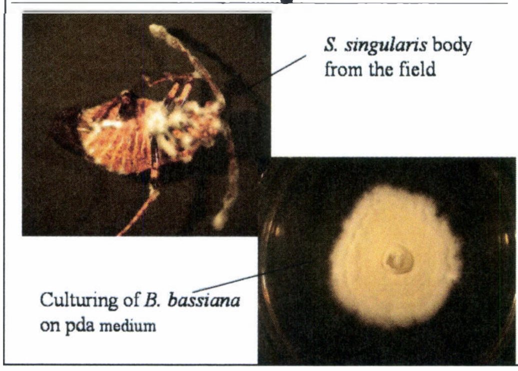
First results:

- Isolation and culturing of fungi strains from a mirid body collected in an experimental plot
- Pathogenicity tests
- Identification: *Beauveria bassiana*

The strain will be tested in the field in Ghana and compared with other entomopathogens

14

Isolation and culturing



S. singularis body from the field

Culturing of *B. bassiana* on pda medium

15

Ongoing activities in Cameroon (4)

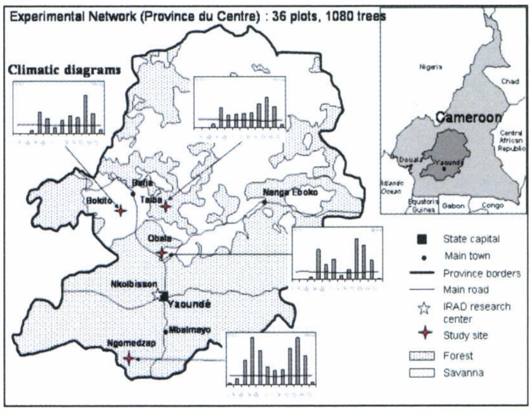
S. singularis populations dynamics in farms

Goals:

- Improve knowledge on the ecology of *S. singularis*
  - Seasonal variations
  - Spatial distribution in farms
- Provide cocoa farmers with recommendations:
  - For effective chemical sprayings
  - For shade management
  - For cocoa tree pruning

16

Experimental Network (Province du Centre) : 36 plots, 1080 trees



17

Method – Spatial distribution

On the sites, 12 plots of 100 trees, in 2006 and 2007.
Knockdown with insecticides, on sampling sheets

- In the evening, installation of sampling sheets on the ground
- Early in the morning, spraying with a mistblower
- 7 hours later, collection of insects.
  Insects kept in alcohol

18

Method – Spatial distribution (2)

Assessment of mirid damage (100 trees plots)

New damage: dried leaves → "Stag-headed" trees | Old damage: cankers

19

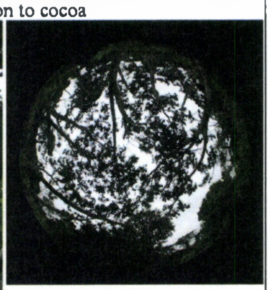
Method – Spatial distribution (3)

Notation of trees by 4 observers according to a notation scale
Scores from 0 (no damage) to 3 (severe damage)

20

Method: Shade characterization

Assessment of light transmission to cocoa

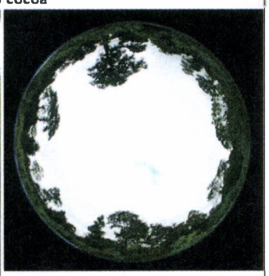


Analysis with GLA software
Transmitted light= 29 %

21

Method: Shade characterization

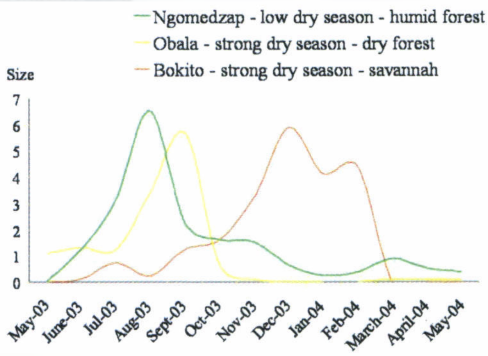
Assessment of light transmission to cocoa



Analysis with GLA software
Transmitted light= 91 %

22

Results seasonal variations of *S. singularis*



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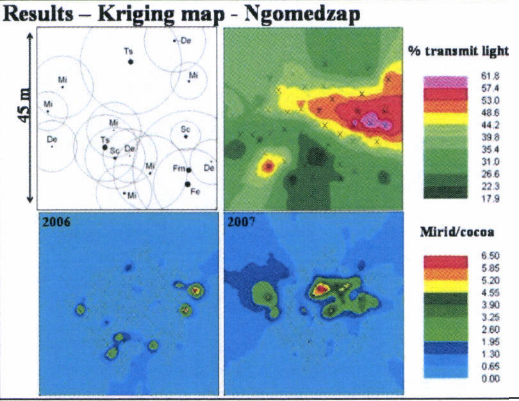
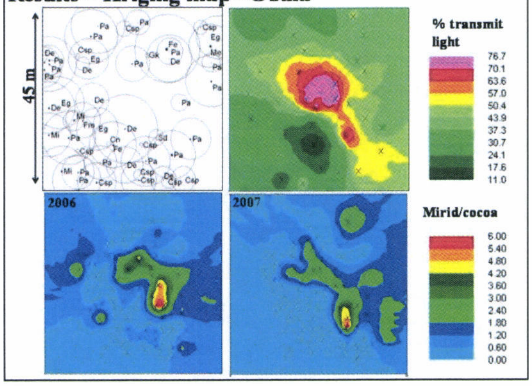
Results – Kriging map - Ngomedzap



24

Results – Kriging map - Obala



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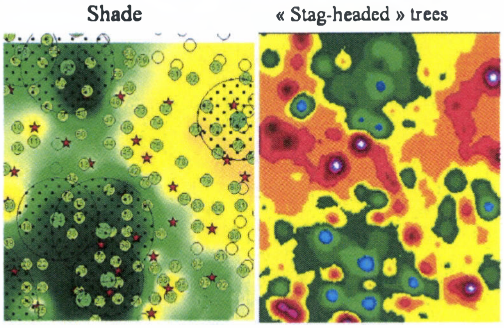
Results: Impact of shade on damage

Shade « Stag-headed » trees



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Partnership and funding

Rearing and biology: CIRAD

Screening for cocoa resistance: USDA-ARS, CFC/ICCO/IPGRI project, Mars

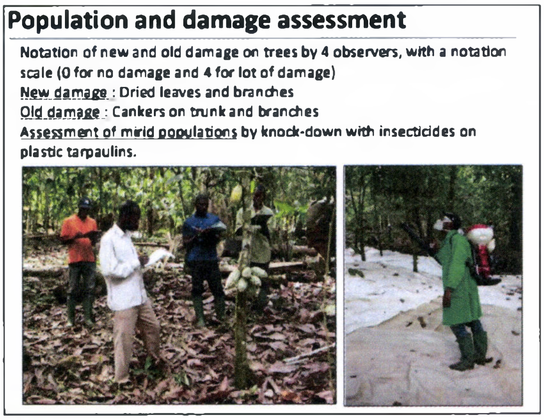
Biocontrol with mycoinsecticides: Imperial College (IPARC), USDA-ARS

Attractive traps (pheromones): NRI, USDA-ARS

Ecology: French Ministry of Foreign Affairs (SCCS Project, REPARAC Project), CIRAD (ATP Caresys)

Annexe 5: Powerpoint presentation showing the methods used in Cameroon to assess cocoa resistance to mirids

1



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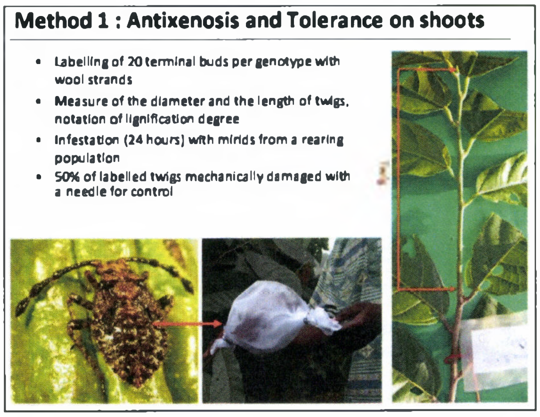

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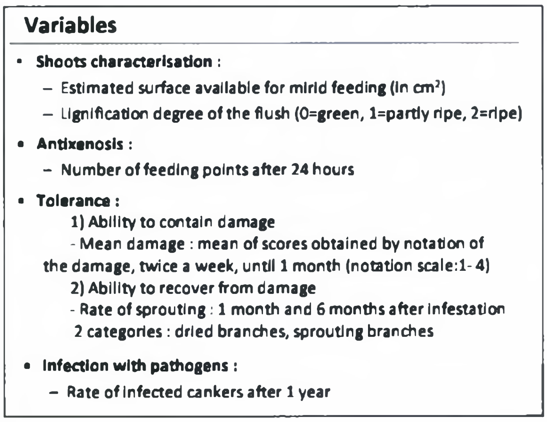

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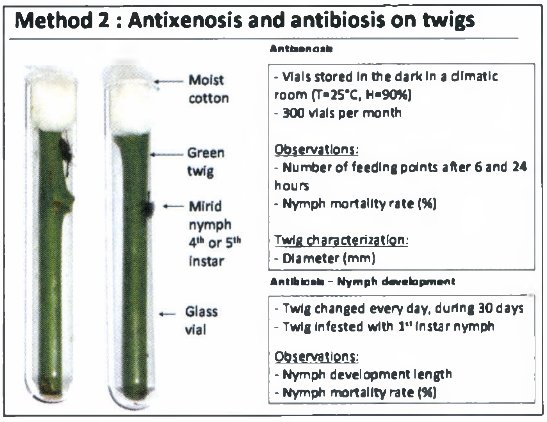
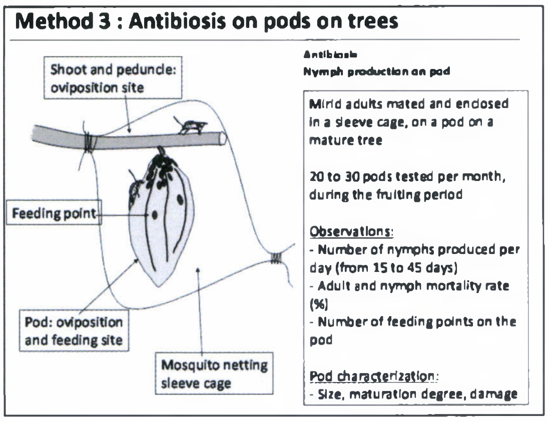


5



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C.S. 06.08.2015