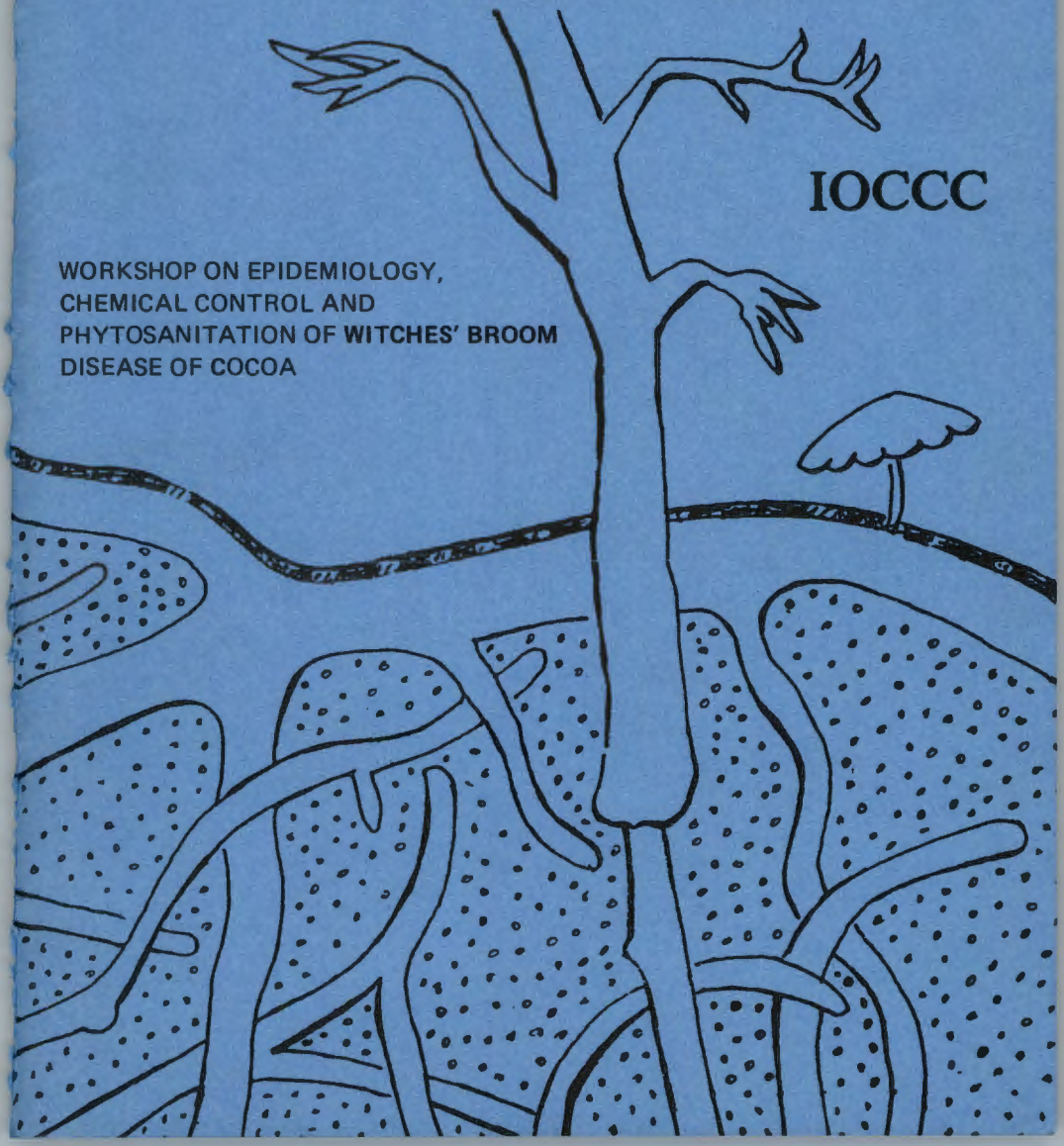
5th Workshop

MANAGING WITCHES' BROOM DISEASE OF COCOA

REPORT OF 5th WORKSHOP
OF INTERNATIONAL WITCHES' BROOM PROJECT
3 – 10th November 1988, Trinidad.



IOCCC

WORKSHOP ON EPIDEMIOLOGY,
CHEMICAL CONTROL AND
PHYTOSANITATION OF **WITCHES' BROOM**
DISEASE OF COCOA

INTERNATIONAL WITCHES' BROOM PROJECT

(IWBP)

IWBP is an international project funded by chocolate manufacturers in Europe and North America with a number of International Agencies and with the governments of 6 cocoa producing countries. It is conducting fundamental research at a total of 21 centres in Europe, Latin America and the United States aimed at a reduction of the devastation caused by Witches' Broom disease of cocoa due to the pathogen Crinipellis perniciosa (Stahel) Singer.

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et de la Confiserie
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REPORT OF THE 5TH IWBP WORKSHOP

3rd - 10th November 1988

Held at:	Asa Wright Nature Centre Arima Trinidad West Indies
Hosts:	Cocoa Research Unit University of West Indies and IOCCC

Report published:	December 1988
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C O N T E N T S

APPENDICES

1. INTRODUCTION TO IWBP

Almost one-third of the world supply of cocoa is produced in the Americas but in many countries maximum production is severely curtailed by Witches' Broom (WB) disease. It occurs in the upper Amazon region of Brazil, in Bolivia, Colombia, Ecuador, Grenada, Guyana, Peru, Surinam, Trinidad and Venezuela. This widespread distribution also places at risk other areas where it is not yet present, such as Bahia, Brazil - the second largest concentration of cocoa plantings in the world - or proposed new plantings of cocoa such as in Amazonia, Brazil. In the Brazilian Amazon pod losses have reached 95 per cent on occasions, and almost all infected pods are a total economic loss. Moreover, there is NO assurance that its absence from cocoa producing countries outside the Americas will continue.

These features make a co-ordinated, multi-centre, multi-national research program on WB a top priority and so a project proposal was formulated by scientists in countries where the disease is important. The pathogen (Crinipellis perniciosa) causes overdevelopment of cocoa meristematic tissues leading to hypertrophied and proliferated growth, to give the characteristic Witches' Brooms (Escoba de Bruja/Vassoura-de-Bruxa/Balai de Sorciere). It also infects many pods. Infected pods fail to ripen and the beans either become liquified or adhere to the pod husk and are commercially valueless. In view of this serious threat, the International Office of Cocoa, Chocolate and Sugar Confectionery (IOCCC) with some other International Donor Agencies are funding a US $ 700,000 multinational research project over a period of about 5 years from 1st July 1985. The objective of the Project is "to develop an economic management system to control Witches' Broom disease of cocoa in a number of cocoa growing environments".

It is also appropriate to record at this point the very generous assistance to IWBP from the governments of these countries in Latin America and the Caribbean where IWBP sites are in operation. Significant assistance in terms of facilities, transport and personnel are being provided by the Governments of Brazil (CEPLAC), Colombia (ICA), Ecuador (INIAP), Grenada (CRP), Trinidad (CRU) and Venezuela (FONAIAP). This assistance is very much appreciated and without it the Project could not operate. Financial assistance from the Science and Technology for Development Fund (STD) of the European Community through DGXII, from UK Overseas Development Administration and Canadian International Development Association (CIDA) is also greatly appreciated and is acknowledged with gratitude.

In early July 1985 participants in IWBP met at Pichilingue, Ecuador, for the 1st IWBP Workshop to develop a major research programme on the epidemiology of Crinipellis perniciosa and the decisions on this were published in October 1985 in the 'Report of the 1st IWBP Workshop'. The data collection of the experiments to investigate the epidemiology are now completed in eight sites in four countries and are drawing to a close at two more sites affected by the disease and two where the disease is not present.

It was considered important to start to consider the evaluation of candidate chemicals for disease control and a preliminary discussion was held at the 2nd IWBP Workshop held in Wageningen, Holland in October 1985. This discussion was published in the 'Report of the 2nd IWBP Workshop'.

The 3rd IWBP Workshop was held at Granja Luker, owned by Chocolateria Luker and situated near Manizales in Colombia from 7-12th July 1987. The experimental

Protocol for the 'Comparative Epidemiology Experiment' (agreed in July 1985) was carefully and extensively reviewed at this Workshop and amended as necessary. An experimental Protocol for recording climatic data at two sites were Witches' Broom disease is presently absent was also developed and data recording at these sites started in mid-1987. Guidelines for conduct of Inoculum and/or Gradient Experiments and for Chemical Evaluations were drawn up at the 4th IWBP Workshop held in Belem, Brazil.

Copies of all these reports are available free of charge from Dr van Kan, Director General, IOCCC, Avenue de Cortenbergh 172, Brussels, 1040, Belgium.

2. NARRATIVE REPORT OF 5TH IWBP WORKSHOP

2.1 OPENING SESSION

Participants arrived in Trinidad on Thursday 3rd November 1988. The 5th IWBP was held at the spectacular Asa Wright Nature Centre, Arima, Trinidad which is an abandoned cocoa estate now converted into a beautiful naturalists centre. A brief description of the Centre is included as Appendix C to this report. All participants would commend the Centre to colleagues and friends. The names, addresses, telephone, telex and telefax numbers (where applicable) of all the participants are included as Appendix A to this report. Secretarial and organisational support was kindly provided by the Cocoa Research Unit, University of the West Indies.

The 5th IWBP Workshop started at 0830 hours on Friday 4th November 1988 with a welcome from Senator John Spence - the Chairman of the Cocoa Research Advisory Committee which directs the work of the Cocoa Research Unit at the University of the West Indies. He spoke as follows:

"Mr Chairman, Distinguished Participants.

My simple task this morning is to bid you welcome to Trinidad and Tobago and to this 5th IWBP Workshop.

As you are all aware Trinidad and Tobago has had a long tradition of cocoa research and has made many important contributions, including early work on witches' broom. Therefore, it is entirely appropriate and, particularly so at this particular time, that you should hold your Workshop here. I say at this particular time, since within recent years the Cocoa Research Unit has, as with all scientific institutions, gone through periods of uncertainty as to its future. However, within the last two to three years a sound basis for its long term activities has been established by way of its recognition as one of two world centres for conservation of cocoa germplasm, such recognition being officially endorsed by the International Board for Plant Genetic Resources. At this point, I want to pay public tribute to the work of Dr Tony Kennedy, who in his very unassuming style has ensured a solid foundation on which others may build. Regretfully Dr Kennedy will be leaving the Unit shortly but fortunately he will be in Barbados, only 35 minutes away by plane, and so I am sure will continue to take an active interest in the Unit.

At a personal level I am glad to see the involvement of an old

friend from Bristol University, Dr Bryan Wheeler, in your activities. It is just about 40 years ago in 1948 when I entered Bristol University as an undergraduate, and Dr Wheeler was then in post-graduate studies under Dr Lilian Hawker. Subsequently, in 1958 I returned to Bristol University and worked for my PhD also under Dr Lilian Hawke and strange as it may seem I worked on a disease of cocoa - however that was black pod disease not witches' broom. This background does cause me to note that your Workshop is discussing Epidemiology and Breeding for Resistance, but I looked in vain for discussion on resistance mechanisms as an aid to the breeders. Perhaps this topic will be addressed in the future.

May I say on behalf the Cocoa Research Unit that we will be very happy to assist (or to continue to assist) in any way if plant material needs to be sent to centres abroad. In my own studies on black pod, conducted in the UK, I had pods shipped to me by air from the Unit here.

As Chairman of the Cocoa Research Advisory Committee of CRU, I want to solicit the aid of all present in the campaign which the Cocoa Research Unit is about to launch to obtain secure long term funding. As you are perhaps aware, the present generous funding from EEC continues to the end of 1989 though we may, with their permission, stretch this into 1990. The Government of Trinidad and Tobago must be given full credit for its support over the years which is now out of all proportion to the reduced size of cocoa production in this country. The Biscuit, Cake, Chocolate and Confectionery Alliance of the UK must also be given credit for its support over the years. If the germplasm which your group, and others like you, will need in the future is to be preserved then we need long term funding and we can only get this by the support of scientists involved in cocoa research who will appreciate the value of the collection.

In closing Mr Chairman may I give a more general welcome to Trinidad and Tobago. You have come at a time when we are discussing our tourism thrust. What kind of tourists should we attract; should we have casinos or not, and so on. Next Tuesday afternoon in the Senate it will be my responsibility to make some comments on these issues. It is my conviction that this Workshop and these surroundings at Asa Wright are just the sort of activity that we should promote on an ever increasing scale to attract the kind of visitor to our shores who will give us as much or more than he or she gets from us. Therefore, so I would ask two things of you (1) please say to us how we may improve our arrangements to make them as attractive as possible for you and (2) please spread the word of Trinidad and Tobago as a suitable venue for scientific conferences and as an attraction for those interested in natural history.

I hope that you will have a successful Workshop but will also have some time to enjoy being in Trinidad and Tobago."

There followed an address from Dr Hermann Flotzinger (President of the International Office of Cocoa, Chocolate and Sugar Confectionery, IOCCC),

which was delivered by Tony Lass (Executive Chairman, IWBP) on his behalf. This address was as follows:

> "I am once again sorry not to be present in person at this 5th IWBP Workshop which is perhaps the most important one yet held within IWBP and is being held at the Asa Wright Nature Centre in Trinidad - a scenic and interesting naturalists' environment. I am sure that you will all enjoy your stay there.
>
> As President of IOCCC I extend my fraternal greetings to all participants in the 5th Workshop of the International Witches Broom Project. As you know the member trade associations of the International Office of Cocoa, Chocolate and Sugar Confectionery have guaranteed a not inconsiderable sum of money to the work of IWBP over a five-year period from 1st July 1985. It is now November 1988 which means that IWBP has already run for 3 years and three months and thus only one year and nine months now remain to produce the economic management system for the disease. Time is now short and I am sure that the remaining 21 months of IWBP will pass very quickly. It is for that reason that I said earlier that this 5th Workshop is perhaps the most important of all, because the data analysis must be completed efficiently so that we can start to translate the conclusions from this into recommendations for cultural practices.
>
> The data so far collected is most impressive but time is not on our side and so I wish you great success in your deliberations in the coming week. These Workshops continue to play a very important role in fostering the excellent cooperation between all the participants in IWBP despite the cultural and language barriers. The members of IOCCC think that IWBP can be considered to be a model for future international cooperative ventures in agricultural research. We are proud to be associated with it.
>
> I wish you all well and close this brief address in the hope that you have a very successful Workshop leading to concrete advances in our understanding of this devastating cocoa pathogen. Good Luck."

The Chairman of the Project Scientific Committee of IWBP, Dr Hank Purdy then welcomed participants to the 5th IWBP Workshop as follows:

> "I am very pleased to welcome you to the 5th Workshop of IWBP on behalf of the Project Scientific Committee. Much progress has been made during the life of the project and there are expectations that the pace of accomplishment will continue.
>
> In October 1988 I reported to the Project Management Committee of IWBP about the scientific progress that has been made. I presented a discussion of selected data from the Comparative Epidemiology Experiment that was based on a preliminary analyses of some of the data by the Project Liaison Officer, Dr S A Rudgard. I believe that the individuals at the meeting are well aware of the tremendous amount of information you all have collected - often under difficult circumstances.

I informed that meeting of our chemical evaluation activity and mentioned, with emphasis the Comparative Phytosanitation Experiment and the disease and gradient experiments. I left that meeting with a comfortable feeling that those responsible in IOCCC feel that their funds are yielding excellent information. I feel strongly that that is exactly what their investment is returning to the cocoa world - new knowledge about witches' broom that will, I am certain, support better management of cocoa in the presence of this very damaging disease.

I look forward to the next week during which we will exchange much outstanding information."

2.2 Adoption of Objectives and Programme for the 5th IWBP Workshop

The Objectives of 5th IWBP Workshop were fully discussed and adopted as follows:

"Objectives of 5th IWBP Workshop

1. To report on the results and analysis from individual sites of the "Comparative Epidemiology Experiment", by country;

2. To report on the comparative analysis of the "Comparative Epidemiology Experiment";

3. To define detailed objectives of, and methodology for, the analysis of the data arising from the "Comparative Epidemiology Experiment";

4. To report on results and progress of the "Comparative Phytosanitation Experiment", by country;

5. To discuss the "Comparative Phytosanitation Experiment" by discussion on Protocol 2;

6. To report on results and progress of gradient studies;

7. To discuss exact layout of IWBP Monograph to include the above mentioned experiments;

8. To report on results and progress of chemical evaluations;

9. To elaborate a workplan for future chemical studies;

10. To discuss resistance breeding and selection;

11. To discuss other work that may be associated with or related to the activities in IWBP;

12. To consider the quarantine implications of the movement of cocoa planting material and of dry cocoa beans;

13. To discuss the future direction of IWBP in relation to long-term IWBP expectations by participating institution".

2.3 The Objective of IWBP

This was restated by Tony Lass as follows:

"TO DEVELOP AN ECONOMIC MANAGEMENT SYSTEM TO CONTROL WITCHES' BROOM DISEASE OF COCOA IN A NUMBER OF COCOA GROWING ENVIRONMENTS."

To achieve this a number of subsidiary objectives have been previously established as follows:

1. "TO STUDY SYSTEMATICALLY INFECTION DYNAMICS OF WITCHES' BROOM DISEASE RELATIVE TO TIME (BOTH SEASONS AND YEARS) WITH RESPECT TO THE CRITICAL ENVIRONMENTAL FACTORS."

   [To achieve this the Comparative Epidemiology Experiment has been set up].

2. "TO EXAMINE AND EVALUATE THE REACTION OF THE PATHOGEN TO AVAILABLE SYSTEMIC, PROTECTIVE AND ERADICATIVE FUNGICIDES INCLUDING THE APPLICATION TO THE SOIL AND THE EFFECT ON BASIDIOCARP DEVELOPMENT OF BROOMS SPRAYED WHEN GREEN."

   [To achieve this experimental guidelines have been drawn up and a number of chemicals are being studied though not always using funds from IWBP sources].

3. TO EXAMINE INOCULUM AND/OR DISEASE GRADIENT EXPERIMENTS"

   [To achieve this experimental guidelines were drawn up at the 3rd IWBP Workshop and will be reported on at the present meeting].

4. "TO EXAMINE AND EVALUATE PHYTOSANITARY PRACTICES AND THEIR IMPACT ON WITCHES' BROOM DISEASE".

   [To achieve this on experimental guidelines for phytosanitary studies was developed at the 4th IWBP Workshop].

During the operation of the first three years of IWBP and in particular the discussion at the 4th IWBP, the need to breed planting material resistant to the disease was reinforced. With this in mind, a fifth subsidiary objective has been added as follows:

"5. TO DEVELOP AN APPROPRIATE STRATEGY FOR BREEDING PLANTING MATERIAL RESISTANT TO WITCHES' BROOM DISEASE AND PREPARE A PROJECT PROPOSAL FOR SUBMISSION TO ANOTHER INTERNATIONAL DONOR AGENCY FOR CONSIDERATION FOR FUNDING".

With these objectives in mind a 'Resistance Breeding Project' was drawn up and submitted to ICCO for consideration for funding. Unfortunately, this donor was unable to respond favourably but this in now ay devalued the importance of this initiative.

3. COMPARATIVE EPIDEMIOLOGY EXPERIMENT'

3.1 Status Reports on Individual Sites in the 'Comparative Epidemiology Experiment

TABLE 1: Data sets available for Comparative Epidemiology Experiment

Country	1985		1986			1987				1988				1989		
Site	Sep	Dec	Mar	Jun	Sep	Dec	Mar	Jun	Sep	Dec	Mar	Jun	Sep	Dec	Mar	Jun	Sep
Brazil																	
Altamira	----	----	----	----	----	----											
Tome Acu	----	----	----	----	----	----											
Ouro Preto				----	----	----	----	----	----	----							
Bahia+*							----	----	----	----	----	----	----	----			
Colombia																	
Llanos				----	----	----	----	----	----	----							
Manizales			----	----	----	----	----	----	----	----							
Santander+*							----	----	----	----	----	----	----	----			
Ecuador																	
Station			----	----	----	----	----	----	----	----	----						
Farm				----	----	----	----	----	----	----	----						
Grenada																	
Mt.Horne+									----	----	----	----	----	----	----	----	----
Trinidad																	
Santa Cruz			----	----	----	----	----	----	----	----							
Venezuela																	
El Pinal+									----	----	----	----	----	----	----	----	----

\+ : Sites not to be included in first phase of data analysis
* : Sites where witches' broom is absent

Reports from individual sites were made as follows:

Trinidad: Steve Mohan

Data were presented for 1986, 1987 and part of 1988. Most basidiocarps formed on brooms in the tree, those suspended higher in the canopy being more productive than the lower ones. Small numbers of basidiocarps were produced on cushions, few on suspended pods but none on brooms or pods on the ground, probably because of the unfavourable microclimate. Observations indicated that 'new' brooms required about 13 weeks rainfall before basidiocarps were initiated, 'old' (2nd year brooms) only required about 6 weeks.

In 1986, the dry season extended from week 1 to approximately week 20. Vegetative flushing reached a peak about week 25, cushions about week 37. Pod set occurred mainly between weeks 33 and 51. In 1987, the weather followed a basically similar pattern. Vegetative flushing and basidiocarp

production were not well synchronized and this might account for the relatively low vegetative infection in both years, with averages of 14 and 10 brooms/tree in 1986 and 1987 respectively. In contrast, pods were developing when basidiocarps were produced and pod infection was relatively high, the percentages with witches' broom (from 50 trees) being 39.2 and 28.6 for 1986 and 1987 respectively. The corresponding figures for pod loss due to Phytophthora were 10% and 16.7% in those years.

There were some differences between the two clones in the planting, generally TSH 919 appeared more susceptible to cushion infection than TSH 1188, but flushing and flowering patterns of trees of the same clone were highly correlated.

Colombia: Fabio Aranzazu

Data were presented from the two sites covering periods from week 14, 1986 to week 26, 1988 at Manizales and from week 27, 1986 to week 26, 1988.

At Manizales the trees are clonal, Colombian Selection 6, which yields high quality cocoa but is very susceptible to witches' broom. Rain occurs throughout the year though basically there are two periods when there are many rain-days each followed by periods (in January/February and July) of less rain. The numbers of basidiocarps produced show corresponding fluctuations, but some are present at most times during the year.

At the Llanos site the planting is a mixture of hybrids. Here, there is a distinct dry period (January to March) and a corresponding break in basidiocarp production. At both sites most basidiocarps were produced on infected parts attached to trees though within this category suspended pods contributed rather little. Substantial numbers of basidiocarps formed on ground brooms especially at Llanos, but generally at this site the brooms rotted more quickly than at Manizales because of the intense rain.

At Manizales there was a well-defined flush in each 3 month period, except the last quarter of the year. Each flush peak corresponded with a period of less rain and thus fewer basidiocarps. The number of flush infections was relatively small but the association with flushing was well marked. In contrast, at Llanos, the pattern of flushing itself was less clear. There was an intense flush in the first period of the year, at the end of the dry period but subsequently flushing was sporadic. No pattern was discernable in the vegetative infections of which, as at Manizales, there were relatively few.

Many cushions became active on trees immediately after the establishment of the Manizales site but, although peaks would be discerned, flowering subsequently tailed off, perhaps due to lack of cultural management. There were normally two well-defined peaks of flush infections per year, the first peak in 1987 being particularly high. This contrasted with Llanos where it was difficult to discern a pattern in cushion infection.

Pod set at Manizales was well defined with the highest peaks during drier periods so that pod development occurred during the wet season when inoculum was available. This gave rise to 6-monthly peaks in infected pods preceding pod harvest. At Llanos there was one main period of fruit set per year, the pod harvest was poor and the incidence of infected pods was highest towards the end of the year.

Venezuela: Ramon Acuna

Data were presented from week 32, 1987 to week 44, 1988. Rain from week 32 to December 1987 was followed by a dry period to April/May 1988 and then a further period of rain. Present data indicate a lower rainfall in 1987 than 1988. Production of basidiocarps corresponded with periods of rain with peaks around weeks 42 and 34 in 1987 and 1988 respectively. Despite the lower rainfall, the indications are that the number of basidiocarps formed in 1987 are likely to be higher than in 1988.

There were two successive peaks of vegetative flushes during the rainy period in 1987 with a third flush extending into the dry period. Generally the number of flush infections was related to the intensity of flushing. There was little cushion infection probably because the main peak in flowering occurs at the beginning of the rainy period before basidiocarp production is really established. The trees at the site are also self-compatible and the flowering period is fairly limited. There has been a large peak in the number of pods with witches' broom in 1988, the numbers exceeding healthy pods.

During 1988, some comparisons have been made of temperatures and relative humidities within the canopy and those from the nearest meteorological station.

Ecuador: Alan Maddison

Data were presented covering three wet seasons at the Station site and two wet seasons at the Farm site. Generally, basidiocarp production was associated with rain periods but there was variation between years at each site and in relation to the material used. At the Station site in 1986 most basidiocarps formed on suspended brooms with similar numbers on the two sets. Some basidiocarps were produced on cushion brooms and on pruned brooms on the ground but very few basidiocarps formed on other material. Generally in 1987 lower values were obtained but again some basidiocarps formed on cushions as well as vegetative parts. Cushions and brooms on the ground also contributed significantly to basidiocarp numbers in 1988 when the month of March was the dryest on record. Similar data were obtained from the Farm site but with less production from the material on the ground. In both 1987 and 1988, cushion brooms were more productive than suspended vegetative brooms; in 1988 production was generally lower in this site, the reason for which is not clear.

At the Station site, there were separate peaks of flushing during the rainy season. In 1987 the first basidiocarps apparently resulted in little infection during the first flush peak but infection was well marked at the second peak. Flushing at the Farm site was almost continuous during 1987 but there was a more rhythmic pattern in 1988. During 1986 some mist periods seemed to induce basidiocarps but these were not associated with infections. In 1987 there was a general association between basidiocarp production and infection but it was difficult to see the details of this association in terms of the amount of infection.

Some flowering occurred at the Station site at most times though there were peaks in the last quarter of one year to the first quarter of the next. Symptoms of infection subsequently developed over a long period, from weeks 9 to 7. Flowering at the Farm site was similar though more flowers were

produced. The appearance of symptoms was haphazard.

Fruit was harvested every 2 weeks and the incidence of Moniliophthora within both sites was high. For example, in 1988, the percentages of pods with Moniliophthora were 33.7 and 16.8 for the Station and Farm sites respectively. In the same year, 22.5% pods at the Station site and 34.2% at the Farm site were affected by witches' broom. Generally few pods were infected by Phytophthora, less than 1% at the Station site, about 5% at the Farm site.

Some analyses of the data have been attempted. A significant regression ($r = 0.86$, $P < 0.01$) was obtained between basidiocarp production during wet periods and the incidence of witches' broom on fruit 12 weeks later. Also, the importance of early, small numbers of basidiocarps in relation to fruit infection at the Farm site has been examined.

Further work at the farm site near Pichilingue examined the relationship between the presence of directly observed surface wetness on various parts of cocoa trees and recordings of wetness taken using two types of artificial wetness sensor. This is more fully described in section 10.2 (page 30).

Grenada: Charles Williams

The site was initiated in August 1987 in the east part of the island. It consists of sixty-four 30-year-old clonal trees of ICS origin. There has been no analysis as yet of the first year's data but some general observations can be made. Most basidiocarps formed on brooms suspended in the canopy, the amounts on the two sets of brooms being similar though with a tendency for more to be produced on brooms at the top of the canopy. Very few basidiocarps were produced on ground brooms. Infection occurred mainly at cushions with 30-40% showing dead flowers, star blooms or infected pods. Flush infection was low with only axillary brooms formed. Only 2% of the harvested pods had symptoms of witches' broom (compared with 16% infected by Phytophthora), probably because most of the pod development was outside the rainy season.

Itabuna, Brazil: Stephen Rudgard

Data were presented from week 22, 1987 to week 24, 1988. Rain was evenly spread throughout this period in moderate to small quantities, the maximum weekly total being 110 mm. Rain was recorded on almost half the days in the year, although amounts of rain per event were small.

Temperatures were generally higher for both maxima and minima during the period November to June (week 45-22). The cooler period in July/August is the normal period for Phytophthora epidemics on pods. Relative humidity was remarkably uniform throughout the year.

One large vegetative flush was recorded in August (week 34) during the cooler period, and two smaller flushes occurred in December and February/March. The large flush may have been due to the rising temperature after the period of rest during the coolest weeks, 28-30. Flowering increased from October, remained high until March, before decreasing to a minimum in June. Pod set occurred throughout the flowering period from November onwards.

Brazil: Teklu Andebrhan

Data for Altamira and Tome Acu were almost all collected before the 4th IWBP and were included in the presentation there but a few features can be emphasized or added. At both sites most basidiocarps were produced on vegetative brooms; cushion brooms and pods contributed little. Pruned brooms on the ground contributed significantly to the inoculum at Altamira (about 10, 9 and 17% of the total basidiocarps in the 3 sets) but not at Tome Acu (about 4% of the basidiocarps produced in the first year but none in other years). At Altamira most basidiocarps (67.5, 51.5 and 66.9% in the 3 sets) formed during weeks 13 to 21. At Tome Acu most basidiocarps (90.5, 70.5 and 41.8 in the 3 sets) formed during weeks 9 to 23 but here the second year brooms (i.e. second set of brooms) were not so productive.

Temperatures at Altamira were between 20 and 25°C for 59% of the time and at Tome Acu for 43% of the time. In 1987, there was less rain at both sites and its duration was less. There was flush activity throughout the year at Altamira where insect attack reduced shade; Tome Acu was very different, with two periods of inoculum production and two corresponding periods of infection.

Analysis of the data for 1986 and 1987 indicated that at both sites there were differences in infection in the two years. At Altamira differences in infection between trees were also highly significant but not at Tome Acu. Similar comparisons have been made of flush activity.

3.2 Concepts of Analysis of Data from the 'Comparative Epidemiology Experiment'

The concepts involved in the analysis were first introduced by Bob Schmidt. This analysis would be concerned essentially with an overview of data from all 9 sites which for 2 years could give 18 data points. But while it would deal mainly at this level, as much analysis as possible of data at each individual site was to be encouraged.

Some ideas of how comparisons might be made using data from all sites were then indicated using tables summarizing basidiocarp production in 1986. For example, interesting points emerge when such data are tabulated by source : the overall production of basidiocarps per object was 6.3, most basidiocarps were produced on brooms in the canopy, the mean number per site being 10.6, and the Pichilingue Farm site had the lowest basidiocarp production. While the mean value for basidiocarps on ground brooms over all sites was low, these were important sources at Manizales, Llanos, Pichilingue (Station site) and Altamira. The reasons for this should be examined, perhaps initially using data for rain.

Other comparisons over the 2-3 years might involve the productivity of particular objects, e.g. brooms suspended at the top of the canopy, the start and finish of basidiocarp production and its duration. Such comparisons even for the data available now indicate similarities at individual sites in the timing of basidiocarp production and the considerable duration of inoculum at some sites, e.g. 48 weeks at Manizales in 1986.

From this first-stage analysis, relationships can be examined using regression analysis. Some of this second-stage analysis could generate information useful for purposes other than plant disease epidemiology.

The Project Liaison Officer then indicated some of the methods he had tried over the last 6 months, in conjunction with people at the various sites and in Florida, to examine infection in relation to phenology. Essentially, these involved two stages, the construction of tables and the examination of relationships using regression analysis. As Bob Schmidt indicated, tabulating data itself revealed interesting information. For example, such data for vegetative infection showed that the % flush exposed to inoculum varied considerably between sites : Tome Acu 48; Altamira 60; Pichilingue (Station) 52; Pichilingue (Farm) 49; Manizales 36 and Trinidad 13. It is then possible to calculate the number of flushes per terminal bud during the inoculum period to give a useful index for site to site comparisons. Relationships can then be examined, for example between infections per 100 buds and flushes per bud at Pichilingue Farm Site and similarly in relation to sites. Graphs of these particular relationships were presented.

Further examples were given in respect of cushion infection and pod infection and the results of these preliminary analyses were also presented.

Discussion on the concepts and methods generated the guidelines which are presented below.

3.3 Guidelines for the Analysis of Data from the 'Comparative Epidemiology Experiment'

These guidelines relate to Protocol 1.

1. Passport Data

Include for each site its 'history' during the Comparative Epidemiology Experiment, that is information regarding practices during the Experiment. Indicate location and extent of nearby cocoa, within a 500m radius from the middle of the plot through 360°.

2. Inoculum Production

For each set in each year:

- Total number of basidiocarps
- Total weeks active; start and finish
- % Active objects
- Mean number basidiocarps per object
- Mean number basidiocarps per object per week
- Mean number active weeks per object

3. Phenology

a. Flushing

- Cumulative total active points per tree per year
  - exposed to inoculum
  - not exposed to inoculum

- Number of terminal buds

- Calculate ratio of number of active points to number of buds to give index for comparing sites

b. Flowering

- Total flowers per tree per year
  - exposed to inoculum
  - not exposed to inoculum

- Number of active cushions
- Number of cushions with open flowers
- Determine correlation between these last two parameters. If significant then calculate -

  Cumulative total active cushions exposed to inoculum
  Cumulative total active cushions not exposed to inoculum

Relate these values to total number of cushions available.

c. Fruit

- Total number harvested per year in following categories : ripe healthy; witches' broom (WB); Moniliophthora (Mon); Phytophthora (Phyt); WB + Mon + Phyt; Others.

- Calculate mean numbers per tree for 10-tree and 50-(90-) tree samples and mean numbers in successive 50-cm heights for the 10-sample trees.

- Number of developing pods (< 12 weeks old) inside branch units
  - exposed to inoculum
  - not exposed to inoculum

4. Infection

- For flushing and flowering total number of each infection type per tree per year. (Each of these could be converted into an index or percentage).

- Total number of fruit infections (See 3c).

5. Meteorology

For inoculum period:
- rain
- temperature
- relative humidity
- wetness

Compare these by correlation analysis (to reduce number).

When the above data have been assembled for the 9 sites and 2 or 3 years, interactions can be determined by regression analysis using in turn as dependent variables parameters of basidiocarp production, infection and phenology with, initially, parameters of climate as independent variables.

Some of the above methods for data handling could also be appropriate for analysis of individual site data. Particular relationships established at any one site might be relevant to the Comparative analysis and should be brought to the attention of the Data Management and Monograph Committee, as appropriate.

3.4 Symptom Document

The symptom document, now in English, French, Spanish and Portuguese is in final draft. Photographs have English captions in the text but captions are given in the four languages at the end of the text.

This document will be published as a Special Issue of the Cocoa Growers' Bulletin sometime during 1989.

Descriptions of symptoms in Spanish and Portuguese were left for checking by participants at the Workshop.

4. INOCULUM/DISEASE GRADIENT EXPERIMENTS

4.1 Introduction

Guidelines for an inoculum/disease gradient experiment were developed and adopted during the 3rd IWBP Workshop held in Manizales, Colombia in July 1986. One experiment was conducted in Pichilingue, Ecuador during 1986 and 1987, and a summary of the results was included in the report of the 4th IWBP Workshop in Belem, Brazil in October 1987. A further experiment was conducted in Manaus in 1988.

4.2 Summary of Results of Inoculum/Disease Gradient Experiments

The results of disease/infection studies in 1988 at the Rio Negro Station near Manaus, Brazil were presented by Teklu Andebrhan. The methods followed the established Guidelines with the addition of several extra procedures. The source was composed of 4000 brooms attached at various heights on two poles 20m apart. There were five experiments; during which all the brooms were first placed on the ground, and finally split in to four strings of 1000 brooms with one placed at each height. Trap plants were placed at 1, 10, 20, 40, 80, 160 and 320m, away from the source, with the 100 seedlings at each distance split in to groups of 25 placed at 0, 1, 2 and 3m above the ground. The brooms and the seedling groups were covered with mesh to give 50% shade. The whole experimental area was set in a clearing in primary forest 30m wide by 400m long, more than 300m through forest from any other cocoa.

Exposure time during the five experiments was not the same and recordings were made of the number of basidiocarps formed each day on 400 (10%) of the brooms in the source. The numbers formed with the brooms at 0m, 1m, 2m, 3m and all heights were 3300 over 6 days, 6218 over 8 days, 5618 over 9 days, 2829 over 4 days, 6218 over 8 days, 5618 over 9 days, 2829 over 4 days and 3566 over 6 days respectively.

The position of the brooms was most important and percentage infection of seedlings at the source (1m) in the five experiments was 15%, 35%, 40%, 30% and 40% respectively. Dispersal was less efficient with inoculum sources placed on the ground.

Data from percentage infection at the different distances from the source and height from the ground at each distance had not yet been transformed to logarithmic values nor had Gregory's multiple infection index been applied. This was to be completed as soon as possible as the data had only recently been assembled. Differences in infection at the four heights at each distance were statistically significant in some cases. It is particularly notable that a significant number of plants became infected at 320m from the source in all experiments.

5. 'COMPARATIVE PHYTOSANITATION EXPERIMENT'

5.1 Overall Status of the 'Comparative Phytosanitation Experiment'

The objective and philosophy of phytosanitation studies within IWBP were discussed at the 4th IWBP Workshop in Belem, Brazil in October 1987. These were presented in the Report of the Workshop, together with the text of Protocol 2 for the 'Comparative Phytosanitation Experiment'. Section 6.4 of that Report detailed "Action to be taken", and following these ideas six sites were successfully set up between September 1987 and July 1988. The operation time at each site is shown in Figure 2, and the final completion date in the experiment will be March 1990. There is one site not shown that was installed at the Palma Chavez site on Pichilingue Station in Ecuador before Protocol 2 was established. It was treated as a pilot site, experience gained from it was essential to the design of the 'Comparative Phytosanitation Experiment'. Two full years data are already available from Palma Chavez, as is reported in Section 5.2 under Individual sites. Data have been sent to the UK covering the calibration period at most sites, and records are being submitted quarterly as for the 'Comparative Epidemiology Experiment'.

TABLE 2: DATA SETS AVAILABLE FOR 'COMPARATIVE PHYTOSANITATION EXPERIMENT'

Site	1987		1988				1989				
	Sep	Dec	Mar	Jun	Sep	Dec	Mar	Jun	Sep	Dec	Mar
Brazil											
Altamira	----------										
Ouro Preto	----------										
Colombia											
Llanos			----------								
Manizales			----------								
Ecuador											
Naranjal		----------									
Venezuela											
Tachira				----------							

5.2 Status Reports on Individual Sites in the 'Comparative Phytosanitation Experiment

Ecuador: Alan Maddison

Experiments at two sites, Palma Chavez and Naranjal, were described.

The experiment at Palma Chavez does not match the requirements of Protocol 2 but follows some of its general principles. The site is about 250m away from other cocoa and consists of 8 rows of trees as inoculum source (Area A) and 17 rows in which brooms were removed (Area B). There were difficulties in starting the experiment in 1986. The outcome was that the number of brooms removed per row of Area B was not determined, but weight per row was recorded. Many passes were made over Area B in an attempt to get it 'clean' but when counts were later made it was clear that this had not been achieved.

Pod harvests in 1987, indicated that there was a difference in production from one end of the plot to the other. In Area B the overall incidence of witches' broom was 12.4% with Moniliophthora at 24.2%. There appeared to be more Moniliophthora where brooms had been removed. Within Area B, the incidence of witches' broom did not appear to decline from the source in Area A.

During 1988, for which data to week 34 are available, pods infected with Moniliophthora (and swollen fruits) have been removed each week. This has reduced the level of Moniliophthora in Area B but the amount of witches' broom in each row is similar with no evidence of a decline in incidence from the source in Area A.

The data have also been re-examined on the basis of shorter (5 week) periods of harvest, but while gradients are apparent in some of these periods, they are not in others. Attempts have also been made to adjust data from each row, using row 9 (the first row in Area B) as a reference to account for the initial differences in infection. When these adjustments are made there appears to be some decline in cushion brooms with row number but not for fruits.

The site at Naranjal in southern Ecuador, where witches' broom is generally considered to be less severe, follows Protocol 2. The planting is of 10-year old hybrid cocoa, tall (4-9m) trees at 3 x 3m spacing with Erythrina shade trees, and is surrounded by bananas or pasture. There are 35 rows in Area B. The experiment started in week 12, 1988 and data are available so far to week 32 for pod production. There is considerable row-to-row variation with about equal amounts (20%) of witches' broom and Moniliophthora. The number of vegetative brooms is small especially at the end of Area B.

Colombia: Fabio Aranzazu

Data for 6 months pod harvest and broom counts from two sites, Manizales and Llanos, were presented.

The planting at Manizales is of the clone SC6 with 10 rows in Area A (source of inoculum) and 35 rows in Area B ('clean' area), but infections with Rosellinia have resulted in circular open patches with no trees. At

the Llanos site Area B has been divided into two sections, one (B1) with rows of 10 trees has brooms removed only, the other (B2) has chemical treatments superimposed on broom removal.

At the Manizales site the production of basidiocarps on 'productive' brooms and brooms collected at random was similar. No basidiocarps were produced on green brooms which formed a treatment additional to Protocol 2. Results from the Llanos site were similar except that basidiocarps formed on green brooms from week 20, with numbers increasing substantially by week 25.

Counts of brooms removed from 6 trees per row in Area B at the start of the two experiments showed that at Manizales there were many more cushion brooms than vegetative brooms with an overall average of about 50 cushion brooms per tree compared to about 15 vegetative brooms per tree. In contrast, at Llanos there were approximately equal numbers of cushion and vegetative brooms but fewer than at Manizales.

A pod harvest in January 1988 (a month before the experiment properly commenced and before the broom removal count), indicated that the relative amounts of ripe pods and those affected by witches' broom and Moniliopthora in Areas A and B at Manizales were similar. However, at Llanos there was a high proportion of pods infected with Phytophthora especially in Area B.

Data for pods harvested during February to June at both sites were presented but no conclusion can be drawn since the harvest of pods coming within the time scale of the experiment is only just beginning. Some further analysis of the broom removal data at both sites has been attempted.

Venezuela: Ramon Acuna

Some time was lost in initiating an experiment because the farm originally chosen was sold, but data are now available from the established site from week 39, 1988. The planting is over 500m from any other cocoa and 10 rows on one side of the experiment and 5 rows on the other side are being cleared of brooms. Data on the site include heights of the trees and soil analysis. Pods have been harvested every 2 weeks from week 39 and so far basidiocarps have been counted for one month.

5.3 Amendments to Protocol 2 for the 'Comparative Phytosanitation Experiment'

The following amendments to Protocol 2 were adopted:

Amendment 1 — In 6.3.1a, substitute 'preferably' for 'preferable' and insert 'through' between 'axis' and 'area A and B'.

Amendment 2 — In 6.3.4a insert the following after 'In area B':
'and in any cocoa contiguous with it (except Area A)';

Amendment 3 — In 6.3.5b delete the third paragraph and substitute the following:
'Immediately following the removal in month 15, 20 trees randomly chosen from those on which removal counts were made within area B, 10 trees to a limit of 250m within each planting which borders a side of area B and two trees of the 10 marked trees within area A are inspected branch by branch

and the remaining infections counted. If broom counts in plantings contiguous with area B exceed those within area B, then a further broom removal should be made in these plantings. Infections are classified within the categories used in Protocol 1A for flush and flower data sets;'

Amendment 4 In 6.3.5c delete 'in each calendar month' and insert 'every 2 weeks';

5.4 Action to be taken on 'Comparative Phytosanitation Experiment'

Pruning tools from Europe and the USA will be provided to all interested participating countries for field evaluation as soon as possible.

6. EXPERIMENTS ON CHEMICAL EVALUATION

6.1 Introduction

Guidelines for chemical evaluation were included in the Report of the 3rd IWBP Workshop in Manizales, Colombia, and a list of Amendments to the Guidelines in the Report of the 4th IWBP Workshop in Belem, Brazil. The first chemical trials were conducted in 1986/87, and results presented in September 1987 in Belem. Several trials were in progress at that time, and results were available in time for discussion at the 5th IWBP Workshop. Summaries of the work are included here with outlines of trials that were unfinished or due to start before July 1989. It is felt appropriate to communicate such summaries as this information is not yet published elsewhere. Samples of chemicals were provided free of charge by the chemical companies in all cases. Very little of this experimental work has been funded by IWBP.

6.2 Report on Chemical Evaluations Completed

TRINIDAD : Presenter, Stephen Rudgard

This work was completed in Trinidad by Henry Laker, not financed by IWBP, and general conclusions drawn by Dr Laker were presented by the Project Liaison Officer on his behalf as he had recently taken up a post with CEPLAC in Brazil. The three systemic fungicides tested were Anvil, Bayfidan and Moncut (commercial names). Trials were carried out within the Guidelines as mentioned above.

Aerial application of the compounds on to pods on mature trees at 15 day intervals resulted in slight reductions in fruit infection by C. perniciosa, but the results were inconclusive. Doses were 500 mg active ingredient of Bayfidan per tree, 125 mg of Anvil and both 200 mg and 400 mg active ingredients of Moncut, for each application. Applications to the soil of Bayfidan and Moncut gave inconclusive results for the control of both pod and shoot infection on mature trees at between 1g and 2g active ingredient per tree for two applications six weeks apart. Anvil gave good control of witches' broom on pods, cushions and vegetative shoots applied to the soil twice at 0.5g active ingredient per tree, but the effect was much reduced at the lower dose of 0.125g per tree. Application of the chemicals to necrotic brooms had little effect on the production of basidiocarps in most cases, although some reduction was found using Moncut. However, production of basidiocarps was almost completely inhibited by two

applications, 14 days apart, of all three chemicals to brooms while they were still green.

BRAZIL : Presenter, Teklu Andebrhan

This work had been carried out in Brazil by Cleber Bastos, not financed by IWBP, and general conclusions drawn by Dr Bastos were presented on his behalf as he was unable to attend the Workshop. Trials were carried out within the Guidelines.

Preliminary screens were carried out using the chemical pencycuron (Folicur), (Bayer AG). An ED50 of about 0.1 ppm was found for inhibition of spore germination, and a single spray treatment completely suppressed basidiocarp formation on necrotic brooms. Pre- and post- inoculation sprays of Folicur greatly reduced infection of young seedlings, in most cases less than 15% against 90% infection in controls. Applications were up to 8 days before or after inoculation, but the best results were achieved with smaller intervals.

In a large field trial in mature cocoa in Rondonia, 15 treatments were used to test the effects of Bayfidan applied at 15 or 30 day intervals as a soil treatment, and aerial sprays applied to the trunk/main branches, to the canopy or to both. Details of doses were not presented, and in general the results expressed as percentage pod infection were inconclusive. Copper oxychloride (Coprantol, Ciba Geigy AG) was used as a chemical standard. The only treatment with any statistical effect was the spray application of Bayfidan applied every 15 days to the trunk/main branches.

ECUADOR : Presenter, Alan Maddison

Five experiments, not financed by IWBP, were conducted to study the effects of Anvil, Bayfidan, Folicur and Plantvax on: pod infection, chupon infection, shoot infection on young trees, seedling infection, and basidiocarp production on necrotic brooms. The small samples of chemical available from the companies involved meant that fewer plants were used than was recommended in IWBP's guidelines. None of the compounds showed any conclusive effect on pod infection by C. perniciosa and M. roreri in mature cocoa, even with a total of 3g active ingredient sprayed on to trees and 15g as soil treatments. These amounts were spread over a maximum of 12 applications. Protection of chupons was also inconclusive, with up to 2g active ingredient for foliar and 5g for soil treatments. The maximum number of applications was ten. Samples were small and variation was large, so no treatment gave a reliable improvement over the untreated chupons. Some activity against shoot infection was shown by Folicur as a foliar spray tested on seedlings planted in the field in an area of high disease pressure. Regular sprays were required for good protection, and some phytotoxicity was observed at 2000 ppm of active ingredient.

The chemicals were also tested on young three-year-old trees applied aerially or via the soil between one and ten times. Folicur inhibited broom formation as a canopy spray even with few applications. Soil treatments with Bayfidan and foliar sprays with Anvil also showed good activity, but Plantvax showed very little effect.

Canopy sprays had little effect on the production of basidiocarps on necrotic brooms attached to trees. Anvil caused a statistically

significant reduction in fructification as compared with untreated brooms, although even in that treatment nearly 100 basidiocarps formed.

An experiment was also conducted to compare the cost efficiency of various protectant fungicide treatments to reduce seedling infection in nurseries. Bravo and Cobre Nordox were applied together or separately at various intervals, and compared with 78% infection in untreated plants. The cost of each treatment related to chemical and labour were calculated, and the most cost-effective treatment was a mixture of the two compounds applied every 2 weeks.

VENEZUELA : Presenter, Humberto Reyes

This work was carried out in mature cocoa in the Oriente of Venezuela by Lilian Reyes, according to the Guidelines but was not financed by IWBP. She did not attend the meeting so the results were presented on her behalf. Calixin, a Calixin-Maneb mixture, Cobox and a new test formulation of Cobox were applied singly and in mixtures using mistblowers. Infection of pods was recorded at harvests and the weight of brooms from each treatment at the end of each year.

Large numbers of pods were infected by Colletotrichum and Phytophthora, and witches' broom normally infected less than 20% of pods. Good yield increases were achieved using the experimental formulation of Cobox alone and in mixtures, although this was not necessarily due to control of witches' broom.

GERMANY (BAYER) : Presenter, Stephen Rudgard

Bayer AG had made results of some preliminary experiments using soil treatments of radio-labelled Bayfidan available to the Project Liaison Officer, and a brief summary of the work was presented at the Workshop.

6.3 Report on Chemical Evaluations in Progress

BRAZIL

The field trial carried out in 1987/8 will be continued, although some of the treatments may be omitted, and the trial area extended to include some additional treatments. This work is not financed by IWBP.

COLOMBIA

Three systemic fungicides are being applied as soil treatments in a field trial in mature cocoa in the Llanos region. There will be three applications of : the granulated formulation of Bayfidan at 0.75g and 1.5g active ingredient per plant; the 250 EC formulation of Bayfidan at 0.75g and 3.75g per plant; Anvil 5% SC formulation at 0.5g per plant; and 2.0g active ingredient per plant of the granulated formulation of Plantvax. This work is financed in part by IWBP resources, as the work is combined with the Comparative Phytosanitation Experiment.

ECUADOR

Experiments from 1987/8 will be repeated in 1988/9, except that the protectant fungicide treatments in nurseries will be replaced by treatments

with systemic compounds. This work is not financed by IWBP.

VENEZUELA

There will be two field trials completed by July 1989, one in Barlovento region near Caucagua and one in Tachira State at El Pinal. The former will compare mistblower treatments using Anvil, Bayfidan and Calixin, and the latter will study soil applications of the granulated formulation of Bayfidan at different doses. This work is financed in part by IWBP resources, as the work is combined with the Comparative Phytosanitation Experiment.

6.4 Discussion on Chemical Evaluation Trials

After several field trials in a number of countries and some controlled environment screening it is possible to make some general observations on the various chemicals tested. Firstly, Folicur (Bayer AG) has been shown to have good activity against C. perniciosa, and is a promising candidate for field trials. Specialists at Bayer have stressed that they would prefer research to continue on Bayfidan rather than Folicur, the former having passed most of the required stages in development and registration in the relevant countries.

Five systemic compounds have been given preliminary field trials, namely Anvil, Bayfidan, Calixin, Moncut and Plantvax. Calixin and Plantvax have shown little or no activity in all tests, and further trials are not recommended. Moncut has shown promising activity, and the manufacturers Nihon Nohyaku have been approached. The Project Liaison Officer and Dr Sreenivasan met the Overseas Manager of Nihon Nohyaku, Mr Tomoi, in Japan in August, 1988. Mr Tomoi stated that they have no plans to develop Moncut in Latin America, and although interested in witches' broom are unlikely to fund larger field trials in cocoa. They did not presently have any plans for registration of Moncut in any of the Latin American countries in which IWBP were interested. They would however be willing to give samples of the chemical to all those interested. IWBP does not have funds to finance trials of a sufficient scale, and therefore does not recommend further work with Moncut.

The other two other compounds have shown good activity and so are suitable candidates for further trials. Bayfidan and Anvil have reduced vegetative infection when applied as soil treatments under small trees, and Anvil only in mature trees. Both are translocated and must be reaching growing flush tissue. Applied externally to green brooms, they seem to inhibit basidiocarp production, and may do so in brooms formed on trees after soil treatments. This needs to be verified in a second year of field work using the same trees/brooms. Neither chemical controlled the disease in pods or chupons when applied as sprays, and only Anvil reduced pod disease as a soil treatment. Rapidly expanding tissues such as chupons will always be difficult to protect.

The two chemicals have similar systemic activity against C. perniciosa, and a major concern is still possible residues or taint in beans from treated trees. Bayer have completed two tests for residues of Bayfidan using beans from the trials in Trinidad, the second showed a small level of residue to be present. ICI have not yet been able to run any residue of taint tests due to pressure of work with Anvil in other crops.

6.5 Action to be taken on Chemical Evaluations

The Executive Chairman of IWBP will write to Nihon Nokyaku informing them of IWBP's inability to finance trials on Moncut and asking them to re-consider their decision. Both Bayer and ICI will be informed of the general results obtained in the various trials, and of work in progress. The importance of residue tests will be stressed and further bean samples arranged from trials during 1989.

7. EXPERIMENTS ON REHABILITATION OF WITCHES' BROOM INFECTED COCOA FIELDS

7.1 Introduction

The rehabilitation of cocoa farms with very high levels of disease was discussed at some length at the 4th IWBP Workshop in Belem, Brazil in October 1988. At that time, no decision was reached regarding the design of an experiment to compare the cost-effectiveness of the various methods available. The recovery of old unproductive cocoa has been much investigated but little concrete information is available on bringing such cocoa back into production and/or improving plantings heavily infected with witches' broom.

7.2 Further Discussions on Rehabilitation

The Executive Chairman of IWBP apologised on behalf of himself and the Project Liaison Officer for not having actively pursued the possibility of an experimental programme on rehabilitation as actively as might have been desirable, but there were many problems with experiments in this subject. Most previous work with rehabilitation had not used cocoa heavily infected with witches' broom. Six main methods of treating old plantings to return them to good pod yields were outlined, and each country indicated which it had used experimentally in relation to witches' broom (Table 3). Unfortunately, most experiences had been gained from informal trials for which little data were available, and few, if any, published. The method selected would depend on the particular farm concerned, and generalisations were inappropriate. Some countries reported that, in many cases, more than one method could be used in the same farm. It was generally felt that results from the two comparative experiments in IWBP would provide much information on the disease, and from these, trials could be designed to test rehabilitation techniques appropriate for local conditions.

TABLE 3: METHODS USED FOR REHABILITATION OF HEAVILY INFECTED FARMS

Country	1 Clear & Replant	2 Cut at Ground Level	3 Cut at 3-3.5m	4 Partly Clear and Underplant	5 Bud on Chupon	6 Bud on Trunk
Brazil		+	+			
Colombia			+			
Ecuador		+		+		
Grenada[a]			+			
Trinidad	+					+
Venezuela	+		+	+		

[a]: Rehabilitation not specifically for witches' broom

7.3 Action to be taken on Rehabilitation Experiments

It was agreed that the Project Liaison Officer should assemble the information available in research reports on previous work on rehabilitation during visits to participating countries in 1989. There would also be a specific session on rehabilitation of old plantations at the 6th IWBP Workshop.

8. BREEDING FOR RESISTANCE TO WITCHES' BROOM DISEASE

8.1 Introduction

Tony Lass summarised the events which led to a meeting in Gainesville of a small Expert Working Group who formulated a proposal on breeding for resistance to witches' broom disease (Report of the 4th IWBP Workshop, p.32).

This proposal had been circulated to IWBP participants (Circular Letter No 42) or 10th February 1988 and had been submitted to ICCO. ICCO had duly considered it and replied as follows:

"The item on the Witches' Broom Project was duly considered (at the recent ICCO Council Meeting) and it was decided that whilst Members recognised the importance of such a project to the cocoa economy, in view of the weak financial position of ICCO at the moment, it would not be possible for the Organisation to give financial support. However, it was suggested that a recommendation could be made to Members which are in a position to make voluntary contributions to do so and that such Members should write to the Secretariat giving an indication of their donation. I enclose a copy of the relevant Decisions and regret that it is not possible to give you a more positive reply."

It was appropriate to review this topic at the present workshop.

8.2 Presentation by A J Kennedy

Tony Kennedy re-iterated the approach to resistance breeding which he had outlined at the last workshop (Report of the 4th IWBP Workshop, para 8.3). He emphasized the need to get away from the traditional approach, which starts at gene banks, selects particular parents, hybridizes them and then assesses the progeny. Material such as SCA 6, IMC 67 and PA 34 has figured largely as parents in breeding programmes following this approach. In many cases, better progeny are still to be sought but by going back to the original parents. Cocoa breeders have historically called these progeny F1 but strictly they are nearer to F2 and F3 since F1 progeny result from two inbred parents and are uniform (homozygous) whereas SCA 6 and IMC 67 are very heterozygous. Going back to these as parents again will not make progress genetically. A programme of recurrent mass selection, or at least a variant of it, should be started as a matter or urgency.

The start is to select from one (or more) germplasm collection a population of about 20 individuals with low incidence of witches' broom. These should be crossed as near as possible at random to give a mass population with as many combinations as possible. The progeny are then screened for witches' broom resistance to again select the best population. This cycle can then be repeated so moving forward the mean of the population in respect of resistance.

Under such a scheme either a 'synthetic variety' can be released to the farmer, that is a hybrid population from the mass selection which will have the benefit of diversity or an individual clone can be made at any stage.

One cycle of such a mass selection scheme might take 4-5 years but this will depend to some extent on screening methods available. It is possible that this might be a 'negative' screen in that it removes highly susceptible progeny.

8.3 Action to be Taken

There was enthusiasm for the approach to breeding for resistance outlined by Tony Kennedy and it was agreed that the project proposal prepared by the Expert Working Group should be submitted to other donors. Participants were asked to forward any ideas on likely donors to the Executive Chairman as soon as possible.

9. QUARANTINE

The Chairman reported that a Quarantine Workshop was held in Miami in September 1988 which discussed aspects relevant to the international shipment of cacao germplasm. This was organized by ACRI on behalf of IBPGR and FAO as the second workshop on quarantine aspects, the first workshop, held in the Philippines, being on bananas. There were delegates from Costa Rica, Ghana, Malaysia, Trinidad, the UK and the USA. The workshop generated information on pests and diseases of relevance to cocoa quarantine and a report will be published by IBPGR early in 1989. Hank Purdy will send a mailing list to IBPGR so that members of IWBP can receive copies. Hopefully, this workshop will lead to a greater consistency in dealing with the international exchange of cocoa germplasm.

The risks of movement of cocoa from the Brazilian Amazon to Bahia was discussed at the request of Paulo Alvim. He opened the discussion by informing members of decree from the Governer of Bahia (promulgated 15th January 1987) which stated as one of its five considerations that because of "the impossibility of safe control over the selection and isolation of cocoa originating from the Amazon before its entry into our territory it is prohibited to bring into the State of Bahia cocoa produced in the Amazon region, until the region has been declared free of the disease witches' broom which at this moment occurs on cocoa in the Amazon."

The Chairman reminded members that it would be totally inappropriate for this 5th IWBP Workshop to comment on policies generated by an internal agency of any country. However, there were scientific aspects concerning the transport of cocoa and other material which were relevant to the movement and survival of the witches' broom fungus and these matters could properly be addressed by this 5th IWBP Workshop.

The ensuing discussion therefore focussed on the following aspects of the transport and survival of Crinipellis perniciosa:-

A. Transport

- dry beans
- dead plant material
- live plant material

- external contamination (mud, wheels, shoes, clothes, etc)

B. Movement (dissemination) by wind

C. Survival of the pathogen in Bahia if transported there.

The general conclusions were as follows:

Dry beans - Farmers usually ferment beans from infected pods separately to those from healthy pods. Experiments (in Belem) indicate that if fermentation has been carried out properly the fungus cannot survive the high temperatures of good fermentation. But, observations in Trinidad show that the fungus can survive on sun-dry beans after inadequate fermentation (i.e. those at a low temperature). The consensus of opinion was therefore that the fungus might survive on dry beans but a lot of unusual events would have to occur together to achieve this.

Dead plant material - There is ample evidence that the fungus can be transported and can survive on dead cocoa material.

Live plant material - The fungus is a viable fungus can readily be transported on cacao and other Theobroma species.

External contamination - At present there are no data on which to base a conclusion but other micro-organisms infecting cocoa are soil-borne, e.g. Phytophthora.

Movement by wind - During the time that cocoa has been grown in Bahia there has been no outbreak of witches' broom there. It must be considered extremely unlikely therefore that infective propagules will arrive by wind.

Survival in Bahia - The consensus of opinion was that if Crinipellis perniciosa arrives in Bahia it will survive.

In the light of this discussion it was agreed that more research should be done on the survival of Crinipellis perniciosa under the sorts of conditions described above.

10. RESEARCH ACTIVITIES ASSOCIATED WITH IWBP

10.1 Presentation by T N Sreenivasan

Dr Sreenivasan outlined several aspects of work on Crinipellis perniciosa within the Cocoa Research Unit, University of West Indies, Trinidad as follows:

i. Particularly for those not present at the last IWBP Workshop a method of inoculating seedlings was illustrated by slides. Pods are allowed to over-ripen slightly before the seeds are planted. This gives a uniform population of seedlings from one pod. Basidiospores are suspended in 0.4% agar to give a known concentration. A drop of this suspension is then applied to the terminal growing point of each established seedling which is then kept in a moist chamber. The drop drains slowly down the tip of the shoot and in a highly susceptible

cocoa, e.g. (such as ICS 43) symptoms appear after 8 days.

ii. Slides were also shown of a striking symptom which appeared on some inoculated seedlings apparently involving premature bark formation. On investigation this proved to be a complicated host reaction associated first with white aggregations of callus cells which later dried to give brown, 'box'-like pustules.

iii. The different forms of the fungus in green, drying and dry brooms were illustrated (see also Report of the 4th IWBP Workshop). It was suggested that some features of the action of fungicides in green brooms might be explained on the basis of the fungus becoming most vulnerable at certain stages of its growth in these brooms.

iv. Examples of naturally-infected seed developing proliferations were shown.

v. Penetration of the fungus through a stoma and directly through the cuticle was illustrated by scanning electron microscope photographs.

10.2 Surface Wetness Records: Gustavo Macias

During 1986 and 1987, visual records were taken near Pichilingue, Ecuador of surface wetness on young shoots, exposed leaves and fruits in traditional cocoa, with the aim of determining the initiation and time of drying of wetness of the various tissues, and to permit comparisons with data from a Belfort Dew Recorder and Campbell electronic wetness sensors attached to a 21X micrologger.

Wetness on shoots and leaves was caused by rain and conventional dew, while fruits were wetted by rain, and by dew resulting from thermal lag in the pods after sunrise. In all tissues, rain-derived wetness lasted longer than wetness from other sources. It seems that dew on pods caused by thermal lag is not important in the development of the witches' broom epidemic in the region because it is most frequently recorded during periods when there is no inoculum in the field (June, July), and it is of short duration.

There were highly significant correlations between the duration of wetness observed on young shoots and that recorded by the Belfort recorder using 25% of full scale deflection as the base line. The r values were 0.90 and 0.98 for rain wetness and dew respectively. With the Campbell system the best correlation ($r = 0.92^{**}$) was obtained using 75% of full scale deflection.

Neither the Belfort nor the Campbell instrument was useful for predicting when dew would occur on fruits as a result of thermal lag.

11. OBJECTIVES OF IWBP: EXPECTATIONS OF PARTICIPATING INSTITUTIONS

11.1 Introduction

The overall objectives of IWBP were established at the 1st Workshop and have been re-affirmed at each succeeding workshop (see para. 2.3, this report). Much progress has been made towards these objectives but with 2

years remaining of IWBP this Workshop seemed an appropriate time to discuss whether the aspirations of participating institutions were being met and, if not, what further action should be taken. It was on this basis that the subject was discussed and this produced the comments listed below by country.

11.2 Response to Country

Trinidad - The present programme satisfied the requirements of Trinidad.

Brazil - There is a need for more practical experiments to determine the value of management systems being developed in the present programme. When the system has been validated in the field then it needs to be demonstrated to farmers. In this connection it is important that farmers should perceive something new in the system proposed. For trees younger than 15 years, a system based on pruning is effective in Brazil, and can potentially reduce costs. Its main features are : leaving pruned brooms on the ground thus reducing labour costs by 40 - 50%, keeping tree height to 3.5m which makes control more efficient and less costly and pruning in August/September with a reprune in October/December.

The economics of this system (and other systems) now need to be addressed. There is also a need to have good pruning implements.

Colombia: While the objectives were satisfactory it was felt that sub-objective 4 (Report of the 4th IWBP Workshop, p.9) had not received enough attention. There was now a need for one or two demonstration plots so that by the end of the IWBP something could be handed on to farmers at once.

Venezuela: The need to start projects which will test integrated management systems was stressed. This might well have to address the problem of reducing the height of existing trees.

Grenada: No additions to the present programme were required.

Ecuador: It was accepted that the typically tall old Ecuadorian cocoa cannot really be subject to management schemes that are likely to emerge from IWBP. Such schemes will be of value in more productive farms. For the latter it would be useful to have demonstration plots.

11.3 Action to be taken

No inputs from IWBP for future work in connection with demonstration plots were required at this stage by most of the countries. But in connection with an economic study in Brazil, Paulo Alvim agreed to prepare a proposal including Terms of Reference and budget which would be sent to the Executive Chairman for consideration.

12. PUBLICATION OF A MONOGRAPH ON IWBP

12.1 Introduction

The Workshop was informed that the Project Management Committee (PMC) had agreed that the publication of a Monograph on the experimental work of IWBP was desirable though no cost estimates had yet been presented. The PMC

would keep the situation under review. In view of this the Project Scientific Committee had appointed a Data Management and Monograph Sub-Committee (DMMC) to be responsible for the tasks implied in its name. It had four members under the Chairmanship of Bob Schmidt and had already met once. The Terms of Reference had been agreed by the Project Scientific Committee and were as follows:

Terms of Reference for the Data Management and Monograph Sub-Committee (DMMC) of IWBP

(This Sub-Committee of PSC was established during the 5th Meeting of the Project Scientific Committee held in Trinidad in November 1988).

1. DATA MANAGEMENT

- To advise PSC on the summaries, analyses, interpretation and presentation of the data from the Comparative Epidemiology Experiment;

- To review the summaries, analyses and interpretation of the above data;

- To present the summaries, analyses and interpretation of the above data at the 6th IWBP Workshop to be held in Florida in November 1989;

- To prepare the chapter(s) on the Comparative Epidemiology Experiment for the IWBP Monograph in a timely way;

- To prepare a draft discussion paper on witches' broom disease management for PSC and for discussion at the 6th IWBP Workshop to be held in Florida in November 1989) and for finalisation at 7th IWBP Workshop (proposed date - late 1990 or early 1991).;

- To catalogue the data from the Comparative Epidemiology Experiment for future reference and potential use by other scientists;

- To consider other project data as agreed;

2. MONOGRAPH PREPARATION

- To prepare an outline of the Monograph in January 1989 and propose the authors for Chapters of the Monograph;

- To obtain and edit manuscripts for individual chapters of the Monograph;

- To advise on, and facilitate, the publication of the Monograph;

- To prepare a budget for the preparation of the Monograph and present it to the Executive Chairman of IWBP;

12.2 Data Analysis for 'Comparative Epidemiology Experiment'

Guidelines for this were agreed earlier in this Workshop (see paragraph 3.3). It was intended that a certain number of preliminary analyses would be available for discussion at the 2nd Meeting of DMMC in January 1989.

12.3 Monograph Preparation

Bob Schmidt then explained the present situation on the Monograph and the following points were noted.

1. The Data Management and Monograph Sub-Committee met for the first time during the course of the 5th IWBP Workshop;

2. The Monograph outline remained as indicated in the Report of the 4th IWBP Workshop (Appendix C);

3. The Country Coordinators would be responsible for the Chapter on the the Project work in their own country by site (Chapters 4 - 11); it was expected that these Chapters would be available in draft form by June 1989 for study by DMMC;

4. The 2nd Meeting of the Sub-Committee would be held in January 1989 at Silwood Park, UK;

5. At this meeting the Sub-Committee will:

   - prepare a more detailed outline of the Monograph for circulation to interested parties for comment;

   - determine authorship for the remaining chapters;

   - recommend an appropriate title (note two proposals are presently indicated in the outline);

   - agree schedule of meetings of the Sub-Committee, the time-scale for Monograph preparation and establish a budget;

6. The title should reflect the market for the Monograph and careful thought needs to be given to it in consultation with the chosen publishers. It was agreed that the title should contain as many key words as possible to facilitate computer based literature searches.

7. The Executive Chairman of IWBP should continue to seek a publisher for the Monograph.

13. Closing Address of the 5th IWBP Workshop

The Workshop was closed by Tony Lass (Executive Chairman, IWBP) with the following words:

> "We have come to the end of the 5th Workshop of the International Witches' Broom Project which happens at the completion of three years of a five year Project. I reported to the Council of IOCCC which met exactly four weeks ago today in Vienna, that we were making good progress with our experiments. I also reported to

them that this Project could turn out to be a model for future international cooperation in agricultural, or indeed other, research, and that we would have results available by early 1991.

I also said that the Project would remain under budget even though we anticipated data analysis and publication costs beyond July 1990 - the present official end of the Project.

Furthermore, I stated my absolute conviction that IWBP was approaching the problem of developing an economic management system to control witches' broom disease of cocoa in a correct and realistic way. I believe that you agree with me that our approach is appropriate.

I thank most positively all of you who have conducted the fieldwork often under most difficult circumstances. Without your dedication we would have no data to analyse and there would be no IWBP.

At the conclusion of this 5th IWBP Workshop, we will have had over 46 hours of discussion on our Project over the last six days. This is a very heavy programme and I thank you all most sincerely for your attention, your patience, your hard work and for the stimulating discussion which we have had. We have once again, moved forward in a superb spirit of cooperation. Please accept my thanks for this and for your interest.

I must specifically thank Alan Maddison for his excellent and good humoured interpretation sometimes in the face of extreme provocation. May I wish you all a safe journey home."

14. ACKNOWLEDGMENTS

Our thanks, and those of the contributors to IWBP, go to all the participants in the 5th IWBP Workshop for their interest and their active and animated debate during the Workshop. Once again, we owe a great debt of gratitude to Bryan Wheeler for acting as Rapporteur - a somewhat thankless and often difficult task which he undertook with both efficiency and enthusiasm. Our thanks must also go to, Mrs Cheryl Gonsalves, Tony Kennedy, T.N. Sreenivasan and the other staff of the Cocoa Research Unit for making the detailed arrangements. We can commend the Asa Wright Nature Centre to organisers of any similar future events like ours.

15. DATE FOR THE 6TH IWBP WORKSHOP

It has been agreed to hold the 6th IWBP Workshop near Gainesville, Florida, USA In November 1989. The precise dates and the precise location remains to be decided but it will be hosted jointly by the University of Florida and IOCCC. Details of the arrangements and the invitations will be issued nearer to the time.

16. ARRANGEMENTS FOR THE 7TH IWBP WORKSHOP

As presently envisaged this will be the final Workshop of IWBP in its existing form. It was previously proposed to hold this final Workshop at Imperial College, Silwood Park in September 1990, but the present intention

would be to delay this until April/May 1991 to permit the maximum allocation of time to the data analysis and Monograph preparation. The precise timing and location will be announced nearer to the time. It is hoped to have the participation of members of the Project Management Committee for part or for all, of the 7th IWBP Workshop and the Workshop location will be selected with that in mind. The Workshop might therefore not be held at Imperial College, Silwood Park.

17. DATE FOR THE NEXT MEETING OF THE PROJECT SCIENTIFIC COMMITTEE

It is presently proposed that the Project Scientific Committee should meet during the course of the 6th IWBP Workshop to be held in Florida in November 1989.

APPENDIX A: NAMES, ADDRESSES, TELEPHONE, TELEX AND TELEFAX NUMBERS OF PARTICIPANTS IN 4TH IWBP WORKSHOP

[N.B. National dialling codes included in telephone numbers wherever possible]

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APPENDIX B: PROGRAMME OF THE 5TH IWBP WORKSHOP,
ASA WRIGHT NATURE CENTRE, ARIMA, TRINIDAD
3rd - 10th November 1988

Thursday 3rd November 1988

Participants arrived in Trinidad and were transported to Asa Wright Nature Centre.

Friday 4th November 1988

0730	BREAKFAST
0830-1000	WELCOME BY REPRESENTATIVE OF COCOA RESEARCH UNIT (Prof J Spence - Chairman Cocoa Research Advisory Committee)
	WELCOME BY REPRESENTATIVE OF IOCCC (R A Lass on behalf of IOCCC President)
	WELCOME BY CHAIRMAN OF PROJECT SCIENTIFIC COMMITTEE (L H Purdy)
	INTRODUCTION OF PARTICIPANTS
	ADOPTION OF OBJECTIVES OF 5TH IWBP WORKSHOP
	ADOPTION OF PROGRAMME FOR 5TH IWBP WORKSHOP
	APPOINTMENT OF MODERATOR (L H Purdy was appointed)
	APPOINTMENT OF RAPPORTEUR (B E J Wheeler was appointed)
1000-1015	COFFEE BREAK
1015-1230 SESSION I	COMPARATIVE EPIDEMIOLOGY EXPERIMENT: REPORTS BY COUNTRY
	Reports on Trinidad : Steve Mohan Colombia : Fabio Aranzazu Venezuela : Ramon Acuna Ecuador : Alan Maddison Grenada : Charles Williams Itabuna, Brazil : Stephen Rudgard
1230-1345	LUNCH
1345-1600 SESSION I	CONTINUED
1600-1615	COFFEE BREAK
1615-1730 SESSION I	CONTINUED
1730-1800	PROGRESS REPORT ON SYMPTOM DOCUMENT
1900	DINNER

Saturday 5th November 1988

0730		BREAKFAST
0830-0930	SESSION I	CONCLUDED
0930-1000	SESSION II	COMPARATIVE EPIDEMIOLOGY EXPERIMENT: COMPARATIVE ANALYSIS Stephen Rudgard and Bob Schmidt
1000-1015		COFFEE BREAK
1015-1230	SESSION II	CONTINUED
1230-1330		LUNCH
1330-1600	SESSION II	CONTINUED
1600-1615		COFFEE BREAK
1615-1715	SESSION II	CONCLUDED
1715-1815		PRESENTATION BY GUSTAVO MACIAS ON THE CORRELATION OF ACTUAL POD WETNESS WITH THE DATA FROM BELFORT AND CAMPBELL RECORDERS
1830		COCKTAILS
1900		DINNER
2000-2200		MEETING OF THE PROJECT SCIENTIFIC COMMITTEE

Sunday 6th November 1988

0730	BREAKFAST
0800	DEPARTURE FOR R MONTANO ESTATE, GRAN COUVA
1030	ARRIVAL AT SAN SALVADOR COCOA ESTATE
1215	LUNCH
1315	DEPARTURE FROM GRAN COUVA FOR MANZANILLA
1800	ARRIVAL AT ASA WRIGHT NATURE CENTRE
1830	COCKTAILS
1900	DINNER
2100-2230	MEETING OF DATA MANAGEMENT AND MONOGRAPH SUB-COMMITTEE

Monday 7th November 1988

0700	BREAKFAST

0815-1000 SESSION III — COMPARATIVE PHYTOSANITATION AND GRADIENT STUDIES: REPORTS BY COUNTRY

Brazil	:	Teklu Andebrhan
Ecuador	:	Alan Maddison
Colombia	:	Fabio Aranzazu
Venezuela	:	Ramon Acuna

1000-1015 — COFFEE BREAK

1015-1230 SESSION III — CONTINUED

1230-1345 — LUNCH

1345-1415 SESSION III — CONCLUDED

1415-1600 SESSION IV — DISCUSSION ON PROTOCOL 2

1600-1615 — COFFEE BREAK

1615-1830 SESSION V — REPORTS ON CHEMICAL STUDIES

TRINIDAD	:	Stephen Rudgard
BRAZIL	:	Teklu Andebrhan
ECUADOR	:	Alan Maddison

1830 — COCKTAILS
DINNER

2030-2230 — MEETING OF DATA MANAGEMENT AND MONOGRAPH COMMITTEE

Tuesday 8th November 1988

0700 — BREAKFAST

0800-1010 SESSION V — REPORTS ON CHEMICAL STUDIES (concluded)

ECUADOR	:	Alan Maddison (concluded)
VENEZUELA	:	Humberto Reyes
VENEZUELA	:	Ramon Acuna
GERMANY	:	Stephen Rudgard

1010-1030 — COFFEE BREAK

1030-1140 SESSION VI — FUTURE WORK ON CHEMICALS

1200 — LUNCH

1245 — DEPARTURE FOR FIELD TRIP

1330 — ARRIVAL AT INTERNATIONAL COCOA, GENEBANK AT UNIVERSITY COCOA RESEARCH STATION, CENTENO

1400 — DEPARTURE FROM CENTENO

1445 — ARRIVAL AT COCOA RESEARCH UNIT, UWI

1700 — DEPARTURE FOR ASA WRIGHT NATURE CENTRE

1815		ARRIVAL AT ASA WRIGHT NATURE CENTRE
1830		COCKTAILS
1900		DINNER
2000-2215		MEETING OF PROJECT SCIENTIFIC COMMITTEE (Concluded)

Wednesday 9th November 1988

0700		BREAKFAST
0800-0930	SESSION VII	MATTERS ASSOCIATED WITH IWBP: REPORTS WITH DISCUSSION: - INTERNATIONAL WORKSHOP ON COCOA QUARANTINE: Hank Purdy - INTERNATIONAL QUARANTINE MEASURES WITHIN BRAZIL: Paulo Alvim
0930-0940		COFFEE BREAK
0940-1030		INVESTIGATIONS ON CRINIPELLIS PERNICIOSA AT COCOA RESEARCH UNIT, UWI: T N Sreenivasan
1030-1215	SESSION VIII	DISCUSSION AND OBJECTIVES OF IWBP IN EACH COUNTRY
1215-1330		LUNCH
1340-1400	SESSION VIII	CONCLUDED
1400-1430		RAIN BREAK
1430-1530	SESSION IX	DATA MANAGEMENT AND MONOGRAPH PREPARATION WITH MISCELLANEOUS MATTERS
1530-1600		COFFEE BREAK
1600-1800	SESSION X	BREEDING FOR RESISTANCE TO WITCHES' BROOM DISEASE OF COCOA
		RECURRENT MASS SELECTION: A J Kennedy
1800-1830		CLOSURE OF 5TH IWBP WORKSHOP R.A. Lass, Executive Chairman, Project Management Committee, IWBP
1830		COCKTAILS
1900		FAREWELL BARBEQUE

Thursday 10th November 1988

0700		BREAKFAST
0830		PARTICIPANTS DEPARTED FROM ASA WRIGHT NATURE CENTRE

APPENDIX C: AN INTRODUCTION TO THE ASA WRIGHT NATURE CENTRE

The Asa Wright Nature Centre, Spring Hill Estate, is located at 360 metres in the mountains of the Northern Range of Trinidad, 12 km north of the Town of Arima. Founded in 1967 under a Trust administered by the Bank of Nova Scotia Trust Co and an international Board of Management, the Centre was established to provide a recreation and study area relating to tropical wildlife open to all, and to serve the wildlife thereon. A special attraction of Spring Hill is a breeding colony of the nocturnal Oilbird, or Guachara (Steatornis caripensis). Located in Dunson Cave a beautiful stream cut gorge on the property, this is the only easily accessible colony known of this remarkable species. The World Wildlife Fund made a substantial contribution toward the establishment of the Centre in order to protect the colony.

Spring Hill is an abandoned cocoa-coffee-citrus plantation partly reclaimed by secondary forest and largely surrounded by impressive rainforest where some original climax areas have an upper-story canopy of 30-45 meters on the steeper slopes. The whole effect is one of being deep in tropical rain forest (over 2280mm rainfall annually). The Centre has long been a haven for both amateur and professional naturalist even before the days of Mrs Wright's ownership, from whom the property was purchased. The usual problem in the tropics is to find a place where one can operate in reasonable comfort and still find wildlife in the immediate area. To see Squirrel Cuckoos, Toucans and all manner of lesser species fly within sight of the front gallery of the main house, to see Tufted Coquettes and half a dozen other species of hummingbirds feeding on the vervain from the back gallery, is but a start of what the birdwatchers will find at the Centre. Botanists and entomologists and other naturalists will find the area equally rich. In 1950, Dr William Beebe, chose the area as the site for Tropical Research Station of the New York Zoological Station. Simla, as it was called, now forms part of the Nature Centre and is available for use by biologists interested in research.

The continental origin and proximity of Trinidad to South America, as well as a multiplicity of habitats, has resulted in an unusually diverse fauna. The species lists are impressive: 108 mammals; 400 birds; 55 reptiles; 25 amphibians; and 617 butterflies. Similar diversity is found in many other less conspicuous animal groups and in the plant life.

No other area in the West Indies and few, if any, areas of comparable size in tropical America can match this species diversity. The ease of transportation to and around the islands enchances in no small manner the value of this diversity to the visiting naturalist: Elfin Forest, Montane Rain Forest, Savannnah, Lowland Rain Forest, Fresh and Salt-Water Swamp, as well as beaches and cultivated areas are all readily accessible. It is not unusual for experienced birdwatchers for example, to add 120-150 species to their 'life-list' during a short stay. Trinidad possesses a number of endemic species of plants. Its continental past and recent insular status have produced an interesting ecological situation.

Rita Iton
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Trinidad