crecer
Rural Equitable Economic Growth Activity

91 Avenida Norte No. 707. Colonia Escalón, San Salvador. Tel: (503) 264 2009, 264 2012 Fax· (503) 263 2539 e-mail· crectech@ejje.com

RURAL EQUITABLE ECONOMIC GROWTH ACTIVITY

Contract No. 519-C-00-94-00154-00

REVIEW OF AVAILABLE INFORMATION ON RED BANDED THRIP (SELENOTHRIPS RUBROCINCTUS) IN CASHEW PLANTATIONS

THIS REPORT INCLUDES INFORMATION ON BIOLOGY, LIFE CYCLE, HOST PLANTS, POTENTIAL FOR DAMAGE AND CONTROL METHODS ESPECIALLY BIOLOGICAL CONTROL OF S. RUBROCINCTUS IN CASHEW

Prepared by:

Ian Duncan
International Consultant

Through:

Chemonics International Inc.
Instituto Interamericano de Cooperación para la Agricultura (IICA)
National Cooperative Business Association (NCBA)
World Council of Credit Unions (WOCCU)
U. S. Agency for International Development (USAID)
El Salvador

August 1999

REVIEW OF AVAILABLE INFORMATION ON RED BANDED THRIP (SELENOTHRIPS RUBROCINCTUS) IN CASHEW PLANTATIONS

THIS REPORT INCLUDES INFORMATION ON BIOLOGY, LIFE CYCLE, HOST PLANTS, POTENTIAL FOR DAMAGE AND CONTROL METHODS ESPECIALLY BIOLOGICAL CONTROL OF S. RUBROCINCTUS IN CASHEW

Prepared by:

Ian Duncan
International Consultant

August 1999

Rural Equitable Economic Growth Activity
Contract No. 519-C-00-94-00154-00

U. S. Agency for International Development (USAID)
Washington, D.C.

This report was supported by the U.S. Agency for International Development, through contract number 519-C-00-94-00154-00, the prime contractor for which is Chemonics International Inc., 1133 20th Street, Washington, D.C. 20036; Tel.: 202-955-3300; Fax: 202-955-3400.

2

INDEX

SUMMARY EXECUTIVE		i
A.	Introduction	i
B.	Technical Review	i
C.	Recommendations	ii
SECTION I INTRODUCTION		I - 1
A.	Background to this Assignment	I - 1
SECTION II INFORMATION ON THRIPS		II - 1
A.	Identification of Species in El Salvador	II - 1
B.	Background to Red Banded Thrips	II - 1
C.	Other Thrips Species in Cashew	II - 2
D.	Biology of Red Banded Thrips	II - 2
	D1. Life Cycle	II - 2
	D2. Reproduction	II - 6
	D3. Feeding Habit	II - 6
	D4. Dispersal	II - 6
E.	Ecology of Red Banded Thrips	II - 7
	E1. Host Plants	II - 7
	E2. Factors Associated with Red Banded Thrip Damage in Cashew	II - 7
	E3. Natural Enemies of Red Banded Thrips	II - 8
SECTION III CONTROL OF THRIPS		III - 1
A.	Chemical Control	III - 1
B.	Organic Insecticides	III - 2
	B1. Petroleum Spray Oils (PSO)	III - 2
	B2. Potassium Soaps	III - 3
	B3. Pyrethrum	III - 3
C.	Control using Predators and Parasites	III - 3
D.	The Recommendation	III - 5
SECTION IV CONCLUSIONS AND RECOMMENDATIONS		IV - 1
A.	Main Conclusions	IV - 1
B.	Recommendation	IV - 2
	B1. For Short Term Control	IV - 2
	B2. Longer Term Strategy	IV - 2
SECTION V ACKNOWLEDGMENTS		V - 1
SECTION VI REFERENCES		VI - 1

SUMMARY EXECUTIVE

A. Introduction

The consultant has observed red banded thrip (*Selenothrips rubrocinctus)* as a pest of cashew during his three visits to El Salvador (January, December 1997, March 1999). Red banded thrips is a significant problem and this pest is inhibiting tree growth at the cooperatives plantations that have immature cashew trees - San Ramon, Chilanguera and Maquigua.

Unfortunately, to date less attention has been paid to red banded thrips because of the overwhelming importance of the damage caused by *Letoglossus sp* at CORALAMA and some other plantations. However it is now important for the cooperative plantations at San Miguel to give some priority to investigating and solving the red banded thrips problems.

In addition in April 1999 the consultant found red banded thrips to be abundant on a number of the cashew trees at the SES plantations in San Vincente. These plantations mainly consist of immature cashew trees and SES are planning to plant more new trees. In this event red banded thrips could pose a significant problem for SES.

Currently, both the cooperative plantations at San Miguel and SES at San Vincente have no control measures against red banded thrips. Both organizations would prefer to use bio-control methods so as to preserve their organic cashew status.

B. Technical Review

There are about 4,500 species of thrips (Thysanoptera). *Selenothrips rubrocinctus,* commonly known as red banded thrip is recorded as a pest species in many tropical and subtropical countries and on many host plants. The major economic damage caused by red banded thrips is on cocoa, avocado, mango, guava and cashew.

Red banded thrips is a very small insect being only 1.5 mm long at maturity. The time period to complete a generation is about 50 days and the female can lay about 30 to 50 eggs. In favorable conditions the insect can produce new generations approximately every month thus giving the possibility of rapid increases in population. However it is an insect that thrives in dry weather - periods of heavy rain can cause significant reductions in populations.

The dispersal potential of red banded thrips can be very significant, it has a wide range of alternative host plants, often including a number of native trees and shrubs and studies has shown their movement by aerial dispersal of 2,000 km or more.

4

These trials should use land based spray equipment. Spraying should commence when insect monitoring determines a 'moderate level 'of red banded thrips population is indicated on the trees. There should be a minimum of two sprays about 14 days apart to break the pest life cycle. A population estimate at the conclusion of the trial can be used to determine the efficacy of the insecticides. Potassium soaps and Petroleum spray oils have been found to be effective against red banded thrips in Australia and therefore these techniques should be tried in El Salvador. There is little information about pyrethrum being used against red banded thrips however this work is part of the entomology investigation underway by the University of El Salvador on behalf of CRECER.

Unfortunately as red banded thrips characteristically inhabit the underside of cashew leaves the use of pyrethrum, petroleum spray oils and potassium soaps are unlikely to be effective when applied from the air. This limits the effective use of this technique to whatever areas in the plantation that can be covered by land based spray equipment.

The **second stage** involves the University of El Salvador investigating the potential of the following:

-Identify and describe abundance of species of green lacewings indigenous to Central America. (It is necessary to find the appropriate species to be able to develop a bio-control system for cashew using the Australian work with *Mallada signata* as a model).

-Investigation parameters for development of control system using selected green lacewing as predator. Assistance from Australia can be given to this project if required.

-Investigate distribution and abundance of *F. vestiformis* and *G parivennis* and determine if these natural predators have been developed as a control agent against red banded thrip in other crops in Central America.

The recommended **management strategy** to help avoid red banded thrip attack is to assist the cashew trees to avoid stress, usually water or nutritional stress. Irrigation of the trees is impractical, however a strict adherence to the nutrition program as previously recommended by the consultant will at least avoid nutritional stress, and this could be a significant factor in the program.

5

SECTION I
INTRODUCTION

SECTION I
INTRODUCTION

A. Background to this Assignment

In January 1997 the consultant visited El Salvador for 4 weeks and undertook an assignment for NCBA and Cracker at the CORALAMA cashew plantations and factory. During this assignment it was evident to the consultant that Leptoglossus insects were a major problem and caused a significant loss of crop, it was estimated that every year about 35 % of the crop processed in the factory was lost mainly due to insect damage.

The problem caused by Leptoglossus was also very evident to the technical staff at Cracker and they were attempting to control the problem in the plantation by aerial applications of Neem oil. At the time thrips was also noted as a pest of cashew however it was dwarfed by the scale of the impact of Leptoglossus. The consultant was advised that the insect pest had been previously identified as *Selenothrips rubrocinctus*.

The consultant was requested to undertake a small assignment collecting the available information on Leptoglossus in cashew. In August 1997 the consultant submitted his **Report on Major Insect Problem at CORALAMA, El Salvador.** In this report the consultant gave the available information on the biology of Leptoglossus. He concluded that the use of neem oil was ineffective as a control measure so he discussed the options for control, especially biological control as would be required by organic producers.

In December 1997 the consultant returned to El Salvador for 3 weeks to review progress in the plantations and the factory. During this period it was agreed that further work would be undertaken by the University of El Salvador into organic control measures of Leptoglossus. Thrips was also recognized as a secondary (but important) pest and it was recommended that pyrethrum be tried for organic control of thrips. In the event this was not possible as pyrethrum was not available in El Salvador.

In March/April 1999 the consultant returned to El Salvador for 4 weeks. During this visit he was able to view progress on the two research projects on Leptoglossus underway at El Salvador university, (1) Diversity and Abundance of Leptoglossus at CORALAMA, and (2) Evaluation of organic products to control Leptoglossus. As part of the Diversity and Abundance project the university collected 20 pest samples at CORALAMA which the consultant passed to Dr. Malipatil for positive identification.

During the consultant's March/April visit it became even more apparent that the potential of damage from thrips required more specific research. In this event it was decided that the consultant would prepare a brief paper on the available information on thrips damage in cashew. This paper would then form the basis for making decisions of future work for the organic control of thrips in cashew in El Salvador.

7

SECTION II

INFORMATION ON THRIPS

SECTION II
INFORMATION ON THRIPS

A. Identification of Species in El Salvador

The consultant has observed the thrips insects on various cashew trees mainly at San Ramon, Chilanguera and Maquigua where the trees are immature. In addition in April 1999 these insects were observed sometimes in significant numbers in the Sistema Economico Social (SES) plantations at San Carlos in San Vincente Department.

The consultant notes that he is satisfied that the insects he has observed appear to be *S.* red banded thrips (*S. rubrocinctus*), however he is not an entomological taxonomist and he has not obtained any positive identification of these species by the appropriate experts in Australia. Instead the consultant is relying on advice from the University of El Salvador of previous work where they have positively identified the species in El Salvador as red banded thrips.

B. Background to Red Banded Thrips

The insect species commonly known as thrips belong to the order Thysanoptera. There are about 4,500 described species of thrips worldwide and they are found in a wide range of different geographic areas and on a large number of different host plants. The distinguishing feature is one of complexity where a number of thrips species may be attracted to a single crop, and where one single species may have a large number of alternative host plants. For example Entwhistle lists over 20 thrips species found on cocoa while the single most important pest species on cocoa, red banded thrips can be found on 44 different host plants solely in the region from Florida to Brazil.

Red banded thrips is one of the most important pest species in the family of Thripidae. The species is recorded as a major pest of a wide range of crops, especially cocoa, avocado, mango and guava. It has also been recorded as a pest of cashew and many other crops and as indicated above it has a number of alternative native host plants. Red banded thrips has been found world wide - in North, Central and South America, Australia, Africa, Asia, and including locations as dispersed as Japan, China, Solomon islands (Pacific Ocean), and Reunion (Indian Ocean).

The most important economic associations of red banded thrips are cocoa and avocado in all major producing countries, and the majority of the research on red banded thrips appears to have been undertaken in relation to these two crops. The species has previously been recorded in the literature as a pest of cashew in Brazil, India, Asia and Africa. In Brazil it is regarded as a major cashew pest in Ceara province, the largest cashew growing area.

In India. red banded thrips is a wide spread pest but at a lower level to Helopeltis. Red banded thrips is recorded as a significant pest of cashew in many of the major producing countries in Africa while in Asia it is known to be present in cashew in all producing areas including Hainan Island in China. red banded thrips has also been observed as a pest of cashew in Australia and Papua New Guinea.

Red banded thrips prefer living and feeding in open sunlight spaces and therefore feed on young trees where canopies are open rather than mature trees where the canopies have closed to made a permanent shade. The action of the thrips damage is to feed on cashew leaves sucking the contents of leaf cells causing a dehydration effect on the tree. This dehydration can cause loss of health and reduced vegetative growth and this effect can be severe on small trees with lower energy reserves.

Some thrips species can also effect plants through the introduction of virus particles (Mount 1973). Two virus diseases are currently considered to be transmitted by thrips and six thrips species are involved. However there is no evidence to suggest that red banded thrips is involved in any virus transmission to any of it's host plants.

While red banded thrips is an important world wide pest of cashew it's significance tends to be undervalued because the impact is on young (largely low-producing) cashew trees rather than on mature producing trees. In this event the loss sustained by reduced young tree health and growth is hard to evaluate economically as compared to a measurable crop loss by pest attack on a mature producing tree. However the overall economic loss caused by thrips damage is long lasting and is much more significant than might first be contemplated.

Some thrips species have also been credited with some beneficial effects including pollination and as a predator species however these cases are rare. Pollination by thrips has been studied very little and appears to be limited to a few crops (oil palm), while experiments have shown one species of thrips to be a primary predator of a citrus pest in China. There is no evidence to suggest that the presence of red banded thrips has any beneficial effect on cashew.

C. Other Thrips Species in Cashew

Apart from red banded thrips (*S. rubrocinctus* , Ohler describes other thrips species have also been recorded as an occasional pest of cashew. These include *Rethithrips aegyptiacus* in Brazil (Peixoto 1960), *R syriacus, Rhipiphorothrips cruentatus, R raoensis* in India (Abrahams 1958), and *Phlaeothrips anacardii,* and *Idolothrips haliday* in Kenya.(Wheatly 1961).

D. Biology of Red Banded Thrips

Red banded thrips are among the smallest species of Thysanoptera, being usually about 1.5 mm long when mature.

D1. Life Cycle

There are 5 stages in the life cycle of red banded thrips. These are (1) egg, (2) first and second instar nymph, (3) pre-pupae, (4) pupae and (5) adult.

Data on the various stages of the life cycle are given below:

Egg	- 15 to 16 days at 25 degrees C (Russell) - 12 days (Reyne) - 3 to 4 days (Ulrich)
Nymph	- 8 to 16 days at 20 to 24 degrees C (Russell) - 9 days (Ulrich) - 9 to 10 days (Reyne)
Pre-pupae	- 1 to 2 days (Russell) - 1 day (Ulrich) - 1 day (Reyne)
Pupae	- 4 to 7 days at 20 to 21 degrees C (Russell) - 2 days (Ulrich) - 2 to 3 days (Reyne)
Adult	- minimum of 14 to 17 days (Russell) - several weeks (Ulrich) - about one month (Reyne)
Adult fecundity	- about 50 (Ulrich) - 30 or more found on cocoa (Reyne)

D1a. The Life Cycle Summary

Is that red banded thrips has a span of about 24 days from egg laying to emergence of adults and a similar or longer period as an adult. Females can lay eggs soon after emerging as adults and have a fecundity of 30 to 50 eggs. The species can breed virtually continuously so one generation can lead to another in about 30 days. This is potentially a very rapid breeding pattern where in theory one adult female could multiply to over 2 million offspring in 4 generations (4 months). In reality normal attrition especially in the first and second instar stages by predators, climatic factors (temperature and humidity) and possible lack of food would reduce these numbers, sometimes dramatically. However in favorable conditions the dangers of an explosive increase in population remains.

D1b. A Description of the Life Stages

Are as follows:

- **Egg**

The eggs are very small (about 0.02 mm) and are usually deposited singly on the underside of the leaf and beneath the epidermis. The point of insertion of the eggs is then sealed with

a drop of liquid excrement which then dries on the leaf as dark flat scale so that the egg pocket is concealed.

As incubation proceeds the egg swells, presumably because it is absorbing water from the leaf. The thrip nymph emerges at the edge of the excrement scale which it may carry away on it's back.

- **Nymph**

In the two instar nymph stages the insect is usually gregarious often occurring together with adults. In this stage the insect commences feeding and when doing so the nymph is holding the tip of it's lower abdomen in a vertical position with the peri-anal hairs supporting o drop of liquid excrement. this liquid excrement periodically falls on the leaf and these spots on the leaf are signs of feeding in first larval stage.

- **Pre-pupae**

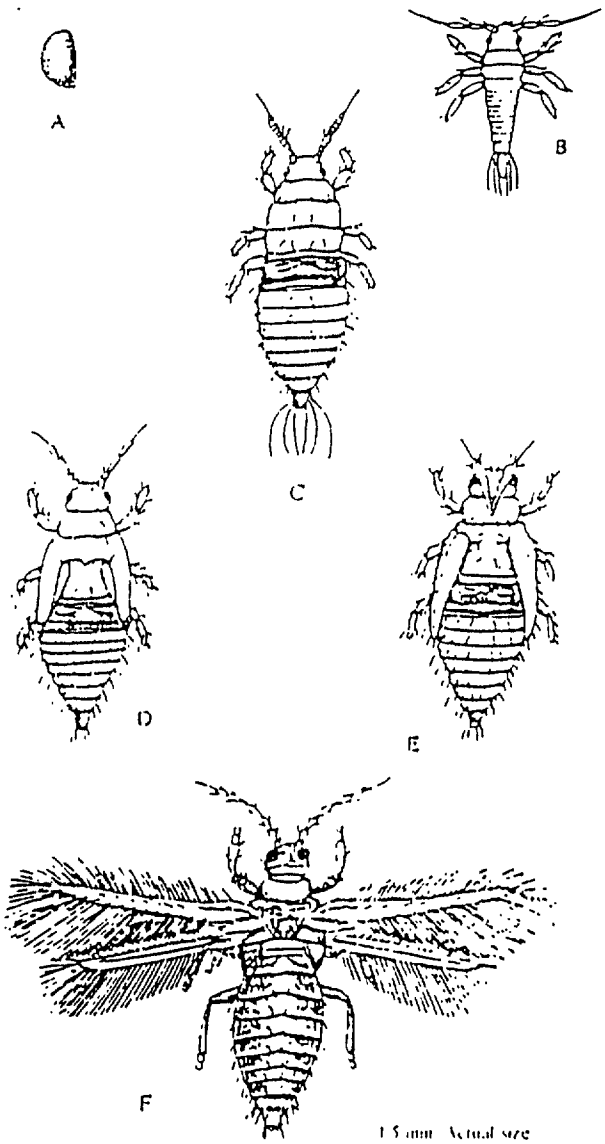
In the second instar stage the nymphs moults and this is followed by the pre-pupae stage when feeding does not take place and the insect is relative inactive. Pre-pupae tend to gather at the proximal end of the leaf. Pre-pupae then undertake another moult to form pupae.

- **Pupae and Adult**

Are also inactive, however they may move if disturbed or subjected **adult** to strong light. There is then a final moult when the pupae become adults. (1.5 mm long).

In terms of **colour** - nymphs are creamy in colour with twp characteristic bright red bands across the abdomen, one band directly behind the rear legs and the other at the tip of the abdomen. The adult is dark brown to black and has similar red bands on the abdomen.

Basic diagrams of the various stages of red banded thrips (*S rubrocinctus)* growth are shown below (from Entwhistle Pests of Cocoa).



13

D2. Reproduction

Although typically bisexual, most thrips probably reproduce by haplodiploid parthenogenesis. Males are generally assumed to be derived from unfertilized eggs, but despite this sex determination process, known as haplodiploid, many species have evolved the ability to reproduce without males. In a few species males are rare or unknown (Mount 1976).

Red banded thrips are probably a completely parthenogenic species (Entwhistle), he describes how Russell never observed males on avocado and mango in Florida while Ulrich found very few on cocoa in Trinidad. In Surinam Reyne found a ratio of 1 male to 378 females. In contrast in Trinidad 16 times more males were found in cashew than on cocoa, apparently no reason has been advanced for this anomaly. Reyne and Callan agree that the male is no longer of importance to the species and is probably a remnant of a former method of reproduction.

Most host specific species appear to be univoltine, but pest species (like red banded thrips) usually breed more or less continuously depending on temperature, humidity and host plant condition. These pests can have a new generation each month.

D3. Feeding Habit

The feeding apparatus of thrips is unique among insects. Both larvae and adults use a 'punch and suck' feeding technique, the single mandible punches a hole in the plant surface through which the paired maxillary stylets are then inserted to suck out the cell contents. These stylets have only one channel, enzymes from salivary glands travel down through the same tube that is used to suck in the food.

As regards the behavior of red banded thrips in cashew it was previously stated that nymphs are more often found on older cashew leaves, while adults are equally numerous on old and younger leaves. Adults and nymphs frequently feed together. In the action of feeding they use their mandible to punch a hole in the epidermis of the cashew leaf, then insert the paired maxillary stylets to suck out the cell contents. This removal of cell contents leads to a dehydration of the leaf and as a result the margins of the leaf tend to curl downwards on the underside. In the early stages, feeding activity produces a silvery sheen on the leaves. In addition brown spots may occur on the underside of the leaf, caused by the dropping of excrement from the tips of the abdomen. In the event of severe infestations the leaves take on a sun-scorched appearance.

D4. Dispersal

Many thrips species (including red banded thrips) are aerially dispersed. However the presence of wings is not a absolute requirement for effective dispersal as some apterous species with the habit of crawling to the top of grasses and twigs appear to be dispersed more readily than winged species with cryptic habits. For example Mount and Walker (1986) estimate that thrips could survive 24 hours in the air and apparently both winged and non winged thrips species have been aerially dispersed from Australia to new Zealand (2,000 km). There is no information of the aerial dispersal potential of red banded thrips, however it is a species that develops wings and therefore is likely to have a very significant dispersal range.

E. Ecology of Red Banded Thrips

E1. Host Plants

Red banded thrips are a leaf feeding species that can be a pest of a wide range of fruit and native trees, ornamental shrubs and crops in many tropical countries. It has previously been recorded as a significant pest of cocoa especially in West Indies, South America (Surinam, Brazil) and West Africa. It is also a major pest of avocado in many countries including South Africa It is recorded as a pest of cashew in virtually all cashew growing countries.

In Australia red banded thrips has been shown to damage avocado, mango ,guava, rambutan, mangosteen and macadamia. Other examples from diverse parts of the world include sweet potato, taro, and areca nut in Solomon Islands (Ministry of Agriculture 1985), tung in China (Wang WX 1985), Brazilian pepper (*Schinus trebinthifolius)* in Florida USA (Economic Botany 1979), fruit, shade and ornamental trees in Florida (Denmark 1971) and groundnut in Brazil (Castro 1975).

Apart from the above list of economic targets red banded thrips also can use a number of alternative host plants during it's life cycle. Entwhistle (Pests of Cocoa) gives a list of 42 of these host plants found in Florida, Caribbean, Central and South America. A complete list of these host plants are given in appendix 1. It has also been suggested that there is a link between these host plants is the form of some common amino acids. Research in Kerala, India by Ananthakrishnan (1974) examined four host plants (cashew, mango, guava and jambo) of red banded thrips in the laboratory. They found increased concentrations of certain free amino acids in these host plant leaves. Additionally it was found that amino acids not normally present in cashew leaves where present when these leaves were infested by thrips.

As described in section 2.3 the life cycle of red banded thrips in cashew begins when the adult lays the eggs under the epidermis on the underside of the leaf. In cashew tree population studies from Ceara in Brazil, Cavalcante (1975) has shown that the immature red banded thrips were more abundant on the old cashew leaves, while the adults were in about equal numbers on both old and young leaves.

E2. Factors Associated with Red Banded Thrip Damage in Cashew

There are four determining factors that influence the target, timing and scale of attack be red banded thrips in cashew. These are as follows:

- Avoids heavily shaded environment therefore the insect will attack younger smaller cashew trees in a plantation where the canopies do not create heavy shaded areas.
- Is more likely to establish itself in cashew trees that are already suffering some level of stress. As most cashew (including in El Salvador) is grown under non-irrigated and frequently with minimum nutrition, this initial stress condition is usually water/nutrition related.

- Is an insect that thrives best in the dry season as heavy rainfall is probably the most important natural reducing agent.

- Likes to avoid direct strong sunlight so insect lives and feeds on underside of leaves of cashew tree that are away from the sunlight.

It has been previously stated that red banded thrips have a number of alternative host plants, and that they can be easily dispersed over considerable distances to new areas via the wind. Therefore when the climatic and host plant conditions (points 1-4 above) are favorable then the situation could be considered ideal for the proliferation of the pest.

The impact of a severe attack by red banded thrips could be to significantly reduce the vegetative growth of a young cashew tree. As the growth in canopy size is the main factor in increasing production this rapidly becomes an important economic loss.

While, initially red banded thrips was considered a primary pest, research in cocoa was first to show that the successful establishment of thrips on the host plant was made possible by the indirect effect of adverse factors in the physical or nutritional environment which would derange the plant's metabolism. (Entwhistle). The insect appears to be able to 'recognize' the existence of this state and it is somehow conducive to their multiplication. This is an important clue as it suggests that red banded thrips is more of an opportunistic pest and that they more easily attack plants already under stress. Examples of this relationship have been found, Denton (1997) demonstrated that the population of thrips was inversely related to the water deficit of the cocoa soils.

While the bulk of the research has been on red banded thrips and cocoa, the available information strongly indicates that the relationship between this insect and cashew is very similar to that already proven in cacao This leads to the theory that a natural defense against red banded thrips in cashew would include helping the plant to avoid stress - especially water and nutritional deficiency stress.

E3. Natural Enemies of Red Banded Thrips

Thrips species do have a number of natural enemies that have been identified in the literature. Predators of thrips include anthocorid bugs, chloropid flies, (Mount and Walker 1986), mites chrysopid and coniopterygid larvae and aeolothripids (Lewis 1973). It has also been found that wasps of the genus *Spilomena* (*Sphecidae*) can collect thrips and store then as larval food. (Mount and Walker 1982). Eulophid wasps, mainly species of *Ceranisus* (*Thripoctenus*) are also listed as thrips parasites by Lewis (1973).

Entwhistle also notes some specific predatory species of *S rubrocinctus* in cocoa in the Caribbean and South America. *Termatophylidea sp* - (Heteroptera, Miridae, Dereocorini), three of the four members of this little known genus of mirids are significant predators. This genus is limited to Central and South America and therefore would be relevant in El Salvador.

T. pilosa Reut was originally discovered in Jamaica in 1905 and both adults and nymphs were recorded as feeding on red banded thrips in cocoa. Similarly the adults and nymphs of *T. maculosa* Usinger were originally described as a predator of red banded thrips in cocoa and cashew in Mexico. In addition, *T. opaca* Cavarlho were found to feed only on red banded thrip nymphs in Surinam. The final member of the genus, *T. ocellata* has been recorded in Costa Rica, but it's feeding habits are unknown.

Entwhistle also lists some parasites of red banded thrips. *Goetheana* (Dasyscaphus) *parvipennis* is a very small internal parasite that was originally found in *S rubrocinctus* in cocoa in Ghana in 1930. It was later found to be present in Venezuela and elsewhere in the region and also to parasitize other species of thrips. The adult *G. parvipennis* is 0.5 mm in length, the female parasite will attack nearly mature thrips larvae and lay a single egg in the body of the host. The egg hatches in 24 hours, the parasite takes 6 days to devour the body contents of the thrips, two days later the parasite emerges and pupates.

The adult emerges after 10 to 11 days and lives perhaps a further 4 to 5 days - the whole life cycle is 17 to 21 days. The highest levels of population increase from an adult female under laboratory conditions was 24. Cotterell has reported that because of this parasitism red banded thrips is not as frequent on mainland of West Africa, compared to the off shore island of San Torme where *G parvipennis* in not present.

Breeding techniques for the multiplication of *G parvipennis* have been developed so that the parasite can be reared in laboratory conditions and released into the natural environment.

Two other related species have been found to be predatory to *S. rubrocinctus* and other thrips in cocoa - these are *Franlinothrips vespiformis* (the more common variety) and *F. tenuicornis*. These insects especially *F. vespiformis* is probably widely distributed throughout Central and South America has been recorded in Honduras, Nicaragua, Panama, Surinam, Venezuela and Brazil. Infection from the insect to the host probably results from the germination of a conidium adherent to the thrips, then the hypa penetrates the host skin by enzymatic digestion. The literature indicates mixed results in utilizing this agent in biological control.

Other natural enemies listed in the literature are predatory larvae of *Chrysopa* (Neuroptera) a species of lacewings, the ants *Wasmannia auropunctata* recorded in Trinidad and *Azteca chartifex* in Brazil has been observed to control thrips.

Recent research by the Department of Primary Industry and Fisheries in the Northern Territory in Australia has identified a species of green lacewings, *Mallata signata* as a predator of various pests including red banded thrips. This work has now progressed to the point where commercial breeding and release of these predators in mango plantations is being practiced. There is no reason why *Mallada signata* could not be used as a predator against thrips in cashew plantations. *Mallada signatua* is a species only found in Australia, however expert advise to the consultant indicates that there are similar species of green lacewings that habitat Central America and that in theory there is no reason why these species could not perform the same bio-control function as is undertaken in Australia.

In addition to the work on *Mallada signata,* work in Australia by Peng (1993 - 1999) has identified the weaver ant, *Oecopyhlla smaragdina* as a powerful predator of a number of cashew insect pests including red banded thrips. This work was carried further by Peng who has developed a system of control in cashew plantations using *O. smaragdina.* Unfortunately *O smaragdina* or related weaver ant species) *O. longiloda* does not habitat North, Central or South America.

SECTION III
CONTROL OF THRIPS

SECTION III
CONTROL OF THRIPS

A. Chemical Control

It is relatively easy to kill thrips including red banded thrips using a number of the commonly used chemical insecticides. However the period of control can be limited depending on the treatment used. There have been a number of trials using chemicals to control red banded thrips and the following table gives a summary of some of these results.

1. Soto 1995, Mexico - chemical spray control of red banded thrips in cocoa.

Chemical	Rates g.a.i. per litre water		
Methyl parathion	1.25,	0.75,	0.50
Monocrotophos	1.50	0.90	0.60
Carbaryl	2.00	1.20	0.80
Malathion	2.50	1.50	1.00

In laboratory all three dose rates applied, only lowest dose rate applied in field trial. Analysis in laboratory and field determined 24 hours after application. Results showed 100 % efficacy of all treatments of methyl parathion and malathion. Monocrotophos gave 94 % and carbaryl 95 %.

2. Omole 1997. Nigeria - field trials chemical spray control of red banded thrips in 13 varieties of cashew.

Chemical	Rates - % active ingredient	
Phenthoate	0.01	0.05
BHC	0.01	0.05
Dimethoate	0.01	0.05
Propuxor	0.01	0.05

Results showed all treatments at of all chemicals at 0.05 % gave good efficacy. Dimethoate was chosen for routine control as this gave the best consistent efficacy and treated trees appeared more healthy than other treatments.

3. Mendes 1984. Brazil - field trials chemical control of red banded thrips in cocoa

Chemical	Rates - grams per hectare
Propoxur	160 gm/ha
BHC	240 gm/ha
Fenitrothion	240 gm/ha
Trichlorfon	400 gm/ha
Endosulphan	480 gm/ha
Carbaryl	1,200 gm/ha

All chemicals gave 90 % control after 14 days, carbaryl, endosulphan and BHC gave 70 % control up to 21 days. Fenitrothion lost efficacy after 7 days.

4. Abreu 1973 Brazil - Comparison of dusts and sprays in control of red banded thrips in cocoa in two separate trials:

	Chemical	Spray/dust	Rates - active ingredient/hectare
A)	BHC.	dust	240 gm/ha
	malathion	spray	240 gm/ha
	phosalone	spray	240 gm/ha
	fenitrothion	spray	240 gm/ha
	diazinon	spray	240 gm/ha
(B)	2.0 % BHC	dust	16 kg/ha
	7.5 % carbaryl	dust	16 gm/ha
	4.0 % Malathion	dust	16 gm/ha
	1.5 % methyl parathion	dust	16 gm/ha
	1.5 % fenitrothion	dust	16 gm/ha

Best results came from dusts of carbaryl and both dust and spray of BHC. which gave good efficacy to 21 days. Dust and stray of Malathion, methyl parathion and fenitrothion gave high mortality in 24 hours but quickly lost effectiveness.

The research shows that a number of chemicals may be used to control red banded thrips, however the choice of chemical in the field will come down to whatever chemical has been registered for use. In the Northern Territory of Australia there are two chemicals registered for control of red banded thrips, (1) dimethoate and (2) endosulphan. However endosulphan has been found to be incompatible for use in cashew as it can cause defoliation in some varieties of cashew.

B. Organic Insecticides

There are a few options that have been found to be relatively effective.

B1. Petroleum Spray Oils (PSO)

Evidence in Australia shows that a PSO (such as DC Tron plus) used at 2 % oil in water achieves satisfactory control of thrips if applied properly. PSO s work by suffocation insects rather than by a poisoning effect. Therefore in order for it to be effective the insect must be coated with a then film of the oil, water solution. As a result the volume of spray that needs to be applied to a given area is about twice as much as the total volume used with a conventional chemical spray.

B2. Potassium Soaps

In the Department of primary Industry and Fisheries in Northern Territory of Australia, has been achieving promising results in the laboratory using potassium soaps (Natrasoap) against thrips. Potassium soaps work in a similar way to PSO's.

B3. Pyrethrum

A natural product if manufactured from pyrethrum (the plant). Some pyrethrum products are enhanced with synthetic pyrethrin. Pyrethrums act as a powerful contact spray but they have the disadvantage of having a short lasting effect - this period is further reduced in presence of strong sunlight. The consultant has no specific research data on the use of pyrethrum against thrips, however it should be effective. With this fact in mind the consultant has previously sent a supply of pyrethrum spray to the University of El Salvador for laboratory trials against red banded thrips.

C. Control using Predators and Parasites

The literature shows that there has been a number of natural enemies found for red banded thrips however there is very limited information as to how they have been utilized as agents in a biological control system.

Based on the available information a complete list of predator/parasite insects that may have the potential to be biological control agents in cashew is listed below.

• Hemiptera	(1) *Termatophylidea sp* (*T. pilosa, T. malculosa, T. opaca, T. ocellata*). (2) *Orius thripoborus*
• Hymenoptera (wasps)	(3) *Goetheana. parvipennis* (4) *Franlinothrips. vespiformis*
• Hymenoptera (ants)	(5) *Wasmannia auropunclata* (6) *Azteca chartifex* (7) *Oecophylla smaragdina*
• Neuroptera	(8) similar species to *Mallada signatus* (green lacewing) (9) *Chrysopa* (larvae)
• Coleoptera	(10) *Exochomus flavipes*
• Family unknown	(11) *Thripobobus semiluteus* (South African species)

22

Some brief conclusions on the potentials of the above species for use in cashew in El Salvador is as follows:

1. Many of the above species have previously been associated with control of red banded thrips in crops other than cashew. Most are associated with **cocoa**, in particular *Termatophylidea sp* and *G parvipennis*. Breeding techniques for *G parvipennis* have been developed and it appears to have been used for bio-control in cocoa. *Orius thripoborus* and *Thripobius semiliteus* have been associated with control in **avocado** in South Africa, however it is unknown if any techniques have been developed for their use in a biological control program.

2. Only a few insect species are recorded as predators of red banded thrips in cashew . These are:

   - *T maculosa* (*Termatophylidea sp*), which was recorded in Trinidad, but there is no further information.

   - Neuroptera, (lacewings). Are fairly common in many countries, in Australia *Mallada signata* (green lacewing) is currently being used in bio-control of *S rubrocinctus* in mango. It could also be used in cashew in Australia, except that the development of *O. smaragdina* with it's wide predatory range has taken precedence.

   - *O., smaragdina* in Australia/Asia and *O. longiloda* in Africa has proved to be a powerful predator of many cashew insect pests and in Australia Peng is developing a general cashew insect pest bio-control system using *O. smaragdina*. Unfortunately these weaver ants do not inhabit Central America.

3. Only some of the identified potential predator species are known to be significant in Central America.

   - *F vespiformis* - recorded as predator on *S rubrocinctus and* is probably widely distributed in Central America. No information if this insect has been developed as a bio-control agent.

   - *A. chartifex* recorded as predator in Brazil, possibly also in Central America. No information of any further development.

   - *G. parivennis* previously recorded in Venezuela, possibly also in Central America.

   - *T. ocellata* has been recorded in Costa Rica, but there is insufficient information about it's feeding habits.

   - Neuroptera (lacewings) similar to Australian species *Mallada signata* will be present in Central America. Need to identify these species as they could have potential as bio-control agent in cashew. Neuroptera

- *Chrysopa sp* are common in many countries and most likely to be present in Central America.

D. The Recommendation

Is for CRECER to request the University of El Salvador to conduct the following work to further identify the potential of using bio-control agents in El Salvador.

- Investigate distribution of *F. vestiformis, G parivennis* and local species of green lacewings (Neuroptera) in El Salvador and more specifically in San Miguel (CORALAMA) and San Vincente (SES).

- Investigate from other local sources (Guatemala, Honduras, etc) if any work on using above insects (and others) has been developed as bio-control agents in Central America.

SECTION IV
CONCLUSIONS AND RECOMMENDATIONS

SECTION IV
CONCLUSIONS AND RECOMMENDATIONS

A. Main Conclusions

1. Red banded thrips is clearly a well established species in El Salvador and has been observed in cashew on a number of plantations. In the consultant's experience he observed that the pest had already caused damage to a significant number of the younger trees.

2. To date there has been no control measures undertaken against thrips on the plantations. In San Miguel all the attention so far has been focused on the *Leptoglossus sp.* which has caused the highly visible damage to the crop. Red banded thrips damage has been tolerated and considered a lower level problem because it is only evident in some of the plantations (San Remon Chilanguera, Maquigua) where there are a lot of smaller trees. At CORALAMA, with it's mature trees, thrips is not really an issue. At SES, red banded thrip is potentially a significant issue on all the plantations as they are virtually all younger trees. However no control measures have been attempted because of a lack of technical information and the lack of resources.

3. In the absence of effective control measures red banded thrips will continue to cause damage to the young cashew trees at both sites. This threat is particularly significant for SES who are planning to plant more areas with cashew.

4. It would be preferred not to use chemical sprays to control thrips as this would negate any chance of producing organic cashew. In addition spray programs are only really effective if the timing and area of spaying is correct and this is difficult to do without and effective insect monitoring program. In addition the cooperative and SES currently lack the necessary land based equipment to properly apply the sprays. Aerial spraying techniques would be less effective against an insect feeding on the underside of leaves.

5. So far no organic spays have been tried because of a lack of sufficient technical data on their effectiveness (+ a lack of resources to apply them)

   However the organic sprays - potassium soaps and petroleum spray oils have been successfully used in Australia to control red banded thrips in mango. Pyrethrum may also be effective against red banded trips but the consultant has no relevant data.

6. There is no information on bio-control of red banded thrips in cashew. However the green lacewing *Mallada signata* is used as a predator agent to control red banded thrip in mango in Australia. There is no reason why this insect could not be used in cashew. However *Mallada signata* does not inhabit Central America and it would be necessary to find a similar species in the region in order to progress this option.

26

B. Recommendation

Isto use short term and long term strategies regarding control methods as well as immediate and continuing management methods to minimized red banded thrip attack.

B1. For Short Term Control

The use of the organic insecticides should be utilized. This strategy involves two phases:

1. The University of El Salvador is currently undertaking some research to identify indigenous organic products that may be effective against red banded thrips. This work should continue.

2. The University of El Salvador can be requested to undertake some simple field trials on the plantations at San Miguel and at SES using potassium soap, petroleum spray oil and pyrethrum. These trials could be part of the current research work being undertaken on red banded thrips on behalf of CRECER.

   These trials would involve say 10 trees in each trial, spraying should commence when moderate populations of red banded thrips have been indicated and there should be two sprays within 14 days to break the life cycle. A population survey a few days after the second spray could determine the efficacy of the spray.

   These trials would use hand operated spray equipment. If successful it allows some control measures to be used but it is only a limited answer as the lack of equipment on the plantation, and the difficult terrain in some plantations (especially San Miguel) makes extensive land based spray operations very difficult. In these circumstances aerial applications are the only practical methods of applications, but unfortunately the application of potassium soaps and petroleum spray oils are unlikely to be effective by aerial application against a pest that characteristically inhabits the underside of the cashew leaf.

   The plantations at SES are largely located on flat land of easier access and assuming sufficient equipment is available land based spraying could be undertaken.

B2. Longer Term Strategy

Of using natural predators as a biological control system may have potential but a significant amount of further work would required to be done. The recommended course of actions would be to identify and clarify the potential of the following:

1. Identified potential predator species of green lacewings (Neuroptera). If the work on identification of appropriate local species of green lacewings is successful, then the consultant can introduce experienced sources from Australia who could assist in the development of that insect in a control scheme.

2. Investigate distribution and abundance of *F. vespiformis, G parivennis).*

3. Find out from other research institutions in Central America if these predators have been developed as a natural control agent in other crops in the region.

4. As a **management strategy** it is necessary to assist the cashew trees to avoid stress - mainly water and nutritional stress. As indicated in section 2.5.2 of this report, red banded thrips appear to be attracted to trees that are under some form of stress, frequently water or nutritional stress. Clearly the use of supplementary water via an irrigation system is completely impractical in El Salvador, however the proper adherence to a nutritional program on the plantations as previously recommended by the consultant would be very beneficial.

SECTION V

ACKNOWLEDGMENTS

SECTION V
ACKNOWLEDGMENTS

My thanks to Dr. Mali Malipatil of Agriculture Victoria for helping me find the reference literature and for his comments on the paper.

My thanks also to Dr Renkang Peng of Northern Territory University for his review of my paper, for his advice on recent developments in biological control using *Mallada signata* in Northern Australia and also for information of his work in developing *Oecophylla samaragdina* as a predator of cashew insect pests.

SECTION VI
REFERENCES

SECTION VI
REFERENCES

Used in this Paper and for Further Study

1. **Pests of Cocoa** P.F Entwhistle. Published in Tropical Science Series. Longman.

2. **Thysanoptera (Thrips)** L.A.Mound and B.S. Hemming. published in Insects of Australia, 1989.

3. **Red Banded Thrips in Fruit Trees.** Graham Young and Deanna Chin. Agnate No 752 may 1998. Northern Territory Department of Primary Industry and Fisheries.

4. **Miridae of Genus Termatophylidea (Hemiptera) as Predators of Cacoa Thrips** E. McC Callan. Entomophaga 20 (4) 1975 pages 389 - 391.

5. **Basis for a Practical Technique for Monitoring Thrips in Avacado Orchards** G.B. Dennill and M.J. Erasmus. University of Pretoria South Africa. Published in Crop Protection Vol 11, February 1992.

6. **Identification of Western flower Thrips (WFT) and Other pest Thrips.** Mali Malipatil and Ketvyn Dunn, Agriculture Victoria. Course Notes. undated.

7. **Host Plants of Red banded Thrips** W.P Steyn, Inligtingsbulletin No 245 , 3 1993

8. **CSIRO Insects of Australia.**

9. **Injury to Young cashew Plants by Red Banded Thrips, Selenothrips rubrocinctus Giard (Thripidae)** A.D. Ogboekew Agriculture Ecosystems and Environment 1985 13, pages 26 - 32.

10. **Minor Pests of Macadamia** D.A. Ironside, Queensland Agricultural Journal November/December 1975 105.

11. **Evaluation de Insecticidas Sobre *Selenothrips rubrocinctus (GIARD)* en el Cacoa de Tabasco, Mexico.** Saul Sanchez Sato y Daniel Arturo Rodriguez Lagunes. Agrotropica 7 (2) pages 27 - 30 1995.