REPORT ON MAJOR INSECT PEST PROBLEM

AT CORALAMA, EL SALVADOR

AN ASSIGNMENT FOR

NATIONAL COOPERATIVE BUSINESS ASSOCIATION
WASHINGTON. DC. USA

and

CRECER, SAN SALVADOR. EL SALVADOR

IAN DUNCAN **August 1997**

BRIEF SUMMARY OF REPORT

At CORALAMA insect pests are causing a 35 % loss of final product This loss is caused because damage to the developing nut in the field results in the kernel being discarded during processing

Insect pests are having a significant financial impact on CORALAMA In the period 11 October to 30 December 1996, CORALAMA processed 100 mt of raw nuts and sold the kernel on the organic cashew market If there had been effective control measures in the plantation to reduce insect pest damage levels by say 80 % (100 % control is impractical), then CORALAMA's net revenue would have been increased by about $US 48,000

If CORALAMA were to process and sell it's total crop of about 600 mt raw nuts and continue to suffer a similar damage ratio then the revenue forgone could be considerable

The main insect pest at CORALAMA is Leptoglossus zonatus (L zonatus), but it is likely that the other Leptoglossus species L concolor, L stigma, and L cinctus are also important In addition there are probably other insects present as minor pests Leptoglossus sp are large sucking insects and feed on the developing nuts by pushing their proboscis through the shell to suck out their nutrients This feeding action causes necrosis on the kernel thus resulting in kernel loss during processing

The current control program at CORALAMA which involves aerial application of neem is highly unlikely to have much impact on these major pests This is because neem's action is like a slow acting 'stomach poison' that is suitable for pests that either have a high metabolic system or spend a long time feeding on the host plant (ie caterpillars) In contrast Leptoglossus sp have a slow metabolic system and are in contact with their host plant only for a brief period during feeding

Chemical insecticides are highly effective against Leptoglossus sp but this is prohibited to CORALAMA to preserve it's OCIA approved status Unfortunately the other alternative organic insecticides (pyrethrum, high potassium soaps, vegetable/ petroleum oils) may have a limited value in this situtation

In the long term good potential may exist with biological control especially through predation and parasitism of Leptoglossus sp eggs, and of adults and nymphs by parasitic wasps like Trichopoda sp However practical use of these options would require significant further work and take time

In the short term a strategy of identifying and neutralising the breeding sites of Leptoglossus could offer immediate relief There are a number of possible breeding sites - the most likely are specific host plants (ie curcubits and legumes like Passiflora sp, Momordica charantia and gourd family plants either growing as weeds inside or adjoining the plantation or being cultivated in private gardens adjoining the plantation The Leptoglossus sp could be breeding in leaf litter on plantation floor (but much less likely), and finally it is possible they could be breeding on the cashew trees

The choice of breeding site may depend on the individual species and as apparently more than one species of Leptoglossus is present at CORALAMA it is also possible that different breeding sites are involved

So far the consultant does not have definitive information on the location of breeding sites at CORALAMA but this information could be obtained with further work Information on the likely breeding sites would allow a targeted control program of search and destroy to be undertaken

The possibility that the major pests may be breeding (and feeding) on the cashew trees makes for increased difficulty in control in the absence of a suitable effective insecticide

In the long term biological control offers the best option, however to obtain the necessary base line data would require a bio-ecology study of the insect environment at CORALAMA This could be achieved at reasonable cost with the cooperation of the Department of Entomology at University of San Salvador, perhaps with assistance from Crecer's contacts in Guatemala (Agri Lab Guatemala)

A number of significant issues have been raised by this report and the consultant will maintain a watching brief to progress matters as more information comes to hand

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1 0 BACKGROUND TO THIS ASSIGNMENT

In January 1997 the consultant visited El Salvador for 4 weeks and undertook an assignment for NCBA and Crecer at the CORALAMA cashew plantations and factory Following the final report it was agreed that the consultant would undertake a further five days of work on entomology issues related to the main consulting work

During the consultant's investigations at CORALAMA during January 1997 it became apparent that the insect pest situation at CORALAMA was quite unlike normally found in cashew growing regions elsewhere It was established that the common major pests found elsewhere (helopeltis, caterpillars etc) were not apparent, however an unusual insect pest for cashew, presumed to be L zonatus and other species were responsible for a major loss of crop This loss was estimated to be a minimum of 35 % of kernel effectively destroyed during processing in the factory because of insect pest damage to the crop in the plantation There was no estimate possible of any crop loss in the field during fruit development This level of loss is unsustainable if the CORALAMA business is to remain profitable

Both the management at CORALAMA and consulting staff at Crecer believed 'chinches colzonudas ' to be L zonatus and possibly other species The consultant was advised that an entomologist (name unknown) had visited CORALAMA a few years previously and had undertaken some very brief identification work The consultant also visited Senor Leopoldo Serrano of Department of Entomology, University of San Salvador who advised that in his opinion the major pest in cashew and other crops was L zonatus and possibly other species but these lacked expert formal identification It was to assist in clarifying these issues that Senor Serrano supplied the consultant with specimens for identification (see 2 0)

As CORALAMA is an organic cashew producer as certified by OCIA they are prohibited from the use of chemicals and their current control measures for Leptoglossus sp involves usually three aerial applications of neem oil per growing season There was no information available in El Salvador as to whether neem was an effective agent to control Leptoglossus sp, however from the observations in the field the consultant had his doubts In addition while aerial application methods are appropriate for the topography at CORALAMA there was no evidence of the effectiveness of the techniques being used by the spraying contractor

In his report of January 1997 the consultant made the following recommendations,

1 To make positive identification of major pest species

2 Undertake a bio-ecology study at CORALAMA to identify pests and beneficial insects as a preliminary for any future biological control work

3 Determine efficacy of neem against major pest species Also investigate efficacy of alternative organic insecticides

4 Evaluate effectiveness of aerial spraying techniques used

In order to help clarify some of the issues raised in his report of January 1997, NCBA and Crecer requested the consultant to undertake this short assignment

The consultant wrote this report from resources available in Australia He is in contact with sources in Guatemala (Nina Romero of Agri-Lab and Dr Sanchez at University of Valle), however these sources were unable to assist in the time frame of this report At a later date when these sources are able to assist, then the consultant can undertake amendments to this report if required

2.0 TERMS OF REFERENCE FOR THIS ASSIGNMENT

The following are the main objectives,

(a) Identification of species found on cashew in El Salvador
(b) Documentation of information about the insect pest
(c) Investigation about control measures, including current measures undertaken at CORALAMA and recommendations for future control

To undertake this assignment the consultant sought assistance from three entomologists experienced in tropical insects and also undertook an extensive literature search of over 250 references From this it became clear that Leptoglossus is a highly unusual pest of cashew and that there is little experience elsewhere in cashew in dealing with such a situation

3 0 IDENTIFICATION OF SPECIES

The consultant was unable to collect any presumed L zonatus and other specimens in the field at CORALAMA However Senor Leopoldo Serrano of Department of Entomology, University of San Salvador was able to supply the consultant with 15 specimens of insects pests of Coriedae family collected on cashew and other crops in El Salvador The university had been unable to positively identify these specimens because of a lack of expert resources

After returning to Australia with the specimens the consultant requested assistance from entomological taxonomist Dr Malipatil of Horticultural Research Station, Knoxfield, Victoria for his assistance in identification

Identification of specimens is a complex and time consuming task and to date Dr Malipatil has reached the following conclusions,

positive identification -	L zonatus
preliminary identification -	L concolor
	L stigma
	L cinctus
	Other Coreidae species

Dr Malipatil will continue his work and will complete a positive identification of all specimens in due course

While only some of the specimens were actually collected on cashew the wide range of host plants used by this insect family suggests that a number of them could be pests of cashew at CORALAMA However all species in this collection are from Coreidae family that have similar breeding and feeding habits and therefore would be subject to a similar control strategy

Finally it must not be concluded that this collection will represent the total insect pest range at CORALAMA - this can only be determined by a bio-ecology study at CORALAMA

4 0 INFORMATION ON LEPTOGLOSSUS SP (chinches calzonudas)

4 1 Background to Genus

Leptoglossus, commonly called 'leaf footed bug' is a Heteroptera Coreidae and there are a number of species of the genus Leptoglossus which occur in many countries on a range of crops The genus occurs throughout a wide range of North, Central and South America, and parts of Asia, Oceania and Australia They attack a wide range of crops including citrus, some tropical fruits, pistachio, almonds, sorghum, maize, legumes, pine seed, etc In addition in Papua New Guinea, L australis was observed attacking the branches of Coffee arabica while in Texas it was reported as a pest of cotton In Cuba, L concolor was reported on cashew and guava

The most common species recorded in the literature appear to be L corculus (pest of pine seed), L clypealis (pest of pistachio, almond) and L phyllopus (pest of citrus, sorghum)

L zonatus is reported as occurring in Southwestern USA, Central and South America and the Caribbean In USA it recorded as a pest of citrus, peaches, dates and watermelon and especially on pomegranate In Costa Rica it is reported as a pest of maize, cotton, dates, citrus, peach, sorghum and watermelon From information collected so far El Salvador is the only country where L zonatus has been observed on cashew

4 2 Biology and Life History of L Zonatus

Like other of the species L zonatus is a large insect attaining 20 mm or more in body length at maturity It is dark brown in colour with a whitish stripe horizontally across the middle of it's back Also like the other species L zonatus has dorsal abdominal scent glands The male scent glands excrete a stronger odour than do females Studies by Aldrich indicate that the scent excretion from the males probably act as long range female attractants However these scent excretions appear distasteful to other insects and this acts as a powerful predator protection system

(In the case of Trichopoda sp - a potential parasite of Leptoglossus sp, this scent probably acts as an attractant which may give a potential for biological control, see 5 3 below)

Laboratory studies on the longevity and fecundity of L zonatus revealed the following data

Fecundity Temperature effects fecundity The proportion of pairs of zonatus depositing eggs ranged from 60 % at 35 degrees C to 90 % at 20 degrees C

Eggs Are brownish in colour and hemi-cylindrical in shape and are laid end to end in long chains usually along leaf midrib and stems of hosts plants The mean number of eggs per fecund female ranged from mean of 74 at 35 degrees C to 153 at 20 degrees C

Hatching Temperature effected the time taken for eggs to hatch, 6 5 days at 30 degrees C to 17 4 days at 20 degrees C The critical temperature for egg hatch was not tested but it appeared that some eggs would hatch at temperatures even below 15 degrees C

Nymph The nymph development stage varied significantly depending on temperature and diet At 35 degrees C the nymph stage was 24 to 34 days while at 20 degrees C it was 80 to 137 days Nymph survival rates to adulthood also varied significantly from 12 % to 64 % in the various experiments

15 degrees C appeared to be the critical level for nymphs to complete development

Adult Longevity also varied significantly depending on diet and temperature Adults showed a shorter longevity at higher temperatures, 48 to 74 days at 35 degrees C and 176 to 260 days at 20 degrees C

Post-reproduction makes up 23 % to 42 % of total adult longevity

4.3 Host Plants, Feeding Methods and Damage Symptoms

Host Plants - The Leptoglossus genus have a wide range of host plants for breeding and feeding purposes (see 4 1) The more likely breeding sites will be on legumes and cucurbits like Passiflora sp, Momordica charantia L, gourd family plants and cucumbers, pumpkins etc (Stuart Smith personal communication 1997) These breeding sites could be inside the plantation (as weeds) or outside the plantation (weeds or private gardens) Some species may breed on the anacardiaceae family plants - ' cashew trees ' (Malipatil personal communication 1997), and it is also possible that other species may breed in leaf litter on the ground (Peng personal communication 1997) We are aware from the literature that Leptoglossus have been observed feeding on a wide range of plants - at CORALAMA the anecdotal evidence suggests that they are found on nearby maize, sorghum and other crops apart from the cashew

If these pests are moving from a preferred breeding site to another feeding area they may have the capacity to move reasonable distances A study undertaken in the UK determined that an insect's capability to fly distances was a function of body length times wing span (Peng, personal communication 1997) As Leptoglossus sp adults are large insects it can be presumed that they would have a significant range There is no specific information available on Leptoglossus sp but a practical estimate could be about 2 km (Stuart Smith, personal communication 1997)

At this stage the consultant has no definitive information on the likely breeding sites for L zonatus and the other species present at CORALAMA

In theory the breeding and feeding pattern at CORALAMA could be as follows,

(a) breeding outside the plantation, perhaps on weeds adoining plantation or in the gardens of the CORALAMA population (curcurbits etc) and moving into the cashew trees to feed

(b) breeding on nearby host plants inside the plantation (gourd family weeds ?) and moving to cashew trees to feed

(c) breeding and feeding in the cashew trees

(d) breeding in leaf litter and feeding on cashew trees

On balance of probabilities options (a) and (b) are the most likely The feeding pattern may involve the Leptoglossus sp moving between cashew and other crops (say maize, sorghum) as feeding sites depending on the respective cropping seasons

The key to determining the breeding areas of L zonatus and the other species at CORALAMA is to identify the location of where Leptoglossus sp eggs and early stage nymphs (which have no wings) are found Where these are found will prove the location of the breeding sites To determine whether cashew is a breeding site this examination needs to be done at time of cashew tree flushing and flowering (December - February)

Method of Feeding and Damage Symptoms - Leptoglossus sp (and all Coreidae) are sucking insects and they have a proboscis which they use to pierce the outer skin of their food in order to suck in the nutrients they require They have the capacity to pierce quite hard outer surfaces to reach their food - the damage to developing pistachio nuts in California by L clypealis and L occidentalis is well documented

Studies have shown that Leptoglossus sp nymphs and adults can pierce the pistachio endocarp layer when it has a firmness of 4 0 kg or more - in other studies Leptoglossus caused damage until the nuts were harvested

The damage to the pistachio epicarp is indicated as epicarp lesion disorder (EL) and the impact on the kernel is described as kernel necrosis (KN) - a brown necrotic lesion on the kernel which marks the damage at the feeding site It has been shown that Leptoglossus sp can cause KN on the kernel within 48 hours of feeding In his study (Uyemoto et al) suggests that the EL symptoms were not due to an externally introduced enzyme by the insect during feeding, but due to the oxidation of phenolic compounds resulting from loss of compartmentation caused by the insect's mechanical probe going through the tissues

The consultant could find no detailed specific references of L zonatus and other species feeding habits on cashew but based on expert advice and his own observations at CORALAMA they could be very similar to the pistachio model However the differences with cashew include cashew nut shell liquid (CNSL) contained within the mesocarp, and a shell that attains significant hardness CNSL - 90 % anacardic acid could be an inhibiting deterrent to insects that like to penetrate the shell during feeding so it is suggested that Leptoglossus sp would prefer to attack cashew nuts prior to maturity and before the shell hardens and the CNSL is fully formed There is no information as to whether the cashew apple acts as an attractant for Leptoglossus sp

5.0 CONTROL METHODS

5 1 Insecticide Control

The literature shows that very effective control of Leptoglossus sp is achieved by chemical insecticides In a study by Debarr and Nord, 34 insecticides were tested for efficacy against Leptoglossus corculus They found that the insect pest was highly susceptible to most of the chemicals used including the well known types, triclorfon, dimethoate, malathion and permethrin

However as an OCIA approved organisation chemical insecticides are prohibited and CORALAMA can only use organic insecticides for insect control The possible substances in this group include neem, pyrethrums, high potassium soaps and petroleum oils The current practice at CORALAMA is to apply neem via aerial application

Neem is an organic insecticide made from azadiractin - the active ingredient processed from neem seed Neem is not a rapid 'knock down' spray, instead it is relatively slow acting and behaves more as a type of 'stomach poison' to discourage feeding by insect pests although it also has fatal toxic effects if it sufficiently ingested by insects

The nature of action by neem makes it highly suitable for leaf eating insect pests like caterpillars that spend considerable time on the foliage and crop during feeding Work in Australia with neem in caterpillar cashew insect pest control has found it to be reasonably effective - usually attaining it's maximum impact 5 - 7 days after application

However neem would appear inappropriate for Leptoglossus sp control as these pests make only brief contact with the crop in the process of feeding It may have a minor deterrent effect only On the positive side neem would have no adverse effects on pollinating insects and little on beneficial species It may also have some control effect on Selenothrips rubrocinctus which is an occasional major pest at CORALAMA - however this is only a suggestion and is not yet documented

Pyrethrum is an insecticide processed from the pyrethrum plant that acts as a contact fumigant It has a rapid 'knock down' effect but is short lived, and this life is further reduced to perhaps two hours in the presence of strong UV light Pyrethrums are very effective at killing insects with a high metabolic rate, however Leptoglossus sp tend to have a slow metabolic system Pyrethrums will also kill pollinators and beneficial species

High Potassium Soaps (HPS) appear to have a chemical toxic effect on the cuticle of the insect pest and this leads to desiccation of the body In general HPS are effective against small insect pests like aphids, thrips etc (Peng - personal communication 1997) - it is highly unlikely they would have any impact on eggs and on adult Leptoglossus HPS could be useful for Selenothrips rubrocinctus which is occasionally a significant pest at CORALAMA Also on the positive side HPS do not effect pollinators and beneficial species like parasitic wasps as these insect are fast moving and will escape the impact of this insecticide

Petroleum/Vegetable Oils (P/V OILS)- These oils cover the foliage when applied and have an impact of causing 'death by suffocation' P/V Oils will have no effect on eggs and whether they have any impact on Leptoglossus nymphs is unknown but very likely none on adults

5 2 Control Using Biological Agents

The expert view (Stuart Smith personal communication 1997) is that Leptoglossus sp adults and nymphs are probably well defended against predators by their scent glands that emit an odour that would make them distasteful to other insects and possibly even birds (see 4 2) The potential predators of adults and especially nymphs will be limited, experience in Australia suggests that these may include some spiders, mantids and possibly small reptiles

Advice from Graham Young (Entomologist Northern Territory DPIF, (personal communication 1997) is that one type of parasitic wasp - Trichopoda sp, can act as a parasite of both adult and nymph Leptoglossus sp Trichopoda sp is native to the Americas (including Central America) and it has the unusual capacity to lay it's eggs on the bodies of the Leptoglossus sp (the consultant has no information specifically regarding Trichopoda sp and L zonatus) There is no reason to suspect that this Tichopoda relationship is different between Leptoglossus sp and this gives a potential for biological control on adults and nymphs of the Leptoglossus sp present at CORALAMA

The parasitism and predatation of Leptoglossus sp eggs also offers a good avenue for future biological control There were no relevant references to L zonatus, however there have been studies on other Leptoglossus sp One study by Paula and Forrest Mitchell in Texas on predation and parasitism of L phyllopus was relevant This study tested some parasitic species and found a wide variation in egg parasitism depending on the time of season and host plant This ranged from 84 % of eggs parasitised in spring to 9 8 % in late summer The effect of one identified parasitiod ranged from 8 3 % to 34 0 % of eggs parasitised on two different host plants The study found that Gryon pennsylvanicum and Anastatus sp (small parasitic wasps) to be an effective parasitiods and Solenopsis sp (fire ants) to be effective predators of Leptoglossus sp eggs

However biological control methods utilising parasitism and predatation of eggs of zonatus will be a longer term business for CORALAMA that would involve further preparatory research

5.3 Control by Management Methods

An additional strategy to the general use of insecticides and biological agents would involve using appropriate management strategies This could be identifying and destroying the breeding sites for L zonatus and other species so as to break the life cycle pattern

The problem here at the outset is to identify the locations of the breeding sites The possibilities are

(a) **Area outside cashew plantation** - legumes, curcubits etc either grown in private gardens or similar plants growing wild In this event at CORALAMA the Leptoglossus sp may be feeding on a range of crops surrounding breeding sites like cashew, maize sorghum etc

(b) **Area inside cashew plantation** - on legume or other weeds in plantation or possibly on cashew trees or in leaf litter

The strategy to resolve this issue should commence with further detailed entomology work (literature search, further communication with University of El Salvador for local expertise etc) to improve knowledge on likely breeding sites for the relevant species This would be followed by a detailed search of the target areas to identify presence of eggs and early stage nymphs

The presence of eggs and early stage nymphs confirms the location of the breeding sites Once these have been located action can be taken to destroy them

The required action will depend on the circumstances as follows,

(a) **If the breeding sites are on weeds** located inside the plantation then physical destruction of these plants may be most appropriate

(b) **If breeding sites are in private gardens or other plants outside the plantation** then the issue is more complicated The flying range of the adult insects needs to considered (perhaps 2 km or more) and balanced with what can be achieved practically in a control program In addition it is necessary to consider CORALAMA's organic status which would prohibit the use of chemical insecticides (the most potent weapons) within a certain distance of the cashews, and also the attitudes of the owners of the private gardens

If it is inappropriate to use chemical insecticides (which kill adults and nymphs but posssibly not eggs) then perhaps pyrethrum, the only likely organic insecticide with some effectiveness in this situation could be used to try and control the breeding sites Pyrethrum is a powerful knock down spray, but is short lived and relatively expensive and there is no information if it is effective against Leptoglossus sp eggs

(c) **If breeding sites involve leaf litter** on the ground then a clean up as best as can be done is required

(d) **If the Leptoglossus sp are breeding on the cashew trees** then the most difficult situation exists given the prohibition of chemical sprays at CORALAMA and the limited effectiveness of the organic insecticides against this pest As yet the consultant can offer no ready made solution in this event

6 0 CONCLUSIONS AND RECOMMENDATIONS

The following main conclusions may be reached,

1 It is confirmed beyond reasonable doubt that L zonatus is the major pest of cashew at CORALAMA There is also reasonable certainty that three other Leptoglossus sp may be present as well as other Coriedae species as minor pests However regardless of the final details of these insects the similarity in life cycle habits of the Coriedae family would require the application of the same control strategy

It must be emphasised that this is only a very superficial description of the total insect pest situation at CORALAMA and that only a specific bio-ecology study at CORALAMA will reveal a more complete picture of the pest and beneficial species

2 It is highly unlikely that CORALAMA's current insect control strategy of using aerial applications of neem will be effective in achieving any worthwhile control of L zonatus or other species It is also very unlikely that any other organic insecticide will do a better job than neem THIS POSES MAJOR PROBLEMS AND REQUIRES A RE-EVALUATION OF THE CURRENT SPRAYING PROGRAM AT CORALAMA

3 The best long term control method would appear to be the development of a system allowing greater use of egg predatation and parasitism - however this approach is long term and would require some years of research to achieve In addition the parasitism potential of the Trichopoda sp on the Leptoglossus nymphs and adults could be exploited

4 Some short term 'ready to use' control measures such as identifying and destroying breeding sites are essential

Following his initial visit to El Salvador in January 1997 the consultant made recommendation on two major issues These were as follows,

1 Specimens of Leptoglossus sp and other likely pests to be positively identified

2 Investigations be undertaken to evaluate whether aerial applications of neem are effective in controlling L zonatus

3 Work on a study of the bio-ecology of the insect species be commenced at CORALAMA as the first step in the biological control program

As a result of this assignment the consultant makes the following adjustments to his recommendations as follows,

A : For Longer Term Benefit

1 **Bio-ecology** work should proceed with the emphasis on the potential of predators and parasites of eggs of L zonatus and other species eggs and on the potential of Trichopoda sp or similar as a parasite of adults and nymphs Progress on this issue can proceed on the following fronts as follows,

(a) Further investigation in Central America where Leptoglossus sp are present will reveal what work has been previously undertaken From his literature search the consultant is aware that work on L zonatus has been undertaken in Costa Rica (see reference no 11) In addition the sources available in Guatemala (Agri-Lab and Dr Sanchez at Universidad de Valle) may be able to assist

(b) The work at CORALAMA can be adjusted depending on what local information is available If applicable previous studies on zonatus and the other Leptoglossus sp egg parasites in Central America are not available

then work will need to be commenced The initial task of identifying parasites of Leptoglossus sp eggs is reasonably straight forward (Stuart Smith personal communication 1997) It involves finding the eggs and allowing them to hatch in the laboratory and identifying what parasitic insects emerge In addition once host plants are known a breeding colony could be set up in the laboratory and the resulting eggs could be exposed at the appropriate time in the field to establish which insects act as parasites

In addition work needs to be commenced on identifying whether Trichopoda sp is present at CORALAMA

HOWEVER the information provided in this report can only be a small basis for and can be incorporated in a Bio-ecology study as recommended in my January 1997 report - see (c) below

(c) Bio-ecology Study of the insect environment at CORALAMA needs to be undertaken This study would provide the base line data and is an essential first step in any future biological control work at CORALAMA

With the cooperation of the Department of Entomology, University of San Salvador this work could be undertaken at relatively modest cost This could involve making this study a Masters degree thesis for an approved student The main phase of this study would involve the collection of specimens of all insects at CORALAMA - both pest and beneficial species Once the complete insect environment is documented the potential exists to evaluate a possible biological control strategy

To undertake this first stage (collection of data in the field) the student would have to be located at CORALAMA for a period of time but would be supervised by the University From his previous discussions with Senor Serrano the consultant believes the potential exists to make such an arrangement

B : For More Immediate Control

2. Introduce appropriate management methods It is necessary to identify as best as possible the breeding sites for L zonatus and other species whether inside and / or outside (radius of say 2 km) to the plantation at CORALAMA Upon discovery these sites need to be destroyed or sprayed which ever is appropriate (Note - there is no information on how far Leptoglossus sp will move from breeding to feeding sites and the 2 km suggested represents an achievable target from a management point of view)

The first stage should be further investigation with expert sources and literature search to try and pin point the type of breeding sites favoured by the specific species present at CORALAMA - L zonatus, L concolor, L stigma, L cinctus and also the other Coriedae pests that are likely to be present

Depending on what information this investigation reveals then the search and destroy program on breeding sites could be targeted on one or some of the following options In all cases the presence of early stage nymphs and eggs indicates the location of a breeding site

Inside the Plantation the staff can do transects across the cashew plantation to

(a) identify location of the preferred host plants (legume weeds etc) being used as breeding sites Upon discovery the host plants need to be destroyed An on-going program of monitoring and removal of host plants would be required

(b) undertake systematic examination of leaf litter to determine whether the pests lay their eggs in this location A systematic removal of leaf litter would be required

(c) Sample examination of leaves on cashew trees to indicate whether they are used as breeding sites This examination to be undertaken when cashew trees are flushing and flowering (December - February)

Outside the Plantation

(d) Survey of area adjoining plantation to identify location of host plants either in private gardens or growing wild The area of examination is suggested to be a minimum 2 km - this is based more what is practical rather than the maximum movement range of the insects Host plants growing in the wild can be destroyed, if host plants are in private gardens then spraying is required Chemical insecticides could be effective however if these are inappropriate then pyrethrum could be used, however the consultant has no information about whether pyrethrum is effective against Leptoglossus sp eggs

C · Current Neem Program

1. Further Evaluation of Neem Program

Although the evidence would suggest that the aerial neem applications are not effective against L zonatus and the other Leptoglossus sp it would be inappropriate to abandon the program immediately for a number of reasons

These are,

(a) There is the 'political' problem of abandoning the program before an alternative program that works can be put in place

(b) The bio-ecology of insect pests at CORALAMA is not yet fully understood and it is possible that other currently minor pests (especially caterpillars) exist and are being controlled by neem In addition Selenothrips rubrocinctus is an occasional major pest and although not as ideal as some chemical insecticides, nevertheless neem appears to have some effectiveness against this pest

For action against thrips there is also the option of using neem / high potassium soaps mixtures which may be more effective than neem alone

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My thanks also to Graham Young (entomologist Northern Territory DPIF, Darwin) for his advice on Trichopoda sp

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11 **Notes on Food Resources and Behavior of family Coriedae (Hemiptera) in Semi-Deciduous Forest** proceedings of Entomological Society of Washington 1981 Pages 428 - 443 (Leptoglossus zonatus in Costa Rica)