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FINAL REPORT - BSS236
MANAGEMENT STRATEGIES FOR RHYPARIDA IN SOUTHERN QUEENSLAND

by

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SUMMARY

Larvae of rhyparida beetles bore into the bases of newly ratooning shoots, causing dead hearts. Very minor damage will kill 'surplus' shoots. More intense damage appears to set plant growth back and cause some yield loss. Prolonged attack will kill all shoots and kill the stool, leaving large gaps and necessitating replanting. No insecticide is registered for control of the pest and the efficacy of cultural controls is unknown.

The project developed a better understanding of the phenology of *Rhyparida nitida* – this species has a one-year life cycle with extended oviposition over summer, slow development of small larvae during autumn and winter, and more rapid development of larger larvae during spring. The extended oviposition means that each generation has individuals of widely varying ages.

Sampling statistics were determined for larvae and adults of *R. nitida* and for the symptoms of larval damage. These allow time-efficient sampling with known degrees of precision and will be useful in further work on this species.

Chemicals that attract adults of corn rootworms were tested to determine if they attract adults of *R. nitida*. None of those tested attracted adults of *R. nitida.*

In field surveys over two years, there were no consistent associations of farming practices with numbers of rhyparida larvae. This is consistent with an insect that has adults that are very mobile and are nonselective for oviposition.

In on-farm participatory field trials, there were no significant effects of varieties, trash management, management of potential harbourage areas or management of breaks on subsequent numbers of rhyparida larvae.

Application of insecticides to the soil surface followed by irrigation did not give any significant reduction in numbers of larvae. When Furadan® was coultered into the soil it did provide some control of larvae, but did not improve subsequent yield of cane. Confidor® and Nemacur® did not provide any significant control or yield increase. These results indicate the compensatory ability of the sugarcane plant following damage and the difficulty in timing applications to adequately target larvae.

Extension of outcomes to stakeholders took place through grower discussion groups, on-farm participatory trials, and newsletters.

1.0 BACKGROUND

In the 1996-97 and 1998-99 sugarcane growing seasons, damage by larvae of rhyparida (especially *Rhyparida nitida* Clark) increased in southern Queensland. Estimates of areas with damage ranged from 3,000 ha in the Isis mill district, 800-1,000 ha in the Millaquin district, lesser areas in the Fairymead and Bingera districts, to a few farms in the Maryborough district. Losses in these areas ranged from 10% of yield to ploughout and replanting. No useful tools for the management of rhyparida have been developed before these outbreaks. The large increase in areas damaged by rhyparida caused considerable concern in the grower community in southern Queensland. The potential for this pest to be a constraint on production was significant, and it was feared that in the Isis mill district rhyparida had the potential to be as important a pest as Childers canegrub.

BSES and the Isis CPPB, together with input from the Bundaberg and Maryborough CPPBs, initiated and funded the Canegrowers Rhyparida Action Program during 1998-1999. In 1998-99, the program focused on a survey aiming to determine factors that predispose fields to damage by rhyparida, on studies of the biology of the pest, and on testing insecticides for control of larvae and adults. BSS236 continued all the objectives of the Canegrowers Rhyparida Action Plan. This project aimed to broaden the control options for rhyparida in southern Queensland through a better understanding of the biology of the pest and the screening of insecticides.

2.0 OBJECTIVES

The project aimed to develop a suite of management techniques for the control of rhyparida from which growers could choose the most appropriate for their situation.

Specific objectives were to:

- improve the understanding of the biology of *Rhyparida nitida* and identify points in its life cycle vulnerable to control measures;
- determine factors that predispose fields to damage by rhyparida;
- manipulate predisposing factors and determine the impact of those on minimizing the economic impact of the pest;
- determine the usefulness of insecticides for reducing numbers of the pest and minimizing damage;
- assist growers to test and evaluate control measures in large-scale commercial situations;
- develop and extend options for management of rhyparida.

3.0 OUTCOMES

- Better understanding of the phenology of *Rhyparida nitida* – this species has a one-year life cycle with extended oviposition over summer, slow development of small larvae during autumn and winter, and more rapid development of larger larvae during spring. The extended oviposition means that each generation has individuals of widely varying ages.

- Sampling statistics determined for larvae and adults of *R. nitida* and for the symptoms of larval damage.
- Chemicals that attract adults of corn rootworms do not attract adults of *R. nitida.*
- No consistent associations of farming practices with numbers of rhyparida larvae. This is consistent with an insect that has adults that are very mobile and are nonselective for oviposition.
- No significant effects of varieties, trash management, management of potential harbourage areas or management of breaks on subsequent numbers of rhyparida larvae in on-farm participatory trials.
- Application of insecticides to the soil surface followed by irrigation did not give any significant reduction in numbers of larvae. When Furadan® was coultered into the soil it did provide some control of larvae, but did not improve subsequent yield of cane. Confidor® and Nemacur® did not provide any significant control or yield increase. These results indicate the compensatory ability of the sugarcane plant following damage and the difficulty in timing applications to adequately target larvae.
- Extension of outcomes to stakeholders through grower discussion groups, on-farm participatory trials, and newsletters.

4.0 BIOLOGY STUDIES

Determining the biology/life cycle to identify points in the life cycle vulnerable to control measures is crucial to development of useful control measures. Because larvae and adults are not seen in fields during January-July, it was not known if there was a dormancy stage or if larvae developed slowly during this period.

We sought to clarify the life cycle by first by using captive populations in a pot-based system and later by monitoring field populations. We trialed a number of chemicals that had potential as attractants and could have been used to monitor adult populations or lure adults to destructive traps. We also attempted to establish laboratory cultures of rhyparida that could supply material for further work on the pest's biology and for testing candidate insecticides.

4.1 Pot-based trial

A pot trial was established in 1999. In this trial, 101 pots were each seeded with 10 late-stage *R. nitida* larvae that had been collected from infested fields. We used plastic 20 cm pots that had Rhodes grass established in them prior to the introduction of larvae. Each pot was covered with a net suspended by a frame approximately 30 cm above the pot. The frame was designed to contain any adults developing from the larvae (Figure 1). Two holes were made at the bottom of each pot to provide drainage and then covered with net to prevent larvae from escaping.

The pots were destructively sampled at weekly intervals using wet sieving (Southwood 1978) and observation under a magnification lamp. The number and stage of development of larvae and adults were recorded; larvae were classified as small (< 3.5 mm long), medium (3.5-6.5 mm long) or large (> 6.5 mm long).

Figure 1: Rhyparida pot trial established at BSES Bundaberg in 1999.

The results obtained from studying the habits of larvae and beetles in the pots were limited by the poor survival of the introduced larvae and/or their offspring. Only five of the 104 pots had second-generation larvae (offspring from beetles and larvae that were introduced in summer 1999-2000) in them when they were sampled (Appendix 1). However, the different stages were present during:

- Adults January-March, August
- Small larvae January-August, November-December
- Medium larvae May-June, November-December
- Large larvae May-July
- Pupae February, May

These are consistent with a one-year life cycle with adults present from late winter to late summer, extended oviposition through the summer, extended presence of small larvae through summer, autumn and winter, and more rapid development during winter and spring through medium and large larvae and pupae to adult emergence.

4.2 Field monitoring

Field monitoring took place at three sites in Bundaberg-Isis area during May 2000 to January 2002. At each sampling, we took two samples 30 cm by 30 cm and 40 cm deep from each site. These samples were then taken back to the laboratory for wet sieving (Southwood 1978) and observation under a magnification lamp. Larvae were classified on the basis of size, using the same categories as above.

The observations are recorded in Appendix 2 and are summarised in Figure 2. Adults are present from September to March and eat the leaves of sugarcane plants, but cause minimal damage. Eggs are difficult to find, because they are very small (< 0.5 mm). They are probably laid over all of this period. This means that there are larvae of different developmental stages present in any one field over much of the year. During January-July, larvae are small (< 1.0 mm) and difficult to see and no grower is likely to be sampling fields at this time. This would explain why there was thought to be some form of dormancy. From July onwards the larvae become larger and are more easily seen by the naked eye. Damage is evident only from July through to December when larvae are large enough, and the cane is small enough for the large larvae to damage the growing point. Most damage occurs during September/October.

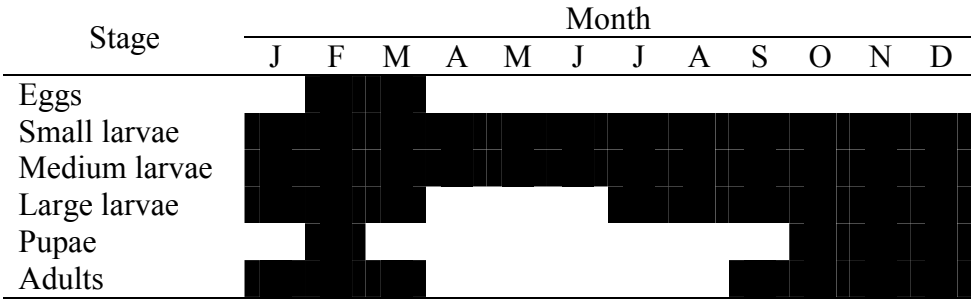

Figure 2. Summary of observations on field life cycle – the different stages were found during the months shaded.

These observations are consistent with those from the pot trial. The life cycle is very similar to the closely related corn rootworms of North America.

4.3 Adult attractants

Four compounds were trialed against adult larvae to investigate their suitability as attractants. All are attractive to adults of corn rootworm (Lance 1990). Attractants could be useful either as monitoring tools or as control measures if attraction was strong enough.

We established the field trial at Henke's farm in the Isis district. The four potential attractants, plus an unbaited control, were tested in a randomised complete-block design with three replicates, each replicate in a separate line of traps. Adjacent traps and lines of traps were separated by 10 m (Lance 1990). Japanese beetle traps were suspended about 1.5 m from the ground at cane height and were checked daily for two weeks. Each potential attractant was impregnated on a cotton wick placed in the centre of the trap's vanes.

The compounds tested were:

- Eugenol: 2-methoxy-(2-propenyl) phenol;
- Estragole: 1-methoxy-4-(2-propenyl) benzene;
- Indole: (2,3-benzopyrrole);
- Vipae mixture: an equal mixture of Veratrole (1,2-dimenthoxybenzene), Indole, Phenylacetaldehyde (benzeneacetaldehyde), Anethole (1-methoxy-4-(1-propenyl) benzene), and Eugenol.

None of the compounds showed significant attractiveness. The highest number of adults found in a trap was two.

4.4 Rearing methods

We tested a method for rearing rhyparida based on that used at University of Queensland Gatton to rear other *Rhyparida* spp. and similar to that used to rear corn rootworms (Branson and Jackson 1988).

Styrofoam boxes were lined with 5 cm of sawdust in the base and covered with insect mesh to prevent escape of the adult beetles. We placed field-collected adults of *R. nitida* into the boxes and gave them access to the artificial diet of Branson and Jackson (1988) and to raw potatoes and carrots. Cotton wicks suspended in containers of water were used to supply moisture. Observations continued for 12 months to determine if eggs had been laid and if larvae were developing.

Observation showed that the beetles died a short time after being placed in the boxes and that no subsequent generation developed.

5.0 RHYPARIDA FARMING SYSTEMS SURVEY

Rhyparida incidence and damage varies considerably from field to field, even on heavily infested farms in known 'hot-spot' areas. By accurately determining the density of the pest and the incidence of damage and correlating them with farming practices, surveys can be extremely useful in indicating what factors predispose fields to the pest. The technique has been used successfully in southern Queensland with pink ground pearls (Walker and Allsopp 1993), highlighting the importance of fallow length and cultivar on cyst numbers, and has also been used to relate farming practices to canegrub incidence (BSS166; Fischer and Allsopp 1997).

Fields were surveyed in 1999/2000 (year 1) and 2000/01 (year 2) in cooperation with BSES extension staff and local Cane Protection and Productivity Board staff (Sugar Services). In each mill area, we attempted to select one field from each of 10 different farms within 'hot-spot' areas during each of July/August, September/October and November/December. Fields that were sampled in July/August were also sampled in September/October and November/December. Fields that were sampled for the first time in September/October were also sampled in November/December. Fields that were sampled in November/December were also sampled in January/February. Fields had to be sampled for the first time within one week of harvest. This sampling regime allowed monitoring of the development of populations over time.

At each sampling, six soil samples were taken, each 30 cm by 30 cm and 40 cm deep, and centred over a sugarcane plant. Larvae were hand sorted from the soil and grouped into class sizes of small (< 3.5 mm long), medium (3.5-6.5 mm long) and large (> 6.5 mm long). Adults were counted on one sugarcane plant at each of the six sample points. Larvae and adults were identified by comparisons with other *R. nitida*.

Each grower was interviewed on farming practices in the sampled field. We used a standard survey form (Appendix 3) to record the data. The survey provided information on variety, time of harvest, cultivation practices, green or burnt harvesting, soil type, chemical use, harvest conditions and previous crop history. Not all growers were able to give accurate information on all practices.

To ensure that the survey was carried consistently across all mill areas and operators, we outlined sampling procedures to BSES, Cane Protection and Productivity Board and Sugar Services staff prior to the commencement of each year's sampling. The set of the procedures that were used for undertaking the survey is given in Appendix 4.

A sample of soil was taken from each sample hole to form an aggregate sample representative of the whole field. Fraction analysis of sand, silt and clay composition was determined using the method of Piper (1942). Soils were grouped on these analyses using the triangular textural diagram of McDonald *et al.* (1984, Figure 13). The pH of each sample was determined by placing 20 g of air-dried soil with 100 g of deionised water, stirring this for 1 h, allowing the container to settle for a short time, and taking readings of pH with an ion analyser.

We used the Kruskal-Wallis one-way nonparametric analysis of variance to determine differences in numbers of larvae under different farming practices.

5.1 Year 1 survey

Five farming practices were associated with significant differences in numbers of larvae. None was associated with significant differences in numbers of damaged shoots.

There were significant differences in numbers of larvae among fields following different fallow strategy regimes (KW=8.44, P=0.038). There were lower numbers in fields that had been cropped in the fallow compared to those fields that had been clean fallowed or where grass, volunteers and weeds were left to grow (Table 1).

Table 1. Mean number (SEM) of rhyparida larvae per sample in crops following different fallow management strategies - 1999/2000.

Fallow strategy	*N*	Mean (SEM)*
Clean	27	0.83 (0.29) a
Unclean (weeds, volunteers, grass)	8	0.17 (0.17) b
Crop in fallow	6	0.00 (0.00) c

*Means followed by the same letter are not significantly different at $P \leq 0.05$.

There were significant differences in numbers of larvae among fields following breaks of different lengths (KW=7.63, P=0.022). There were significantly fewer larvae following a break of > 10 months than in crops following shorter breaks. There were also significantly fewer larvae in crops following a plough-out replant than one following a 4-10 months break (Table 2).

Table 2. Mean number (SEM) of rhyparida larvae per sample in crops following breaks of different lengths - 1999/2000 and 2000-2001.

Break length	1999-2000		2000-2001	
	N	Mean (SEM)*	*N*	Mean (SEM*)
Ploughout replant <4 months	19	0.46 (0.23) b	24	2.25 (0.99) a
4-10 months	26	0.74 (0.22) a	18	0.00 (0.00) b
> 10 months	18	0.18 (0.16) c	16	2.44 (1.44) a

*Means within a column followed by the same letter are not significantly different at $P \leq 0.05$.

There were significant differences in numbers of larvae among fields that were located at different distances from bushland (KW=7.57, P=0.023). There were significantly higher numbers of larvae in fields that were < 100 m from bushland, compared to fields further away (Table 3).

Table 3. Mean number (SEM) of rhyparida larvae per sample in crops at different distances from bushland - 1999/2000.

Distance from bushland	*N*	Mean (SEM)*
< 100 m	20	1.40 (0.63) a
100-1000 m	25	0.39 (0.18) b
> 1000 m	21	0.21 (0.12) b

*Means followed by the same letter are not significantly different at P ≤ 0.05.

There were significantly more larvae in fields that had experienced rhyparida damage in previous ratoons (mean 1.7, SEM 0.84, N=40) than in fields that had not been damaged previously in the crop cycle (mean 0.15, SEM 0.10, N=31) (KW=10.59, P=0.0011).

There were significant differences in numbers of larvae among fields that had the trash burnt, retained on the surface or incorporated at the harvest (KW=8.59, P=0.035). There were significantly fewer larvae in blocks that had been burnt compared to those that had been harvested green and the trash retained or incorporated (Table 4). There were also high numbers in blocks that were plant crops.

Table 4. Mean number (SEM) of rhyparida larvae per sample in crops from sites with different residue management in the previous ratoon - 1999/2000.

Residue management	*N*	Mean (SEM)*
Trash retained	55	0.47 (0.14) b
Burnt	8	0.33 (0.31) c
Trash incorporated	4	0.79 (0.33) a
Plant crop	8	5.79 (4.58) a

*Means followed by the same letter are not significantly different at P ≤ 0.05.

5.2 Year 2 survey

Only one farming practice was associated with significantly different numbers of larvae. None was associated with significant differences in numbers of damaged shoots.

There were significant differences in numbers of larvae among fields following breaks of different lengths (KW 10.38, P=0.0056). There were significantly fewer larvae following a break of 4-10 months than where fields were ploughed out and replanted within four months or where the break was longer then 10 months (Table 2).

5.3 Summary

There were no consistent patterns in the results over the two years that the surveys were undertaken. This indicates that there are no specific factors associated with the incidence of rhyparida or with the incidence of symptoms. This is consistent with an insect that has adults that are very mobile and are nonselective for oviposition.

6.0 DEVELOPMENT OF SAMPLING PLANS

Efficient sampling and monitoring methods are essential for studying the population dynamics and for timing the most efficient control strategies against rhyparida. To allow time-efficient sampling for estimating numbers of rhyparida and symptoms of larval damage, we derived a series of stop lines that allows sampling at pre-set levels of precision.

Sampling statistics were determined for larvae, pupae and adults of *Rhyparida nitida* associated with sugarcane in Australia and for symptoms of their damage. In the published paper (Appendix 5), there is a full treatment of the methodology, results and discussion for the derivation of the sampling plans.

Iwao's patchiness regression was inappropriate for modelling the mean-variance relationships of the insect counts. Taylor's power law was used to model these data and relationships were developed for counts of small, medium and large larvae, all larvae combined, pupae and adults. The mean-variance relationships of counts of live shoots and shoots killed by larvae of *R. nitida* were modelled using Iwao's patchiness regression; Taylor's power law was not appropriate to either data set. Relationships to determine sample sizes for fixed levels of precision and fixed-precision-level stop lines for sequential sampling of the different stages and live and dead shoots were also developed. Neither the $\ln(x+1)$ transformation nor the Healy and Taylor transformation consistently standardised the mean-variance relationships of insect counts and the appropriate transformation should be selected on a case-by-case basis. Counts of both live and dead shoots were adequately transformed by the Iwao and Kuno transformation.

7.0 GROWER ACTION GROUPS AND BEST-BET ON-FARM PARTICIPATORY RESEARCH TRIALS

7.1 Grower action groups

Meetings were held with concerned growers, CPPB staff and BSES Pest Management and Extension Officers throughout the first 2.5 years of the project. Initially Warren Hunt, IPM Co-ordinator, facilitated the meetings.

Each meeting canvassed the expectations of the participants and these were re-addressed at the end of the meeting to make sure that the groups' expectations had been met. Timothy Fischer provided a summary of the work that has been undertaken between each meeting and an overall summary of progress in the project. The group then actively participated in identifying best-bet options for chronically affected blocks. Participants were also encouraged to identify research options that they

would like tested. The group then voted on what research strategies were practical and what R&D should be done in the following rhyparida season. Interest was sought from growers to help test the research strategies in commercial on-farm situations.

The meetings provided a forum for growers to express individual ideas and opinions and for BSES to relay research information back to growers. They provided ownership of the outcomes to those that were affected by rhyparida.

7.2 On-farm participatory research

On-farm participatory research was the main mechanism by which best-bet strategies identified at focus group meetings could be tested. Strip trials testing various cultural practices were established in the Millaquin, Fairymead and Bingera mill areas of the Bundaberg district. Growers were responsible for establishing and maintaining these trials. BSES was responsible for sampling the trials, and assisted growers to plan trial layouts and farming practices.

The trials that were established and the results obtained are summarised below.

Variety trials

Four strip trials sought to determine if numbers of rhyparida larvae were different in crops of different varieties of sugarcane.

At Trudgian's (Millaquin), the cultivars Q124, Q138, Q150 and Q170$^{(\flat)}$ were compared in a block that previously had a rhyparida problem. In October 1999, numbers of rhyparida larvae were low; five standard soil samples were taken at random from each cultivar and the highest number of larvae recorded was three in Q124. In October 2000, numbers were also low; the highest number of larvae recorded was seven in Q151 and Q124.

At Price's (Fairymead), the cultivars Q124, Q138, Q141 and Q151 were compared. No rhyparida were found in October 1999 and, in October 2000, the highest number of rhyparida larvae found was four in Q141.

At Green's (Fairymead), the cultivars Q124, Q138, Q141 and Q154 were compared. In October 1999, numbers of rhyparida were low, with one larva in Q124 the highest number found in samples. In October 2000, no larvae were found in any of the samples.

At Strathdee's (Fairymead), the cultivars Q135, Q141, Q155 and Q170$^{(\flat)}$ were compared. In October 2001, numbers were low, with a maximum of nine found in the Q170$^{(\flat)}$ portion of the trial.

Trash management trials

These sought to determine if different ways of managing crop residues affected subsequent numbers of rhyparida larvae.

At Cronin's (Bingera), we compared burning at the previous harvest with green-cane trash-blanket in three blocks of Q124. The blocks were devastated by rhyparida in 1997 and planting followed a long fallow. In October 1999, numbers of rhyparida were low, with four larvae found in the green-cane trash-blanketed sections of the trial and three found in the burnt sections of the trial.

At Harte's (Millaquin), we compared a previously burnt crop with a green-cane trash-blanketed section and a trash-incorporated section of a field of Q151. In late 1999, numbers of rhyparida were low, with five larvae found in the burnt section, three in the green-cane trash-blanketed section, and two in the trash-incorporated section. In late 2000, eight larvae were found in burnt section, 11 in the green-cane trash-blanketed section and five in the trash-incorporated section.

Management of potential harbourage areas

One trial tested the hypothesis that areas of unmown grass are harbourage areas for rhyparida beetles and subsequent populations of larvae will be higher in crops adjacent to these areas. We tested this at Price's (Fairymead), comparing two blocks having the headlands and other adjacent areas mown regularly, and the other having long grass in these areas. In October 2000, numbers of rhyparida larvae were low, with six found in samples taken from the grassed area and none found in the part of the trial adjacent to the mown area. In October 2001, numbers were also low, with 12 found in samples taken from adjacent to the grassed area and four found in samples from adjacent to the mown area.

Management of breaks

Two trials sought to determine if the management of the break before the current crop of sugarcane was planted affected subsequent numbers of rhyparida larvae.

At Trudgian's (Millaquin), the trial compared continuous cane, pumpkins grown in a break and a bare fallow. In October 2001, numbers of larvae were low in all portions of the trial, with seven larvae found in the bare-fallow portion and four in the portion where pumpkins had been grown.

At Schulte's (Fairymead), the trial compared soybeans grown in a break and bare fallow. In October 2000, numbers of larvae were low, with only one found in each portion. In October 2001, five larvae were found in the soybean portion of the trial and 11 larvae were found in the bare-fallowed portion.

Summary

Low numbers of larvae in all of these trials precluded any useful conclusions.

7.3 *Rhyparida Newsletter*

Five editions of a *Rhyparida Newsletter* were circulated to 154 growers who have had a history of rhyparida. These explained the current situation of numbers and damage, and the progress made on the project since the last edition.

8.0 INSECTICIDE TRIALS

Most growers see insecticides as potentially useful control measures for rhyparida but no insecticide is currently registered for use against rhyparida in sugarcane. We considered that no insecticide company was likely to register an insecticide in sugarcane solely for rhyparida – the market size is simply too small. If a registration could be 'piggybacked' onto a current registration, a submission might be viable. Hence, we tested insecticides currently registered or soon likely to be registered in sugarcane.

We tested insecticides in six trials directly targeting larvae and in one trial targeting adults to reduce oviposition and subsequent numbers of larvae. The insecticides that we chose for testing against larvae all show some systemic activity – our thinking was that such insecticides could be more effective against an insect that burrows into the plant than would a contact insecticide.

8.1 Trials directly targeting larvae

Six trials were conducted in the Bundaberg-Isis area. These tested application times, product and rates of products. Trial sites were selected after monitoring fields for larval numbers. Only fields with the high numbers of larvae were used as trial sites.

Trials 1-5 used randomised complete-block designs with four replicates. Each plot was four rows wide and 10 m long. Trial 6 used a similar design, except that each plot was split into early and late application (28 days apart). In trials 1-3, Nemacur® 100 G and Furadan® 100 G were mixed with dry 1 mm sieved sand and the mixture sprinkled evenly over the rows in a 15 cm band. Confidor® 200 SC was mixed with water and 1 L of each mixture applied to 1 m of row in a similar band. Each treatment was watered in with the equivalent of 25 mm of rain over the 15 cm band. In trials 4-6, all chemicals were applied 100 mm below the soil surface behind two coulters, one either side of the stool. They were watered in with a commercial overhead irrigator (about 25 mm of water).

Larvae were sampled 14 days after application (after the second application in trial 6) by taking two 30 by 30 by 40 cm deep soil samples, each over a stool. These were wet sieved and larvae were counted. Numbers of larvae were analysed by ANOVA and means separated by the protected LSD test. To stabilise variances, counts were first transformed by the square-root transformation in trials 1-2, the Taylor and Healy transformation ($x^{0.285}$) in trial 3, and the log transformation in trial 4.

In trial 1 (ES99-11), there was a significant difference in numbers of larvae between treatments ($F=2.68$, $df=6,18$, $P=0.049$), but no insecticide treatment was significantly different from the untreated control (Table 5).

Table 5. Mean number of rhyparida larvae per sample (SEM) at Peterson's (Farnsfield) (ES99-11) on 27 October 1999, 14 days after treatment (early insecticide application).

Active ingredient	Product	Rate (g AI/100 m row)	Mean (SEM) number of larvae*
Imidacloprid	Confidor 200 SC	7.5	5.4 (1.4) ab
		3.75	5.6 (2.2) b
Fenamiphos	Nemacur 100 G	60	4.1 (1.3) b
		30	10.6 (2.9) a
Carbofuran	Furadan 100 G	45	2.3 (0.5) b
		22.5	4.1 (2.2) b
Untreated	-	-	6.3 (1.9) ab

*Means followed by the same letter are not significantly different at $P \leq 0.05$. Values are untransformed means.

In trial 2 (ES99-13), there was no significant difference in numbers of larvae among any of the treatments ($F=1.37$, $df=6,18$, $P=0.28$) (Table 6).

Table 6. Mean number of rhyparida larvae per sample (SEM) at Lutz's (Bingera) (ES99-13) on 19 November 1999, 14 days after application (mid-season insecticide application).

Active ingredient	Product	Rate (g AI/100 m row)	Mean (SEM) number of larvae*
Imidacloprid	Confidor 200 SC	7.5	2.7 (1.4) a
		3.75	2.4 (1.4) a
Fenamiphos	Nemacur 100 G	60	1.4 (0.6) a
		30	4.8 (2.1) a
Carbofuran	Furadan 100 G	45	2.6 (0.1) a
		22.5	1.6 (0.5) a
Untreated	-	-	2.3 (0.6) a

*Means followed by the same letter are not significantly different at $P \leq 0.05$. Values are untransformed means.

Table 7. Mean number of rhyparida larvae per sample (SEM) at Gordon's (Millaquin) (ES99-19) on 20 December 1999, 14 days after treatment (late-season insecticide application).

Active ingredient	Product	Rate (g AI/100 m row)	Mean (SEM) number of larvae*
Imidacloprid	Confidor 200 SC	7.5	1.4 (0.4) a
		3.75	2.5 (1.2) a
Fenamiphos	Nemacur 100 G	60	1.5 (0.5) a
		30	2.3 (0.6) a
Carbofuran	Furadan 100 G	45	0.6 (0.3) a
		22.5	1.3 (0.4) a
Untreated	-	-	1.3 (0.3) a

*Means followed by the same letter are not significantly different at $P \leq 0.05$. Values are untransformed means.

In trial 3 (ES99-19), there was no significant difference in numbers of larvae among

any of the treatments (F=0.97, df=6,18, P=0.47) (Table 7).

These three trials indicated no benefit from application of insecticide. We thought that the application method (applying the insecticide to the soil surface) might be inefficient, despite the occurrence of rhyparida larvae close to the soil surface, so in trials 4-6 we tested incorporation the insecticide into the soil behind coulters.

In trial 4 (ES00-6), there were significant differences in numbers of larvae among treatments (F=4.45, df=6,18 P=0.0063). Numbers of larvae were significantly lower than in the untreated plots in the two Furadan treatments, with the higher application rate of Furadan significantly more effective (Table 8). This trial was harvested on 22 June 2001 using the standard BSES hand-harvesting technique. There was no significant difference in cane yields among treatments (F=2.19, df=6,18, P=0.092) (Table 9).

Table 8. Mean number of rhyparida larvae per sample (SEM) at Lutz's (Bingera) (ES00-6) on 5 September 2000, 14 days after treatment (early-season application).

Active ingredient	Product	Rate (g AI/100 m row)	Mean (SEM) number of larvae*
Imidacloprid	Confidor 200 SC	7.5	21.9 (3.8) ab
		3.75	28.8 (5.7) ab
Fenamiphos	Nemacur 100 G	60	35.0 (7.8) ab
		30	33.1 (9.7) ab
Carbofuran	Furadan 100 G	45	8.0 (2.5) c
		22.5	16.8 (3.7) bc
Untreated	-	-	47.1 (9.2) a

*Means followed by the same letter are not significantly different at $P \leq 0.05$. Values are untransformed means.

Table 9. Mean cane yield (SEM) at Lutz's (Bingera) (ES00-6) on 22 June 2001.

Active ingredient	Product	Rate (g AI/100 m row)	Mean (SEM) cane yield
Imidacloprid	Confidor 200 SC	7.5	80.5 (4.4)
		3.75	89.8 (6.1)
Fenamiphos	Nemacur 100 G	60	87.0 (7.7)
		30	79.1 (4.9)
Carbofuran	Furadan 100 G	45	89.3 (3.0)
		22.5	79.0 (2.8)
Untreated	-	-	78.8 (3.5)

A similar insecticide trial (trial 5) was established at Howlett's (Millaquin) in November 2000 (ES00-15). Post-treatment larval counts showed very low numbers in the untreated sections (<1 larva per sample) and the remainder of the trial was not sampled.

A further insecticide trial (trial 6) was established to test the efficacy of Confidor® and Furadan® at Lutz's (Bingera) (ES01-8) with two times of application four weeks apart. There were very low numbers of larvae in the untreated plots at 14 days after the second application (<1.1 larva per sample) and the remainder of the trial was not sampled.

Overall, these insecticides provided no useful information for registration purposes. Application of insecticides to the soil surface, followed by irrigation, did not give any significant reduction in numbers of larvae. When Furadan® was coultered into the soil it did provide some control of larvae, but did not improve subsequent yield of cane. Confidor® and Nemacur® did not provide any significant control or yield increase. These results indicate the compensatory ability of the sugarcane plant following damage and the difficulty in timing applications to adequately target larvae.

8.2 Trial targeting adults

A trial was established at Les Baker's (Millaquin) in February 2000 in a crop of Q124. Half of the block was sprayed with 800 mL Lorsban® 500 EC (chlorpyrifos) per hectare and the other half of the block was not sprayed. Spraying reduced the numbers of beetles by 85% within two days, but there was no significant population of larvae late in 2000 to allow the effect on subsequent numbers of larva to be determined.

9.0 PUBLICATION

Allsopp PG and Fischer TWA. 1999. Sampling *Rhyparida nitida* Clark (Coleoptera: Chrysomelidae) and symptoms of their damage on sugarcane. *Australian Journal of Entomology* 38: 318-322.

10.0 RECOMMENDATIONS

The success of the project was hampered by generally low populations of rhyparida. This indicates that the pest is likely to remain of minor importance within the Bundaberg-Isis area. As such, the returns from further work are likely to be low.

Areas in which further work might be useful are:

- sampling plans for rhyparida could be developed further and released to the industry to allow monitoring of fields. This might allow the identification of blocks likely to experience damage. However, the time and skills necessary to monitor blocks would require this being done by a consultant rather than individual farmers;
- further development of insecticidal controls in years when populations are high. Efficient use of such insecticides would be conditional on being able to predict which fields will be damaged;
- further testing of cultural control options, especially the effect of fallow length on subsequent populations.

11.0 REFERENCES

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Fischer TWA and Allsopp PG. 1997. Farming practices influence populations of Childers canegrub (*Antitrogus parvulus* Britton) in Australian sugarcane: preliminary results. *In* Allsopp PG, Rogers DJ and Robertson LN (Eds) *Soil Invertebrates in 1997* pp. 48-51. Bureau of Sugar Experiment Stations, Brisbane.

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APPENDIX 1 DATA FROM POT TRIAL AT BUNDABERG DURING 2000

Date sampled	Pot number	Rhyparida present
10 January	1	3 small larvae, 1 adult
	2	None
20 January	3	None
	4	None
25 January	5	None
	6	2 adults
11 January	7	2 adults
	8	1 adult
10 February	9	1 adult
	10	1 adult
17 February	11	1 small larva
	12	None
24 February	13	1 pupa, 1 adult
	14	2 adults
01 March	15	3 adults
	16	1 adult
10 March	17	None
	18	1 adult
16 March	19	None
	20	None
23 March	21	1 adult
	22	2 adults
29 March	23	None
	24	None
6 April	25	None
	26	1 adult
14 April	27	None
	28	None
20 April	29	9 small larvae
	30	None
02 May	31	None
	32	None
11 May	33	None
	34	21 small larvae
15 May	35	None
	36	10 small larvae
19 May	37	6 small, 1 medium and 2 large larvae, 1 pupa
	38	None
24 May	39	None
	40	None
29 May	41	None
	42	None
07 June	43	None
	44	None
13 June	45	None
	46	None
20 June	47	1 small
	48	43 small and 5 medium larvae
27 June	49	None
	50	1 adult
04 July	51	1 small larva
	52	None
12 July	53	None
	54	1 large larva
19 July	55	None
	56	1 large larva

Date sampled	Pot number	Rhyparida present
28 July	57	None
	58	None
02 August	59	1 adult
	60	2 adults
09 August	61	None
	62	None
16 August	63	5 small larvae
	64	None
23 August	65	None
	66	None
29 August	67	None
	68	None
06 September	69	None
	70	None
13 September	71	None
	72	None
22 September	73	None
	74	None
27 September	75	None
	76	None
04 October	77	None
	78	None
20 October	79	None
	80	None
23 October	81	None
	82	None
30 October	83	None
	84	None
2 November	85	None
	86	None
9 November	87	6 small and 31 medium larvae
	88	None
16 November	89	None
	90	None
30 November	91	None
	92	None
5 December	93	None
	94	None
12 December	95	None
	96	11 small and 7 medium larvae
19 December	97	None
	98	None
22 December	99	None
	100	None
	101	None

APPENDIX 2 FIELD SAMPLING OF EGGS, LARVAE AND PUPAE

Farm and date sampled	Eggs	Larvae			Pupae
		Small	Medium	Large	
G. Peterson					
18 May 2000	0	34	0	0	0
25 May 2000	0	12	0	0	0
7 June 2000	0	1	0	0	0
14 June 2000	0	21	3	0	0
22 June 2000	0	46	4	0	0
29 June 2000	0	13	1	0	0
S. Lutz					
22 May 2000	0	42	0	0	0
6 June 2000	0	7	0	0	0
20 June 2000	0	13	1	0	0
7 July 2000	0	57	3	0	0
19 July 2000	0	69	6	0	0
26 July 2000	0	12	0	1	0
3 August 2000	0	14	0	0	0
11 October 2000	0	14	3	1	0
20 October 2000	0	14	6	1	0
30 October 2000	0	8	2	0	0
3 November 2000	0	12	2	0	0
7 November 2000	0	9	0	1	0
15 November 2000	0	11	2	2	0
28 November 2000	0	0	7	4	3
4 December 2000	0	14	8	2	0
11 December 2000	0	3	6	2	1
22 December 2000	0	0	2	2	1
4 January 2001	0	0	3	0	0
11 January 2001	0	0	2	0	0
18 January 2000	0	3	0	1	0
24 January 2001	0	2	3	0	0
6 February 2001	0	0	0	2	0
12 February 2001	0	2	1	0	0
22 February 2001	0	12	0	0	0
28 February 2001	0	10	0	0	1
5 March 2001	0	7	0	0	0
12 March 2001	7	93	0	0	0
18 March 2001	0	102	0	0	0
26 March 2001	0	18	0	0	0
2 April 2001	0	62	0	0	0
9 April 2001	0	76	0	0	0
16 April 2001	0	4	13	0	0
23 April 2001	0	0	1	0	0
30 April 2001	0	23	5	0	0
7 May 2001	0	20	20	0	0
15 May 2001	0	20	16	0	0
21 May 2001	0	53	1	0	0
28 May 2001	0	7	0	0	0
4 June 2001	0	8	0	0	0
12 June 2001	0	13	6	0	0
18 June 2001	0	0	12	0	0
26 June 2001	0	0	8	0	0
2 July 2001	0	27	11	17	0
9 July 2001	0	14	10	2	0
16 July 2001	0	17	13	1	0
23 July 2001	0	10	8	0	0
30 July 2001	0	15	0	0	0

Farm and date sampled	Eggs	Larvae			Pupae
		Small	Medium	Large	
6 July 2001	0	0	0	0	0
16 July 2001	0	17	13	1	0
23 July 2001	0	10	8	0	0
30 July 2001	0	15	0	0	0
6 August 2001	0	5	3	0	0
13 August 2001	0	4	8	0	0
20 August 2001	0	14	9	0	0
27 August 2001	0	25	1	0	0
3 September 2001	0	3	3	3	0
10 September 2001	0	0	0	0	0
17 September 2001	0	18	6	0	0
24 September 2001	0	8	11	0	3
2 October 2001	0	15	6	0	0
10 October 2001	0	22	0	0	0
15 October 2001	0	11	11	0	0
22 October 2001	0	6	3	2	0
29 October 2001	0	1	3	0	0
5 November 2001	0	1	3	2	0
12 November 2001	0	6	8	11	0
26 November 2001	0	3	9	0	0
3 December 2001	0	3	8	7	0
10 December 2001	0	7	10	1	1
17 December 2001	0	3	5	4	0
24 December 2001	0	3	3	0	0
3 January 2002	0	7	2	0	0
14 January 2002	0	0	0	0	0
G. Gastons					
6 February 2001	0	1	0	0	0
12 February 2001	2	31	0	0	0
22 February 2001	0	40	0	0	0
28 February 2001	0	41	0	0	0
5 March 2001	0	0	0	0	0
12 March 2001	0	29	0	0	0
18 March 2001	2	23	0	7	0
26 March 2001	0	15	1	0	0
2 April 2001	0	17	0	0	0
9 April 2001	0	17	3	0	0
16 April 2001	0	13	3	0	0
23 April 2001	0	9	1	0	0
30 April 2001	0	2	21	0	0
7 May 2001	0	3	0	0	0
15 May 2001	0	1	6	0	0
21 May 2001	0	13	0	0	0
28 May 2001	0	6	0	0	0
4 June 2001	0	2	8	0	0
12 June 2001	0	6	1	0	0
18 June 2001	0	2	11	0	0
26 June 2001	0	1	3	0	0
2 July 2001	0	0	6	0	0
9 July 2001	0	2	3	0	0
16 July 2001	0	5	7	1	0
23 July 2001	0	1	3	0	0
30 July 2001	0	5	0	0	0
6 July 2001	0	5	3	0	0
16 July 2001	0	5	7	1	0
23 July 2001	0	1	3	0	0
30 July 2001	0	5	0	0	0
6 August 2001	0	11	3	0	0

Farm and date sampled	Eggs	Larvae			Pupae
		Small	Medium	Large	
13 August 2001	0	3	3	0	0
20 August 2001	0	11	3	2	0
27 August 2001	0	4	0	0	0
3 September 2001	0	2	12	4	0
10 September 2001	0	9	5	0	0
17 September 2001	0	4	6	6	0
24 September 2001	0	10	4	0	0
1 October 2001	0	23	17	0	0
10 October 2001	0	12	4	3	0
15 October 2001	0	0	0	0	0
22 October 2001	0	5	5	5	0
29 October 2001	0	2	0	0	0
5 November 2001	0	6	2	0	0
12 November 2001	0	4	4	2	0
19 December 2001	0	6	13	0	0
3 December 2001	0	0	0	1	0
10 December 2001	0	5	3	3	1
17 December 2001	0	2	6	0	0
24 December 2001	0	1	0	0	0
3 January 2002	0	6	2	1	0
14 January 2002	0	0	0	0	0

APPENDIX 3 SURVEY FORM

RHYPARIDA-SURVEY

GROWER/BLOCK INFORMATION:

Grower:
Address:
Mill area:
Field / Block Number:
Variety : **Crop class:**
Variety present in previous crop cycle:
In what ratoon was this crop ploughed out:
Soil type: (✓)

Red Volcanic	
Red Forest	
Grey Forest	
Sandy	
Alluvial	
Other (specify)	
pH (from BSES)	

Shoot Count
July/August
Date Sampled: _____

Site	**1**	**2**	**3**	**4**	**5**	**6**	***Total***
Live shoots							
Dead shoots							

September/October
Date Sampled: _____

Site	**1**	**2**	**3**	**4**	**5**	**6**	***Total***
Live shoots							
Dead shoots							

November/December
Date sampled: _____

Site	**1**	**2**	**3**	**4**	**5**	**6**	***Total***
Live shoots							
Dead shoots							

January
Date Sampled: _____

Site	1	2	3	4	5	6	*Total*
Live shoots							
Dead shoots							

Insect count
July/August
Date Sampled: _____

No. of Rhyparida:	*Development Stage*	1	2	3	4	5	6	*Total*
	Small							
	Medium							
	Large							
	Pupae							
Adults on single stool	**Black**							
	Brown							

September/October
Date Sampled: _____

No. of Rhyparida:	*Development Stage*	1	2	3	4	5	6	*Total*
	Small							
	Medium							
	Large							
	Pupae							
Adults on single stool	**Black**							
	Brown							

November/December
Date Sampled:_____

No. of Rhyparida:	*Development Stage*	1	2	3	4	5	6	*Total*
	Small							
	Medium							
	Large							
	Pupae							
Adults on single stool	**Black**							
	Brown							

January
Date Sampled:_____

No. of Rhyparida:	***Development Stage***	**1**	**2**	**3**	**4**	**5**	**6**	***Total***
	Small							
	Medium							
	Large							
	Pupae							
Adults on single stool	**Black**							
	Brown							

Comment (eg comment on overall damage in the block sampled, particularly mention damage in those areas not sampled within the field)

_____
_____
_____

Have you had Rhyparida damage in this block before (If so in what year and ratoon):

_____
Proximity of sample block to bushland (metres or km estimate):_____

What main species of grass occurs in close proximity to this block:_____

Is there evidence of damage from other pests:_____

Is this block wet considered wet : yes:_____no:_____ (eg poorly drained)
Is this block considered dry: yes:_____no:_____ (eg well drained)

<u>CROPPING METHODS:</u>

- **When was the crop planted (year/month): _____**
- **Fallow strategy (✓) : bare ____ grass/ weed _____cover crop (what was the crop) _____**
- **Length of fallow:_____**
- **Was the block minimum tilled during the last break (tick): yes:_____no:_____.**
- **Was the block cultivated during the last break (tick): yes:_____no:_____.**
- **Comment (fallow length, exceptional abnormal treatments, eg recultivation by ripping interow)**

_____
_____
_____

IRRIGATION:

What form of irrigation was used ?	Tick (✓)	Was it watered just prior to harvest? (yes/no)	How many times watered since harvest? (1,2,3 etc)
Furrow			
Overhead			
Trickle			
Combination			

When was the plant crop harvested: month _____ year_____
Was this block standover last year (tick) yes:_____ no:_____
Was this block ever stood over (tick) yes :_____ no:_____ if yes in what year:_____

METHOD OF CROPPING USED	WHEN HARVESTED?
TRASH BLANKETED	1st Ratoon: 2nd Ratoon: 3rd Ratoon: 4th Ratoon: 5th Ratoon: Other Ratoon:
TRASH INCORPORATED	1st Ratoon: 2nd Ratoon: 3rd Ratoon: 4th Ratoon: 5th Ratoon: Other Ratoon:
BURNT	1st Ratoon: 2nd Ratoon: 3rd Ratoon: 4th Ratoon: 5th Ratoon: Other Ratoon:
BURNT INCORPORATED	1st Ratoon: 2nd Ratoon: 3rd Ratoon: 4th Ratoon: 5th Ratoon: Other Ratoon:
Conditions at last harvest (eg soil compaction, stool damage, soil moisture).	
Conditions at this harvest (eg soil compaction, stool damage, soil moisture).	

NB: For harvest date give specific date that the crop was harvested this year. For previous ratoons (if applicable) give month harvested.

Insecticide/ Nematicide (✓)	Applied to Crop Cycles	Rate (✓)	Method of Application. (standard application leave blank.)

Insecticide/ Nematicide (✓)	Applied to Crop Cycles	Rate (✓)	Method of Application. (standard application leave blank.)
suSCon® Blue	**At plant:** **1/2 at plant:** **1/2 open Drill:**	**21 kg/ha:** **Other:**	
Lorsban® for wireworm	**At plant:**	**1.5 L/ha:** **Other:**	
Lorsban® for Armyworm:	**Plant:** **1st:** **2nd:** **3rd:** **4th:** **5th:** **Other:**	**0.7-0.9 L/ha** **Other:**	
Rugby®	**Plant:** **1st:** **2nd:** **3rd:** **4th:** **5th:** **Other:**	**20 kg/ha:** **25 kg/ha:** **30 kg/ha:** **Other:**	
Mocap®	**At Plant:** **Plant:** **1st:** **2nd:** **3rd:** **4th:** **5th:** **Other:**	**25 kg/ha:** **40 kg/ha:** **Other (specify):**	
Temik®	**At Plant:** **Plant:** **1st:** **2nd:** **3rd:** **4th:** **5th:** **Other:**	**17 kg/ha:** **Other (specify)**	
Other	**At Plant:** **Plant:** **1st:** **2nd:** **3rd:** **4th:** **5th:** **Other:**		

GROWER'S COMMENTS:

APPENDIX 4 PROCEDURES FOR SURVEYS

Selection of site

1. Ten farms are to be surveyed (you can choose more or fewer depending on your individual time constraints).
2. Choose one Block from each of 10 farms. When choosing sites consider the following:
   - varieties: try to sample different varieties, or mix of the most popular;
   - cropping methods: beneficial to have mixture of burnt, green, etc.;
   - CPPBs and Sugar Services staff know their individual areas, and may be helpful to choose farmers who they know use different farming practices.

Sampling requirements

- In July/August select 10 fields, then
  - ⇒ Sample for larvae, adults within 1 wk of harvest.
  - ⇒ Sample for larvae, adults and take shoot counts in September/October.
  - ⇒ Sample for larvae, adults and take shoot counts in November/December.

- In September/October select another 10 fields, then
  - ⇒ Sample for larvae, adults within 1 wk of harvest.
  - ⇒ Sample for larvae, adults and take shoot counts in November/December.

- In November/December select another 10 fields, then
  - ⇒ Sample for larvae, adults within 1 wk of harvest.
  - ⇒ Sample for larvae, adults and take shoot counts in January.

Sampling for larvae / taking shoot counts

Sampling of survey sites will follow a standard procedure for each 2-month period.
* July/August (refer to attached diagram).
* September/October (refer to attached diagram).
* November/December (refer to attached diagram).
* Late January (refer to attached diagram).

The diagrams provided map out the system for sampling stools and taking shoot counts for each 2-month period. These can be used as a guide, or if you feel confident you can randomly select stools within the field.

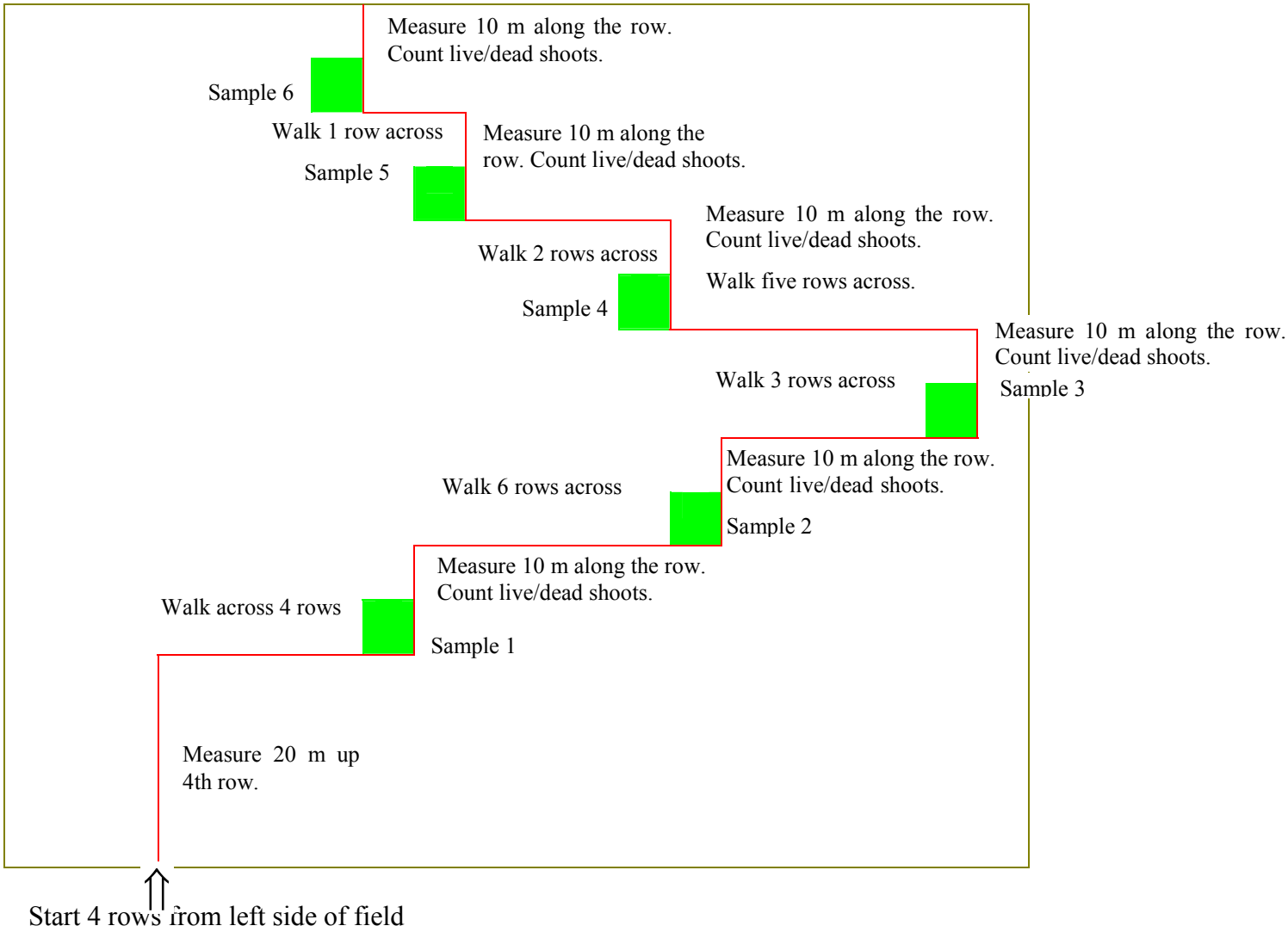
When sampling for larvae, one stool of sugarcane should be dug up at each of the sample sites within the field being surveyed (see attached diagram). All soil and roots should be thoroughly sorted to determine the presence of rhyparida larvae.

Larvae should be hand sorted from the soil and grouped into class sizes of small (<3.5 mm long), medium (3.5-6.5 mm long) and large (>6.5 mm long). Adults must be counted on one sugarcane plant at each of the six sample points. Larvae and adults to be identified by comparisons with other *R. nitida*; you will be provided with these.
Shoot counts involve recording the number of live and dead shoots in 10 metres of row at selected sample sites within the blocks (see attached diagram). Shoot counts are taken after each a stool is dug. For each field surveyed, take six shoot counts.

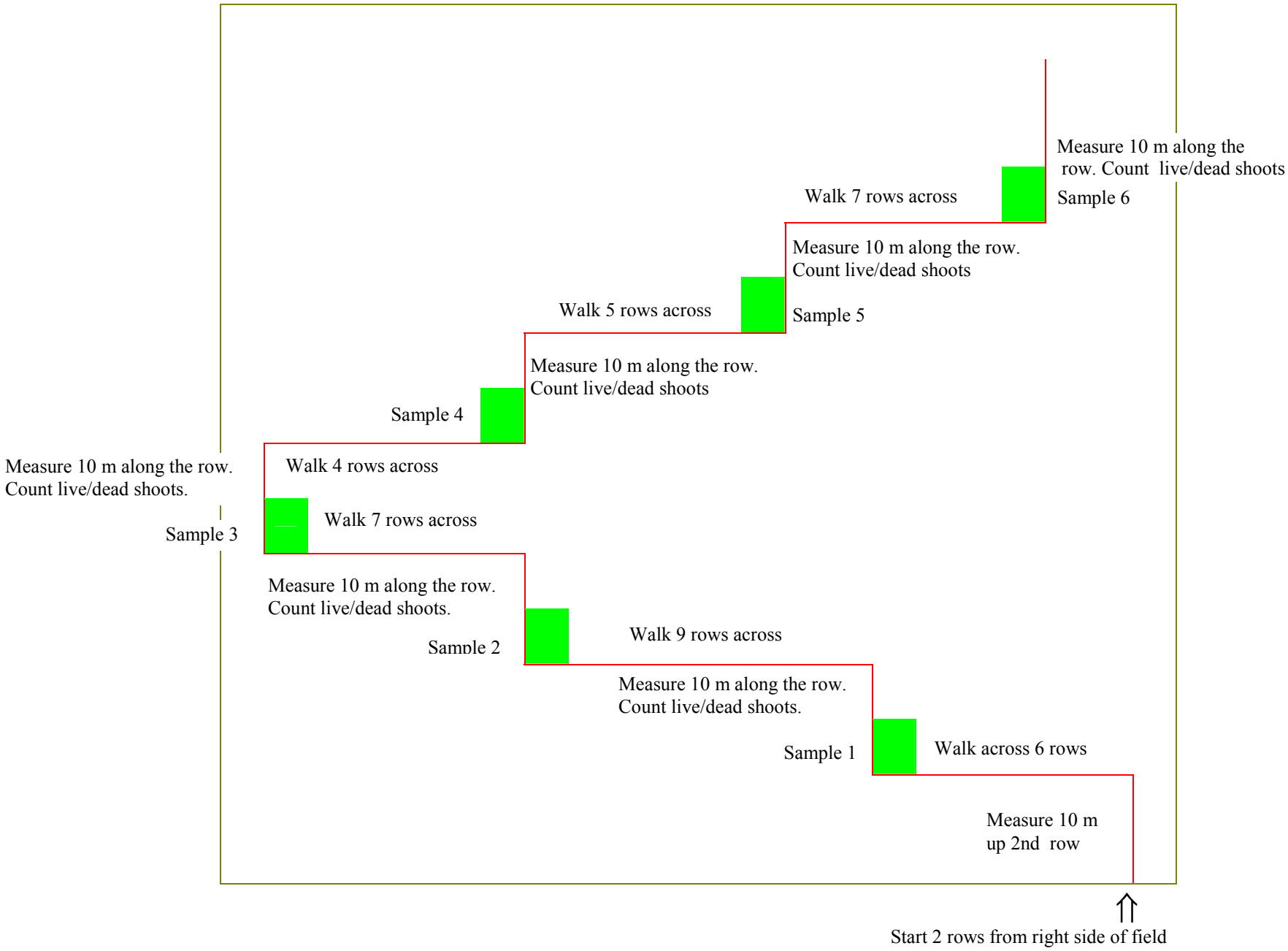
Soil samples

When a site is sampled for the first time a soil sample must be taken each time a stool is removed. The soil sample is made up of a small portion of soil, ie handful, and placed into a plastic bag. The bag should be clearly marked with grower's name, block number, and date first sampled. These soil samples will be analysed by BSES for pH.

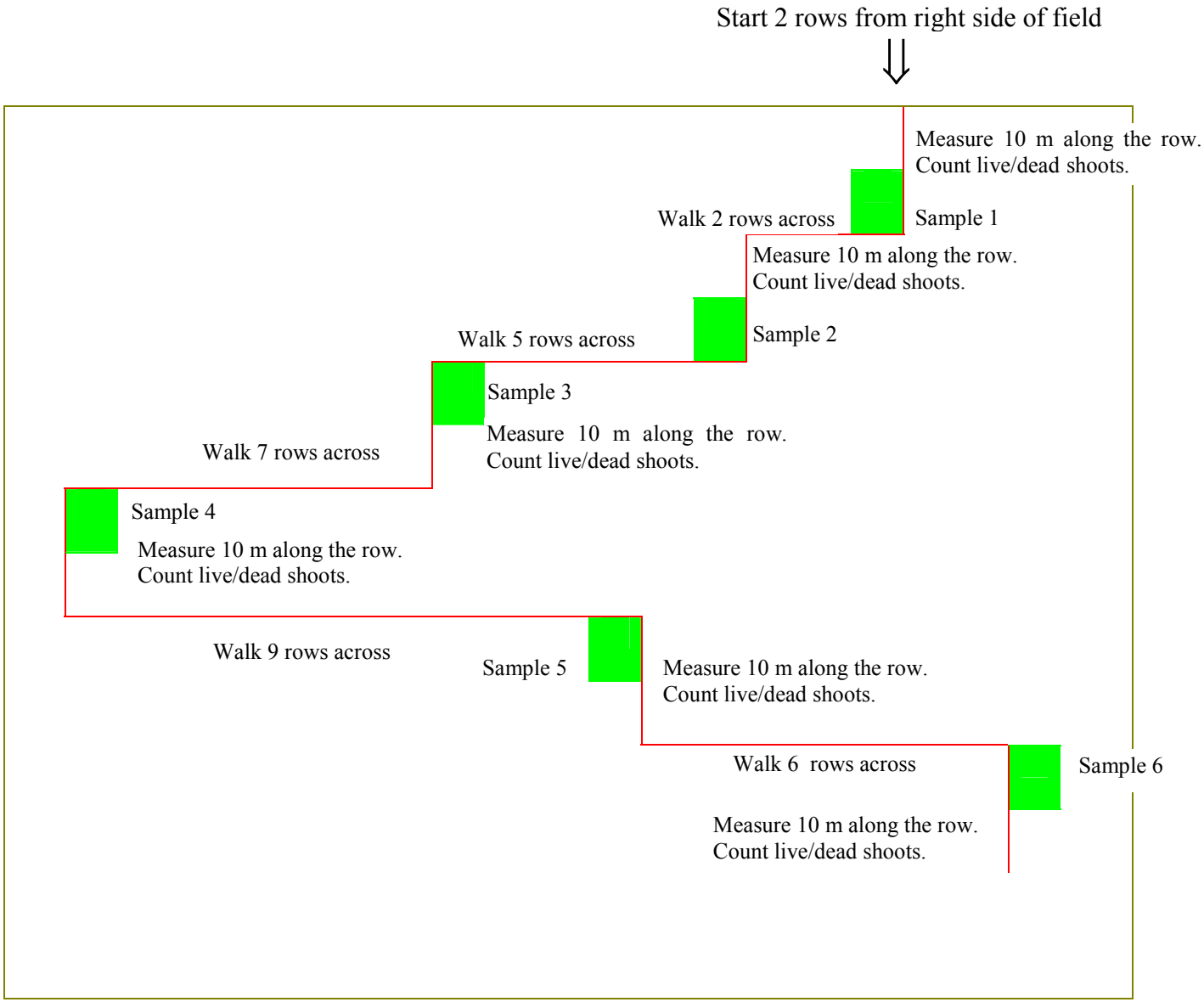
July/August


Measure 10 m along the row.
Count live/dead shoots.
Sample 6
Walk 1 row across
Measure 10 m along the
row. Count live/dead shoots.
Sample 5
Measure 10 m along the row.
Count live/dead shoots.
Walk 2 rows across
Walk five rows across.
Sample 4
Measure 10 m along the row.
Count live/dead shoots.
Walk 3 rows across
Sample 3
Measure 10 m along the row.
Count live/dead shoots.
Walk 6 rows across
Sample 2
Measure 10 m along the row.
Count live/dead shoots.
Walk across 4 rows
Sample 1
Measure 20 m up
4th row.
Start 4 rows from left side of field

September/October



November/December



Late January