

The current and potential costs of invertebrate pests in grain crops



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Abbreviations

ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
APVMA	Australian Pesticides and Veterinary Medicines Authority
BFE	Black field earwigs
BYDV	barley yellow dwarf virus
GRDC	Grains Research and Development Corporation
Ha	<i>Helicovera armigera</i>
NACMA	National Agricultural Commodities Marketing Association
NIPI	National Invertebrate Pest Initiative
NPV	Nucleopolyhedrovirus
NRT	No Registered Treatment
PSPE	Post Sowing Pre-Emergent
SP	Synthetic pyrethroid
WSMV	wheat streak mosaic virus

EXECUTIVE SUMMARY

The purpose of this study was to estimate the value of current and potential losses from invertebrate pests for the six most important Australian grain crops. Invertebrate pest species were identified using Australian literature and advice from entomologists with experience in grain crops. Current and potential losses from invertebrates were estimated through a survey of entomologists and reported on a GRDC Region basis. Estimates were prepared for wheat, barley, oats, canola, lupins and grain sorghum. A ranking of pests by economic importance is summarised in Table E1.

Based on current loss the three most important invertebrate pests of **wheat** are redlegged earth mite, blue oat mite and locusts. These three species are also the most important invertebrate pests of **barley** and **oats**.

The three most important invertebrate pest species of **canola** are diamondback moth, redlegged earth mite and canola aphids (various species) while for **lupins** they are aphids (various species), budworms and bryobia / balaustium (various species) mite. The most important

invertebrate pests of **grain sorghum** are budworm (corn earworm), sorghum midge and false wireworms (various species).

Aggregated across the six major Australian grain crops, the estimated present annual loss due to invertebrate pests totalled \$359.8 million. The relative importance of invertebrate pests varied between regions. Nationally, the five most important invertebrate pests, based on estimated present losses aggregated across the six crops, were redlegged earth mite (\$44.7 million), budworms (\$36.3 million), blue oat mite (\$35.5 million), lucerne flea (\$28.4 million) and locusts (\$28.4 million). Present cultural and pesticide controls of invertebrate pests effectively reduced losses by \$1,366.1 million, but pest management remained very dependent on pesticides. Nationally, pesticide treatment costs aggregated across all six crops totalled \$159.1 million.

Results from this study will inform future GRDC investment decisions related to invertebrate pests.

TABLE E1 Ranking of the top ten invertebrate pest groups and contribution of all other pest groups as determined by present loss aggregated across crops

Ranking	Pest	Crops affected #	Total present loss across affected crops (\$ million)
1	Redlegged earth mite	Wheat, barley, oats, canola, lupins	44.716
2	Budworms	Wheat, barley, oats, canola, lupins, grain sorghum	36.315
3	Blue oat mite	Wheat, barley, oats, canola, lupins	35.491
4	Lucerne flea	Wheat, barley, oats, canola, lupins	28.427
5	Locusts (various)	Wheat, barley, oats, grain sorghum	28.385
6	Slugs (various)	Wheat, barley, oats, canola	25.927
7	Aphids (various)	Wheat, barley, oats, canola, lupins	25.615
8	Snails (various)	Wheat, barley, oats, canola, lupins	17.678
9	Armyworms (various)	Wheat, barley, oats	15.958
10	Bryobia / balaustium	Wheat, barley, oats, canola, lupins	14.464
	Others	Wheat, barley, oats, canola, lupins, grain sorghum	86.795
	TOTAL	Wheat, barley, oats, canola, lupins, grain sorghum	359.771

1 INTRODUCTION

The grains industry attracts significant public funds for research, development and extension. Part of these funds is raised from production levies that are matched by government funds and then invested by bodies such as the Grains Research and Development Corporation (GRDC).

Allocation of resources for the control of invertebrate pests depends on an assessment of the losses caused by those pests. This applies both at the individual level, when a grower decides whether control of a particular pest is warranted, and at the national level, when funds are allocated for research, development and extension on pest management. Gordon Murray and John Brennan have developed estimates of the current and potential costs of diseases in Australia for wheat, barley, pulses and oilseeds (Murray and Brennan 2009c, 2010). The GRDC requested a similar study of the current and potential costs of invertebrate pests, to assist in the allocation of resources for pest management. There are no comprehensive studies estimating costs of invertebrate pests in Australian grain crops, although estimates have been provided for some individual pest/crop situations (Adamson *et al.* 1997, Henzell *et al.* 1996). Furthermore, while action thresholds drive treatment for most pests, very few of these have been derived from empirical analysis. There is also evidence to suggest that a move from tillage towards minimum or no-tillage farming systems and a changing climate have altered the status of invertebrate pests in the Australian grain industry (Hoffmann *et al.* 2008).

2 METHOD

2.1 Introduction

Estimates of invertebrate pest losses should be fully transparent and documented; that is, the processes by which the data, assumptions and calculations are used to produce the final estimates should be clearly spelled out. This enables a critical appraisal by others and a recalculation of the estimates when new information becomes available.

The key processes involved in estimating the value of losses from invertebrate pests for major Australian grain crops (adapted from Murray and Brennan (2009b)) are:

- 1 Identification of an appropriate geographical unit from which to collect data. Prior to commencement of this project it was agreed with the GRDC that given the small number of Australian entomologists with experience in grain crops it would not be possible to collect data at the GRDC agro-ecological zone level. A GRDC regions based analysis was adopted.
- 2 The scope of the analysis was restricted to those crops whose total Australian production was in excess of 500,000 hectares per year during the period 2006-07 to 2011-12 (ABARES forecast). Crops selected were wheat, barley, oats, canola, lupins and grain sorghum.
- 3 The average (2006-07 to 2011-12) area, production and value of wheat, barley, oats, canola, lupins and grain sorghum in each region were estimated.
- 4 Development of a list of major invertebrate pests relevant to each grain crop. This task was completed with reference to both the Australian literature and

TABLE 2.1 Agro-climatic zones and GRDC regions in the Australian cropping belt

Region and zones within it	
Northern Region	
1	Queensland Central
2	NSW North-East/Queensland South-East
3	NSW North-West/Queensland South-West
Southern Region	
4	NSW Central
5	NSW-Victoria Slopes
6	Victoria High Rainfall
7	TAS Grain Growing
8	SA-Victoria Border-Wimmera
9	SA-Victoria Mallee
10	SA Mid-North/Lower Yorke, Eyre
Western Region	
11	WA Sandplain-Mallee
12	WA Central
13	WA Northern
14	WA Eastern

Source: Murray and Brennan (2009a)

entomologists with experience in grain crops prior to survey commencement.

the estimated area treated and the costs of treatment application versus leaving crops untreated.

5 A survey was developed to identify invertebrate pest control methods that were used by farmers,

6 The survey was delivered, data modelled and reviewed. Data were collected from Australian entomologists,

TABLE 2.2 Crop areas – eight largest Australian summer and winter grain crops ('000 ha)

	2006-07	2007-08	2008-09	2009-10	2010-11s	2011-12f	Average
Wheat	11,798	12,578	13,530	14,028	13,374	13,808	13,186
Barley	4182	4902	5015	4446	4077	3931	4426
Canola	1052	1277	1693	1712	1642	1742	1520
Oats	1003	1238	870	865	917	871	961
Grain Sorghum	613	942	767	516	637	702	696
Lupins	736	752	577	698	568	574	651
Chickpeas	284	306	338	363	546	491	388
Triticale	369	360	323	350	330	323	343

Source: ABARES 2011; s = ABARES estimate; f = forecast

TABLE 2.3 Wheat, Barley and Oats invertebrate pests in Australia

Scientific Name	Common Name	Pest Group
Snails		
<i>Ceruella virgata</i>	common white snail	Snails (various)
<i>Cochlicella acuata</i>	pointed snail	
<i>Cochlicella barbara</i>	small pointed snail	
<i>Theba pisana</i>	white Italian snail	
Slugs		
<i>Milax gagates</i>	black-keeled slug	Slugs (various)
<i>Deroceras reticulatum</i>	reticulated slug	
Mites		
<i>Halotydeus destructor</i>	redlegged earth mite	Redlegged earth mite
<i>Penthaleus</i> spp.	blue oat mite	Blue oat mite
<i>Bryobia</i> spp.	Bryobia mite	Bryobia (Various) / Balaustium mite
<i>Balaustium medicagoense</i>	Balaustium mite	
<i>Petrobia latens</i>	brown wheat mite	Brown wheat mite
<i>Aceria tosichella</i>	wheat curl mite – vector of wheat streak mosaic virus (WSMV)	Wheat curl mite
Springtails		
<i>Sminthurus viridis</i>	lucerne flea	Lucerne flea
Crickets		
<i>Cylindracheta psammophila</i>	sandgroper	Sandgropers
Locusts		
<i>Chortoicetes terminifera</i>	Australian plague locust	Locusts (various)
<i>Austacris guttulosa</i>	spur-throated locust	
Aphids		
<i>Rhopalosiphum padi</i>	oat aphid	Cereal aphids (various)
<i>Rhopalosiphum maidis</i>	corn aphid	
Beetles		
<i>Acrossidius</i> spp., <i>Sericesthis</i> spp., <i>Othononius</i> spp., <i>Heteronyx</i> spp., <i>Heteronychus</i> spp.	cockchafer, white grub	Cockchafers (various)
Caterpillars		
<i>Hednota</i> spp.	pasture webworm	Pasture webworms (various)
<i>Leucania</i> spp., <i>Persectania</i> spp.	armyworm	Armyworms (various)
<i>Agrotis</i> spp.	cutworm	Cutworms (various)
<i>Heliothis/Helicoverpa</i> spp.	budworm	Budworms (various)
Earwigs		
<i>Forficula auricularia</i>	European earwig	European earwigs

Source: developed from Bailey (2007)

spreadsheet models developed and draft findings returned to participants for review.

2.2 Geographical regions for survey

The geographical units used for the survey are the GRDC's three grain growing regions. The three regions are made up of 14 'agro-ecological zones' (Table 2.1). The regions and zones are fully discussed in Section 2.2 of Murray and Brennan (2009a).

2.3 Crop coverage

The six crops selected with an average area of production greater than 500,000 hectares were identified using Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) data (ABARES 2011). Annual area and average production for the period 2006-07 to 2011-12

(forecast) is shown in Table 2.2.

It is understood that a separate process may be commissioned by the GRDC in the future for crops with less than 500,000 ha of annual Australian production.

2.4 Crop production data

In this study crop losses are estimated for current production. Data for crop area, yield and production in recent years were collected for each region, on the basis that recent averages would represent expected values over the next several years. The period 2006-07 to 2011-12 was selected to calculate the mean annual area and production (see Section 3 for a more detailed explanation).

2.5 The invertebrate pests

This report deals with the crop losses caused by invertebrate

TABLE 2.4 Canola invertebrate pests in Australia

Scientific Name	Common Name	Pest Group
Snails		
<i>Ceruella virgata</i>	common white snail	Snails (various)
<i>Theba pisana</i>	white Italian snail	
<i>Cochlicella acuata</i>	pointed snail	
Slugs		
<i>Milax gagates</i>	black-keeled slug	Slugs (various)
<i>Deroceras reticulatum</i>	reticulated slug	
Springtails		
<i>Sminthurus viridis</i>	lucerne flea	Lucerne flea
Mites		
<i>Halotydeus destructor</i>	redlegged earth mite	Redlegged earth mite
<i>Penthaleus</i> spp.	blue oat mite	Blue oat mite
<i>Bryobia</i> spp.	Bryobia mite	Bryobia (Various)/Balaustium mite
<i>Balaustium medicagoense</i>	Balaustium mite	
Aphids		
<i>Lipaphis erysimi</i>	turnip aphid	
<i>Brevicoryne brassicae</i>	cabbage aphid	Canola aphids (various)
<i>Myzus persicae</i>	green peach aphid	
Beetles		
<i>Adelium brevicorne</i>	bronzed field beetle	
<i>Gonocephalum</i> spp.	vegetable beetle	False wireworms (various)
<i>Pterohelaeus</i> spp.	false wireworm	
<i>Mandalotus</i> spp.	Mandalotus weevil	
<i>Listroderes difficilis</i>	vegetable weevil	Weevils (various)
<i>Steriphus diversipes</i>	spotted vegetable weevil	
Caterpillars		
<i>Helicoverpa punctigera</i>	budworm	Budworms
<i>Plutella xylostella</i>	diamondback moth	Diamondback moth
<i>Agrotis</i> spp.	cutworm	Cutworms (various)
<i>Achyra affinitalis</i>	weed web moth	Weed web moth
Bugs		
<i>Nysius vinitor</i>	Rutherglen bug	Rutherglen bug
Earwigs		
<i>Forficula auricularia</i>	European earwig	European earwig
Millipedes		
Millipedes	millipede	Millipedes

Source: developed from Bailey (2007)

TABLE 2.5 Lupin invertebrate pests in Australia

Scientific Name	Common Name	Pest group
Snails		
<i>Cermeuella virgata</i>	common white snail	Snails (various)
<i>Theba pisana</i>	white Italian snail	
Mites		
<i>Halotydeus destructor</i>	redlegged earth mite	Redlegged earth mite
<i>Penthaleus</i> spp.	blue oat mite	Blue oat mite
<i>Bryobia</i> spp.	Bryobia mite	Bryobia (various)/ Balaustium mite
<i>Balaustium medicagoense</i>	Balaustium mite	
Springtails		
<i>Sminthurus viridis</i>	lucerne flea	Lucerne flea
Aphids		
<i>Aphis craccivora</i>	cowpea aphid	Aphids (various)
<i>Acyrtosiphon kondoi</i>	bluegreen aphid	
Caterpillars		
<i>Etiella behrii</i>	lucerne seed web moth	Etiella moth
<i>Helicoverpa punctigera</i>	native budworm	Budworms
<i>Agrotis</i> spp.	cutworm	Cutworms (various)
<i>Achyra affinalis</i>	weed web moth	Weed web moth
Beetles		
<i>Mandalotus</i> spp.	Mandalotus weevil	
<i>Steriphus diversipes</i>	spotted vegetable weevil	Weevils (various)
<i>Listroderes difficilis</i>	vegetable weevil	
Earwigs		
<i>Forficula auricularia</i>	European earwig	European earwigs

Source: developed from Bailey (2007)

pests. Many invertebrate pests are crop specific and reference to *Pests of Field Crops and Pastures: Identification and Control* (Bailey 2007) revealed a very long list of invertebrate pest species for each of the target crops.

The majority of minor pests identified in Bailey (2007) have a very low frequency of occurrence (less than one in 10 or one in 20 year occurrence) and restricted distribution and would not figure prominently in national crop loss estimates. The inclusion of the full pest list was deemed to produce a very cumbersome spreadsheet model that could deter some entomologists from completing the survey. In addition, species specific information of groups such as 'armyworm', 'cutworm' and 'false wireworm' was unlikely to be available because field identification is often not at the species level and species involved may vary from region to region.

For these reasons, a focus on major pests listed in Bailey (2007) was proposed. The major pest list was reviewed by survey entomologists and the GRDC prior to project scope finalisation.

For each crop, the Pest Group are the categories for which estimates of loss were sought. However, for clarity it was appropriate for the survey to show both the scientific and common names of the pests where appropriate.

It is noted that while a comprehensive list of pests has been put together for oats, limited information was received. Compared to wheat and barley, oats is considered a crop with relatively few invertebrate pest problems and a smaller area of production.

TABLE 2.6 Grain Sorghum invertebrate pests in Australia

Scientific Name	Common Name	Pest group
Beetles		
<i>Pterohelaeus</i> spp.	false wireworm	
<i>Gonocephalum</i> sp.	false wireworm	False wireworms (various)
Caterpillars		
<i>Helicoverpa armigera</i>	budworms	Budworms (corn earworm)
Flies		
<i>Stenodiplosis sorghicola</i>	sorghum midge	Sorghum midge
Bugs		
<i>Nysius vinitor</i>	Rutherglen bug	Rutherglen bug
Locusts		
<i>Chortoicetes terminifera</i>	Australian plague locust	Locusts (various)
<i>Austacris guttulosa</i>	spur-throated locust	

Source: developed from Bailey (2007)

TABLE 2.7 Entomologist Survey responses by GRDC region

Region	Responses	Contributors
Northern	6	7
Southern	3	7
Western	1	4
Total	10	18

Many of the invertebrate pests shown in the above tables are widely distributed throughout the three GRDC Australian cropping regions. However, the frequency that they cause noticeable yield and quality loss varies between regions since pests can be and are present without causing significant loss. This report seeks to estimate these frequencies and losses under current growing conditions.

2.6 Potential and present pest losses

Incidence and severity of invertebrate pest

Average loss in a region is determined by the incidence and severity of a pest. Incidence is the frequency with which environmental conditions enable the pest to reach economically damaging levels in that region. Severity is the level of damage caused during those periods when the pests are at or above the economically damaging level. Often only a proportion of crops grown within regions will be affected by an outbreak.

Estimating average yield loss

Respondents were asked to indicate percentage yield loss when the pest was not controlled and when controls were applied. Control includes cultural practices, biocontrol and use of pesticides. For example, budworm is capable of reducing grain sorghum yield by more than 40% if not controlled and by 6% if controls are applied. Monetary losses can be estimated using these data coupled with incidence and regional production data.

Effects of quality loss

Entomologists report the following in relation to the effects of invertebrate pests on grain quality:

- Generally speaking for the grain crops under consideration, invertebrate pests directly affect yield and have a lesser impact on grain quality. National Agricultural Commodities Marketing Association (NACMA) Receival Standards provide the basis by which grain quality may be affected by invertebrate pests. Apart from direct yield effects, downgrading may arise from invertebrate contaminants (dead or alive), insect-damaged grain caused 'in-field' and high screenings (undersized or pinched grain) in samples at the point of delivery.
- There are some notable exceptions for quality effects. For example, feeding by Rutherglen bug (*Nysius vinitor*) in canola may reduce seed size and alter oil quality and seed germination. Rutherglen bug is very sporadic in nature, occasionally being a grain contaminant from harvested wind-rowed canola.
- *Helicoverpa* spp. and some other caterpillar pests may chew and pit grain when infestations are severe and directly affect grain yield in most of the cereals and canola under consideration. Infestations severe enough to affect grain quality in cereals are rare. Quality downgrading from caterpillars are much more common for pulse crops, which includes lupins.

For these reasons, the impact of invertebrate pests on grain quality loss has not been quantified in this analysis.

Other losses

Aphids are known to vector viruses, such as barley yellow dwarf virus (BYDV) of cereals, which can contribute to substantial crop losses. In this paper the damage attributed to aphids is for calculated "feeding damage" only and does not consider the added loss which could occur from viruses.

Wheat curl mites rarely cause damage to cereals except when in excessively high numbers. In this study the wheat curl mites are considered for the losses that are likely to occur when they vector wheat streak mosaic virus (WSMV).

2.7 Control methods

Murray and Brennan (2009a, 2009b) identify three broad categories of controls for dealing with disease losses in cereals:

- Breeding i.e. resistant cultivars;
- Cultural practices including stubble management, tillage and crop rotations; and
- Pesticides e.g. fungicides, in furrow or foliar sprays, insecticides for vector control.

These broad categories require revision for application to the control of invertebrate pests.

Review of the relevant literature for the crops under consideration reveals two crops (grain sorghum and lupins) where breeding has made a significant contribution to pest control (Gu *et al.* 2008). Breeding is also underway for

wheat cultivars resistant to Russian wheat aphid which may establish in Australia in the future, and there are prospects for pest resistance in canola. While host plant resistance and genetic engineering hold promise for the future, their current deployment in the crops under consideration is mostly negligible. For this reason 'breeding' was excluded from the invertebrate pest survey. Notable exceptions where breeding has made an impact are the widespread adoption of sorghum midge resistant cultivars for grain sorghum and aphid-resistant cultivars for lupins.

Cultural controls such as conservation of natural enemies, time of sowing, crop destruction, crop rotation, weed management and cultivation are available for some invertebrate pests (Bailey 2007). Survey data were collected on percentage of pest area treated with cultural controls, but for most of the pests pesticide intervention is the main control measure. Therefore, the survey focussed on capturing data on the main pesticide treatment used for each pest, knowing full well that there will be a range of products registered. For some pests e.g. cockchafers in cereals, pesticides are not effective, and few registered controls are available.

To capture data on the main pesticide treatment used for each pest, Murray and Brennan (2009b) was modified and the following questions were posed:

- proportion of crops receiving pesticide at identified Incidence and Severity levels (%); and
- name of representative pesticide control agent.

The consulting team was then able to follow up and cost control agents and their application costs. Control pesticides were limited to those registered by the Australian Pesticides and Veterinary Medicines Authority (APVMA). In some States where a pesticide is registered on a crop for the control of a pest, that pesticide can be used on that crop for the control of any pest at an existing rate and use pattern. In some instances this may offer a cheaper alternative to a registered pesticide. For example, while fenitrothion is registered for locust control, a less expensive and frequently used alternative is alpha-cypermethrin, even though the latter is not formally registered against locusts.

Recommended retail prices of representative pesticides were obtained during February 2012. Application costs vary depending on whether aerial or ground-rig application is used. An average application cost of \$13.00/ha was assumed for all pesticide treatments except seed dressings.

For all pests except sorghum midge where two sprays were suggested, it was assumed that only a single pesticide application was made to control any one pest during a growing season. Thus, for some pests control costs may be underestimated. For example, up to four pesticide sprays may be applied to control diamondback moth on susceptible canola crops in a single season (Umina and Hoffmann 2003).

2.8 Survey and survey sample

Data to develop the cost assessment were collected from

entomologists with experience in the Australian grains industry and were drawn mostly from participants of the National Invertebrate Pest Initiative (NIPi). In total 20 plus entomologists were targeted and after allowing for a collective response from those who work together (see Table 2.7), 10 complete data sets were received. Survey responses were collated and checked for consistency. Where major variation was evident in responses for a region, relevant survey respondents were consulted in order to negotiate final values. Results were then tabulated for each GRDC region and form the base data for calculating the costs of invertebrate pests.

2.9 Calculating pest costs

Current cost summary

- lost returns with control in place i.e. extra production minus cost of pesticide control

Potential cost summary

- lost returns without control in place

In a production environment where pests cause yield losses in the presence of current controls, there is an implied (higher) yield that would occur if that pest were fully controlled. From the observed current yield (with the pest) and the estimated yield reduction that has occurred, an estimate of the without pest yield can be made and the size and value of the loss calculated. The method used to estimate the size of the potential and current yield losses and the associated value of those losses is outlined in Murray and Brennan (2009a).

The value of the current control measure is the difference between the outcome if there were no controls and the outcome with current controls in place as per Murray and Brennan (2009a). The value of the controls across a production zone can be converted to a per hectare basis by dividing by the number of hectares in the region.

Implicit in these estimations is the assumption that there is no interaction between pests. However, if all pests developed uncontrolled, there would be significant interaction between them. The first to develop would be expected to have a greater effect on yield than subsequent pests. Thus the estimates of potential losses assume that for each pest, it is the only one that develops. Therefore, it is not appropriate to sum the total potential loss over all pests.

For current losses, there would be far less interaction between pests. In this case it has been assumed that it is possible to sum total current pest losses.

3 CROP PRODUCTION

Crop production data for the period 2006-07 to 2011-12 were assembled for the project by Neil Clark & Associates and provide an average across a range of wet and dry seasons.

TABLE 3.1 Mean wheat area, yield, production and value, by GRDC region, 2006-07 to 2011-12 (f)

Region	Area (ha)	Yield (t/ha)	Production (t)	Unit Value (\$/t)	Gross value (\$)
Northern	2,572,983	1.7	4,428,503	253	1,120,332,870
Southern	5,852,170	1.5	8,773,441	252	2,214,200,199
Western	4,548,638	1.5	6,903,879	275	1,897,769,275
Total	12,973,791		20,105,824		5,232,302,344

(f) = forecast

Source: Neil Clark & Associates

TABLE 3.2 Mean barley area, yield, production and value, by GRDC region, 2006-07 to 2011-12 (f)

Region	Area (ha)	Yield (t/ha)	Production (t)	Unit Value (\$/t)	Gross value (\$)
Northern	507,979	1.8	899,646	221	198,807,971
Southern	2,649,026	1.6	4,234,533	204	863,039,582
Western	1,282,477	1.8	2,345,952	228	535,631,988
Total	4,439,482		7,480,130		1,597,479,541

Source: Neil Clark & Associates

TABLE 3.3 Mean oats area, yield, production and value, by GRDC region, 2006-07 to 2011-12 (f)

Region	Area (ha)	Yield (t/ha)	Production (t)	Unit Value (\$/t)	Gross value (\$)
Northern	140,402	0.8	105,640	222	23,431,812
Southern	515,573	1.1	590,914	211	124,497,549
Western	297,041	1.8	536,510	192	103,116,387
Total	953,016		1,233,064		251,045,748

Source: Neil Clark & Associates

TABLE 3.4 Mean canola area, yield, production and value, by GRDC region, 2006-07 to 2011-12 (f)

Region	Area (ha)	Yield (t/ha)	Production (t)	Unit Value (\$/t)	Gross value (\$)
Northern	46,942	1.3	60,047	510	30,609,625
Southern	681,536	1.1	716,503	477	342,048,597
Western	732,562	1.1	778,443	485	377,351,231
Total	1,461,039		1,554,994		750,009,453

Source: Neil Clark & Associates

TABLE 3.5 Mean lupins area, yield, production and value, by GRDC region, 2006-07 to 2011-12 (f)

Region	Area (ha)	Yield (t/ha)	Production (t)	Unit Value (\$/t)	Gross value (\$)
Northern	19,338	1.4	27,758	342	9,486,707
Southern	166,057	1.0	162,548	301	49,006,988
Western	538,949	1.1	607,500	240	145,617,912
Total	724,344		797,806		204,111,607

Source: Neil Clark & Associates

TABLE 3.6 Mean grain sorghum area, yield, production and value, by GRDC region, 2006-07 to 2011-12 (f)

Region	Area (ha)	Yield (t/ha)	Production (t)	Unit Value (\$/t)	Gross value (\$)
Northern	703,848	3.1	2,201,160	213	468,272,264
Southern	3770	1.9	7035	208	1,463,942
Western	735	1.5	1121	178	199,714
Total	708,353		2,209,316		469,935,920

Source: Neil Clark & Associates

4 WHEAT – INVERTEBRATE PEST COST

4.1 Incidence and severity of invertebrate pests in wheat

The following tables report pest presence, incidence and severity using survey data for wheat.

TABLE 4.1 Presence of invertebrate pests causing wheat damage – GRDC Regions and Australia

Invertebrate pest	Northern	Southern	Western	Australia
Snails				
Snails (various)	N	Y	Y	Y
Slugs				
Slugs (various)	Y	Y	Y	Y
Mites				
Redlegged earth mite	N	Y	Y	Y
Blue oat mite	Y	Y	Y	Y
Bryobia (various) / Balaustium mite	N	Y	Y	Y
Brown wheat mite	Y	Y	Y	Y
Wheat curl mite	Y	Y	Y	Y
Springtails				
Lucerne flea	N	Y	Y	Y
Crickets				
Sandgropers	N	N	Y	Y
Locusts				
Locusts (various)	Y	Y	Y	Y
Aphids				
Cereal aphids (various)	Y	Y	Y	Y
Beetles				
Cockchafer (various)	Y	Y	Y	Y
Caterpillars				
Pasture webworms (various)	N	Y	Y	Y
Armyworms (various)	Y	Y	Y	Y
Cutworms (various)	Y	Y	Y	Y
Budworms (various)	Y	Y	Y	Y
Earwigs				
European earwigs	N	Y	Y	Y
Additional Pests				
Slaters	Y	Y	Y	Y

Y: present in region, N: not recorded in region

Notes: If an invertebrate pest is present in any GRDC region, it is recorded as being present in Australia. Slaters are present in both the Northern and Southern Regions but are not currently rated by entomologists as pests of economic significance. This may change in the future as the area of minimum till increases.

TABLE 4.2 Incidence of invertebrate pests in wheat as a proportion of years when pests occur at economically damaging levels (%) and as a proportion of the whole crop area affected (%) during those years in the GRDC Regions and Australia

Invertebrate pest	Northern		Southern		Western		Australia	
	Years	Area	Years	Area	Years	Area	Years	Area
Snails								
Snails (various)			32.5%	7.5%	70.0%	5.0%	39.2%	5.1%
Slugs								
Slugs (various)	8.3%	0.7%	43.3%	7.7%	80.0%	4.0%	49.2%	5.0%
Mites								
Redlegged earth mite			45.0%	30.7%	30.0%	10.0%	30.8%	17.3%
Blue oat mite	4.2%	1.1%	45.0%	27.3%	40.0%	10.0%	35.1%	16.1%
Bryobia (various) / Balaustium mite			45.0%	24.0%	60.0%	10.0%	41.3%	14.3%
Brown wheat mite	6.7%	1.2%	10.0%	2.9%	5.0%	5.0%	7.6%	3.3%
Wheat curl mite	3.3%	0.3%	53.3%	33.6%	30.0%	5.0%	35.2%	17.0%
Springtails								
Lucerne flea			43.3%	27.0%	40.0%	10.0%	33.6%	15.7%
Crickets								
Sandgropers					20.0%	1.0%	7.0%	0.4%
Locusts								
Locusts (various)	6.0%	8.0%	21.7%	30.0%	10.0%	20.0%	14.5%	22.1%
Aphids								
Cereal aphids (various)*	36.3%	24.4%	60.0%	16.7%	60.0%	40.0%	55.3%	26.4%
Beetles								
Cockchafer (various)	4.2%	2.5%	40.0%	2.1%	30.0%	10.0%	29.4%	4.9%
Caterpillars								
Pasture webworms (various)			15.0%	2.3%	50.0%	15.0%	24.3%	6.3%
Armyworms (various)	19.0%	22.5%	28.3%	8.0%	50.0%	8.0%	34.1%	10.9%
Cutworms (various)	13.3%	3.5%	26.7%	7.3%	50.0%	15.0%	32.2%	9.3%
Budworms (various)	25.7%	18.0%	51.7%	12.3%	10.0%	2.0%	31.9%	9.8%
Earwigs								
European earwigs			16.7%	3.9%	100.0%	4.0%	42.6%	3.2%
Additional Pests								
Slaters					100.0%	2.0%	35.1%	0.7%

Note: Australia Years and Area percentages are a weighted average total based on percentage for each Region multiplied by the total crop area average for that region, with the total then divided by the total crop area average for all regions.

* Assessment for feeding damage only, not virus transmission.

TABLE 4.3 Severity: Estimated potential damage (% yield loss) in the absence of chemical and cultural controls and present levels of damage (% yield loss) with current chemical and cultural control of invertebrate pests in wheat in the GRDC Regions and Australia

Invertebrate pest	Northern		Southern		Western		Australia	
	Potential	Present	Potential	Present	Potential	Present	Potential	Present
Snails								
Snails (various)			30.0%	12.0%	10.0%	5.0%	17.0%	7.2%
Slugs								
Slugs (various)	8.3%	2.5%	24.0%	12.0%	10.0%	5.0%	16.0%	7.7%
Mites								
Redlegged earth mite			14.3%	3.7%	5.0%	1.0%	8.2%	2.0%
Blue oat mite	1.3%	0.6%	14.3%	3.7%	20.0%	1.0%	13.7%	2.1%
Bryobia (various) / Balaustium mite			8.0%	1.3%	10.0%	1.0%	7.1%	1.0%
Brown wheat mite	5.2%	0.8%	1.2%	0.4%	5.0%	1.0%	3.3%	0.7%
Wheat curl mite	0.4%	0.3%	3.1%	0.9%	30.0%	0.5%	12.0%	0.6%
Springtails								
Lucerne flea			15.3%	3.3%	20.0%	1.0%	13.9%	1.9%
Crickets								
Sandgropers					30.0%	30.0%	10.5%	10.5%
Locusts								
Locusts (various)	42.5%	10.8%	58.3%	10.0%	15.0%	2.0%	40.0%	7.4%
Aphids								
Cereal aphids (various)	6.3%	2.6%	6.3%	0.7%	10.0%	2.0%	7.6%	1.5%
Beetles								
Cockchafer (various)	13.3%	13.3%	7.0%	6.3%	5.0%	5.0%	7.6%	7.3%
Caterpillars								
Pasture webworms (various)			13.3%	2.7%	20.0%	5.0%	13.0%	3.0%
Armyworms (various)	11.5%	4.0%	28.7%	5.7%	5.0%	2.0%	17.0%	4.1%
Cutworms (various)	15.8%	3.3%	20.3%	5.7%	20.0%	3.0%	19.3%	4.3%
Budworms (various)	14.8%	4.5%	10.3%	3.7%	10.0%	3.0%	11.1%	3.6%
Earwigs								
European earwigs			3.8%	1.1%	10.0%	5.0%	5.2%	2.2%
Additional Pests								
Slaters					10.0%	5.0%	3.5%	1.8%

Note: Australia Potential and Present percentages are a weighted average total based on percentage for each Region multiplied by the total crop area average for that region, with the total then divided by the total crop area average for all regions.

4.2 Potential cost to wheat crop – no control of invertebrate pests

The potential economic loss in the absence of cultural and pesticide controls is summarised in Table 4.4. These values take into consideration both the incidence (% years) and severity (% area damaged).

TABLE 4.4 Potential average annual loss (\$/ha and \$ million) from invertebrate pests in wheat in the GRDC Regions and Australia

Invertebrate pest	Northern		Southern		Western		Australia	
	\$/ha	\$ million	\$/ha	\$ million	\$/ha	\$ million	\$/ha	\$ million
Snails								
Snails (various)	\$0.00	\$0.000	\$2.98	\$17.437	\$1.46	\$6.642	\$1.86	\$24.079
Slugs								
Slugs (various)	\$0.12	\$0.311	\$5.12	\$29.936	\$1.34	\$6.073	\$2.80	\$36.320
Mites								
Redlegged earth mite	\$0.00	\$0.000	\$16.33	\$95.581	\$0.63	\$2.847	\$7.59	\$98.428
Blue oat mite	\$0.00	\$0.010	\$14.52	\$85.002	\$3.34	\$15.182	\$7.72	\$100.194
Bryobia (various) / Balaustium mite	\$0.00	\$0.000	\$7.10	\$41.538	\$2.50	\$11.387	\$4.08	\$52.925
Brown wheat mite	\$0.04	\$0.106	\$0.01	\$0.074	\$0.05	\$0.237	\$0.03	\$0.417
Wheat curl mite	\$0.00	\$0.001	\$2.94	\$17.178	\$1.88	\$8.540	\$1.98	\$25.720
Springtails								
Lucerne flea	\$0.00	\$0.000	\$14.03	\$82.105	\$3.34	\$15.182	\$7.50	\$97.287
Crickets								
Sandgropers	\$0.00	\$0.000	\$0.00	\$0.000	\$0.25	\$1.139	\$0.09	\$1.139
Locusts								
Locusts (various)	\$1.31	\$3.365	\$18.02	\$105.482	\$1.25	\$5.693	\$8.83	\$114.540
Aphids								
Cereal aphids (various)	\$3.59	\$9.239	\$3.04	\$17.763	\$10.01	\$45.546	\$5.59	\$72.549
Beetles								
Cockchafer (various)	\$0.22	\$0.560	\$0.45	\$2.648	\$0.63	\$2.847	\$0.47	\$6.055
Caterpillars								
Pasture webworms (various)	\$0.00	\$0.000	\$0.21	\$1.230	\$6.26	\$28.467	\$2.29	\$29.697
Armyworms (various)	\$3.27	\$8.426	\$3.92	\$22.956	\$0.83	\$3.796	\$2.71	\$35.178
Cutworms (various)	\$0.39	\$1.005	\$2.64	\$15.458	\$6.26	\$28.467	\$3.46	\$44.929
Budworms (various)	\$4.15	\$10.674	\$4.63	\$27.113	\$0.08	\$0.380	\$2.94	\$38.167
Earwigs								
European earwigs	\$0.00	\$0.000	\$0.15	\$0.884	\$1.67	\$7.591	\$0.65	\$8.475
Additional Pests								
Slaters					\$0.83	\$3.796	\$0.29	\$3.796
Total	\$13.10	\$33.70	\$96.10	\$562.38	\$42.61	\$193.81	\$60.88	\$789.89

Note: Australia \$/ha amounts are a weighted average total based on \$/ha for each Region multiplied by the total crop area average for that region, with the total then divided by the total crop area average for all regions. Australia \$ million is aggregate of the three regions.

4.3 Current cost to wheat crop – with control of invertebrate pests

The current cost to the wheat industry of invertebrate pests is shown in Table 4.5. These values take into consideration both the incidence (% years) and severity (% area damaged).

TABLE 4.5 Present average annual loss (\$/ha and \$ million) from invertebrate pests in wheat in the GRDC Regions and Australia

Invertebrate pest	Northern		Southern		Western		Australia	
	\$/ha	\$ million	\$/ha	\$ million	\$/ha	\$ million	\$/ha	\$ million
Snails								
Snails (various)	\$0.00	\$0.000	\$1.19	\$6.975	\$0.73	\$3.321	\$0.79	\$10.296
Slugs								
Slugs (various)	\$0.04	\$0.093	\$2.56	\$14.968	\$0.67	\$3.036	\$1.39	\$18.098
Mites								
Redlegged earth mite	\$0.00	\$0.000	\$4.18	\$24.451	\$0.13	\$0.569	\$1.93	\$25.020
Blue oat mite	\$0.00	\$0.005	\$3.72	\$21.745	\$0.17	\$0.759	\$1.73	\$22.508
Bryobia (various) / Balaustium mite	\$0.00	\$0.000	\$1.18	\$6.923	\$0.25	\$1.139	\$0.62	\$8.062
Brown wheat mite	\$0.01	\$0.017	\$0.00	\$0.026	\$0.01	\$0.047	\$0.01	\$0.090
Wheat curl mite	\$0.00	\$0.001	\$0.88	\$5.172	\$0.03	\$0.142	\$0.41	\$5.315
Springtails								
Lucerne flea	\$0.00	\$0.000	\$3.05	\$17.849	\$0.17	\$0.759	\$1.43	\$18.608
Crickets								
Sandgropers	\$0.00	\$0.000	\$0.00	\$0.000	\$0.25	\$1.139	\$0.09	\$1.139
Locusts								
Locusts (various)	\$0.33	\$0.858	\$3.09	\$18.083	\$0.17	\$0.759	\$1.52	\$19.699
Aphids								
Cereal aphids (various)	\$1.49	\$3.833	\$0.32	\$1.870	\$2.00	\$9.109	\$1.14	\$14.812
Beetles								
Cockchafters (various)	\$0.22	\$0.560	\$0.41	\$2.396	\$0.63	\$2.847	\$0.45	\$5.802
Caterpillars								
Pasture webworms (various)	\$0.00	\$0.000	\$0.04	\$0.246	\$1.56	\$7.117	\$0.57	\$7.363
Armyworms (various)	\$1.14	\$2.931	\$0.78	\$4.538	\$0.33	\$1.518	\$0.69	\$8.987
Cutworms (various)	\$0.08	\$0.212	\$0.74	\$4.308	\$0.94	\$4.270	\$0.68	\$8.789
Budworms (various)	\$1.26	\$3.238	\$1.64	\$9.621	\$0.03	\$0.114	\$1.00	\$12.973
Earwigs								
European earwigs	\$0.00	\$0.000	\$0.04	\$0.258	\$0.83	\$3.796	\$0.31	\$4.054
Additional Pests								
Slaters					\$0.42	\$1.898	\$0.15	\$1.898
Total	\$4.57	\$11.748	\$23.82	\$139.427	\$9.31	\$42.339	\$14.92	\$193.514

Note: Australia \$/ha amounts are a weighted average total based on \$/ha for each Region multiplied by the total crop area average for that region, with the total then divided by the total crop area average for all regions. Australia \$ million is aggregate of the three regions.

4.4 Value of invertebrate pest controls in wheat

The value of invertebrate pest control in wheat is estimated by subtracting the potential loss (Table 4.4) from the present loss (Table 4.5) and is shown in Table 4.6.

TABLE 4.6 Value of current control practices (\$/ha and \$ million) by GRDC Region and Australia

Invertebrate pest	Northern		Southern		Western		Australia	
	\$/ha	\$ million	\$/ha	\$ million	\$/ha	\$ million	\$/ha	\$ million
Snails								
Snails (various)	\$0.00	\$0.000	\$1.79	\$10.462	\$0.73	\$3.321	\$1.06	\$13.783
Slugs								
Slugs (various)	\$0.08	\$0.218	\$2.56	\$14.968	\$0.67	\$3.036	\$1.40	\$18.222
Mites								
Redlegged earth mite	\$0.00	\$0.000	\$12.15	\$71.130	\$0.50	\$2.277	\$5.66	\$73.407
Blue oat mite	\$0.00	\$0.005	\$10.81	\$63.257	\$3.17	\$14.423	\$5.99	\$77.685
Bryobia (various) / Balaustium mite	\$0.00	\$0.000	\$5.91	\$34.615	\$2.25	\$10.248	\$3.46	\$44.863
Brown wheat mite	\$0.03	\$0.089	\$0.01	\$0.048	\$0.04	\$0.190	\$0.03	\$0.327
Wheat curl mite	\$0.00	\$0.000	\$2.05	\$12.006	\$1.85	\$8.398	\$1.57	\$20.405
Springtails								
Lucerne flea	\$0.00	\$0.000	\$10.98	\$64.256	\$3.17	\$14.423	\$6.06	\$78.679
Crickets								
Sandgropers	\$0.00	\$0.000	\$0.00	\$0.000	\$0.00	\$0.000	\$0.00	\$0.000
Locusts								
Locusts (various)	\$0.97	\$2.507	\$14.93	\$87.399	\$1.08	\$4.934	\$7.31	\$94.841
Aphids								
Cereal aphids (various)	\$2.10	\$5.406	\$2.72	\$15.893	\$8.01	\$36.437	\$4.45	\$57.736
Beetles								
Cockchafers (various)	\$0.00	\$0.000	\$0.04	\$0.252	\$0.00	\$0.000	\$0.02	\$0.252
Caterpillars								
Pasture webworms (various)	\$0.00	\$0.000	\$0.17	\$0.984	\$4.69	\$21.350	\$1.72	\$22.334
Armyworms (various)	\$2.14	\$5.495	\$3.15	\$18.418	\$0.50	\$2.277	\$2.02	\$26.191
Cutworms (various)	\$0.31	\$0.794	\$1.91	\$11.150	\$5.32	\$24.197	\$2.79	\$36.140
Budworms (various)	\$2.89	\$7.436	\$2.99	\$17.492	\$0.06	\$0.266	\$1.94	\$25.194
Earwigs								
European earwigs	\$0.00	\$0.000	\$0.11	\$0.626	\$0.83	\$3.796	\$0.34	\$4.421
Additional Pests								
Slaters					\$0.42	\$1.898	\$0.15	\$1.898
Total	\$8.53	\$21.95	\$72.27	\$422.96	\$33.30	\$151.47	\$45.97	\$596.379

4.5 Value of cultural controls in wheat

The value of cultural controls for invertebrate pest control in wheat is estimated by multiplying the value of invertebrate pest control (Table 4.6) by the proportion of treated area receiving cultural controls.

TABLE 4.6A Percentage of treated area receiving cultural controls and value of current cultural control practices (\$ million) by GRDC Region and Australia

Invertebrate pest	Northern		Southern		Western		Australia
	% treated area	\$ million	% treated area	\$ million	% treated area	\$ million	\$ million
Snails							
Snails (various)	0.00%	\$0.000	40.00%	\$4.185	50.00%	\$1.661	\$5.846
Slugs							
Slugs (various)	20.00%	\$0.044	48.33%	\$7.235	60.00%	\$1.822	\$9.101
Mites							
Redlegged earth mite	0.00%	\$0.000	2.33%	\$1.660	30.00%	\$0.683	\$2.343
Blue oat mite	0.00%	\$0.000	2.33%	\$1.476	30.00%	\$4.327	\$5.803
Bryobia (various) / Balaustium mite	0.00%	\$0.000	2.33%	\$0.808	60.00%	\$6.149	\$6.957
Brown wheat mite	0.00%	\$0.000	0.00%	\$0.000	60.00%	\$0.114	\$0.114
Wheat curl mite	0.00%	\$0.000	52.50%	\$6.303	60.00%	\$5.039	\$11.342
Springtails							
Lucerne flea	0.00%	\$0.000	19.00%	\$12.209	50.00%	\$7.212	\$19.421
Crickets							
Sandgropers					0.00%	\$0.000	\$0.000
Locusts							
Locusts (various)	0.00%	\$0.000	0.67%	\$0.583	0.00%	\$0.000	\$0.583
Aphids							
Cereal aphids (various)	8.33%	\$0.450	35.00%	\$5.563	0.00%	\$0.000	\$6.013
Beetles							
Cockchafer (various)	2.50%	\$0.000	8.67%	\$0.022	0.00%	\$0.000	\$0.022
Caterpillars							
Pasture webworms (various)	0.00%	\$0.000	0.00%	\$0.000	70.00%	\$14.945	\$14.945
Armyworms (various)	10.00%	\$0.550	0.00%	\$0.000	0.00%	\$0.000	\$0.550
Cutworms (various)	6.67%	\$0.053	0.00%	\$0.000	0.00%	\$0.000	\$0.053
Budworms (various)	8.33%	\$0.620	1.67%	\$0.292	0.00%	\$0.000	\$0.912
Earwigs							
European earwigs	0.00%	\$0.000	33.33%	\$0.209	80.00%	\$3.036	\$3.245
Additional Pests							
Slaters					80.00%	\$1.518	\$1.518
Total		\$1.717		\$40.545		\$46.506	\$88.768

4.6 Cost of invertebrate pest controls in wheat

Cultivars are not presently tested for relevance to the control of vertebrate pests in wheat. The survey revealed limited and unspecified cultural controls for invertebrate pests in wheat.

Cultural controls are sometimes used on slugs, various mites, aphids, cockchafers, armyworms and budworms. Invertebrate pest control in wheat is most often achieved with pesticides. Representative pesticides used and their cost are shown in Table 4.7.

TABLE 4.7 Representative pesticide treatment used and cost – wheat

Invertebrate pest	Representative pesticide control	Active ingredient	Chemical cost per ha
Snails			
Snails (various)	baits	metaldehyde	\$12.00
Slugs			
Slugs (various)	baits	metaldehyde	\$12.00
Mites			
Redlegged earth mite	PSPE	bifenthrin	\$1.60
Blue oat mite	PSPE	bifenthrin	\$1.60
Bryobia (various) / Balaustium mite	pre-sowing with knockdown	omethoate	\$1.90
Brown wheat mite	pre-sowing with knockdown	omethoate	\$1.90
Wheat curl mite	no treatment*		
Springtails			
Lucerne flea	post emergence	omethoate	\$1.90
Crickets			
Sandgroper	no treatment*		
Locusts			
Locusts (various)	fenitrothion	fenitrothion	\$16.00
Aphids			
Cereal aphids (various)	dimethoate	dimethoate	\$6.25
Beetles			
Cockchafers (various)	no treatment*		
Caterpillars			
Pasture webworms (various)	SP	alpha-cypermethrin	\$0.64
Armyworms (various)	SP	alpha-cypermethrin	\$2.04
Cutworms (various)	SP	alpha-cypermethrin	\$0.64
Budworms (various)	SP (West and South for Hp) methomyl (North for Ha)	alpha-cypermethrin methomyl	\$2.04 \$22.00
Earwigs			
European earwigs	SP*	alpha-cypermethrin	\$2.04
Additional Pests			
Slaters	baits*	metaldehyde	\$8.00

PSPE: post sowing pre-emergent, SP: Synthetic pyrethroid, Hp: *Heliothis punctifera*, Ha: *Helicovera armigera*
* Controls may be permitted under relevant State Pesticide Regulations

TABLE 4.8 Invertebrate pest treatment costs – wheat

Invertebrate pest	Northern		Southern		Western		Australia	
	Incidence %	Total cost of treatment \$ million	Incidence %	Total cost of treatment \$ million	Incidence %	Total cost of treatment \$ million	Incidence %	Total cost of treatment \$ million
Snails								
Snails (various)			2.63%	\$2.016	3.50%	\$2.786	2.4%	\$4.802
Slugs								
Slugs (various)	0.33%	\$0.000	5.63%	\$2.885	3.20%	\$2.547	3.7%	\$5.432
Mites								
Redlegged earth mite			30.12%	\$5.232	3.00%	\$1.594	14.6%	\$6.826
Blue oat mite	0.07%	\$0.000	26.78%	\$3.890	4.00%	\$2.125	13.5%	\$6.015
Bryobia (various) / Balaustium mite			23.45%	\$2.112	6.00%	\$3.252	12.7%	\$5.365
Brown wheat mite	0.18%	\$0.021	0.29%	\$0.003	0.25%	\$0.136	0.3%	\$0.159
Wheat curl mite	0.03%		25.03%		1.50%		11.8%	NRT
Springtails								
Lucerne flea			24.18%	\$5.973	4.00%	\$2.168	12.3%	\$8.141
Crickets								
Sandgropers					0.20%	\$0.000	0.1%	NRT
Locusts								
Locusts (various)	0.71%	\$0.090	8.17%	\$5.036	2.00%	\$0.791	4.5%	\$5.917
Aphids								
Cereal aphids (various)#	13.16%	\$1.247	12.67%	\$1.903	24.00%	\$14.710	16.7%	\$17.860
Beetles								
Cockchafer (various)	0.38%	\$0.000	1.71%	\$0.000	3.00%	\$0.000	1.9%	NRT
Caterpillars								
Pasture webworms (various)*			0.42%	\$0.069	7.50%	\$3.722	2.8%	\$3.791
Armyworms (various)	6.54%	\$0.991	3.62%	\$0.913	4.00%	\$1.368	4.3%	\$3.272
Cutworms (various)	0.57%	\$0.139	3.43%	\$0.785	7.50%	\$3.722	4.3%	\$4.647
Budworms (various)	6.42%	\$0.583	11.85%	\$2.607	0.20%	\$0.068	6.7%	\$3.259
Earwigs								
European earwigs			1.06%	\$0.062	4.00%	\$1.368	1.9%	\$1.430
Additional Pests								
Slaters					2.00%	\$0.955	0.7%	\$0.955
Total		\$3.072		\$33.486		\$41.314		\$77.872

Incidence %: Incidence years x Incidence area

Australia Incidence % are a weighted average total based on percentage for each Region multiplied by the total crop area average for that region, with the total then divided by the total crop area average for all regions.

Australia Total Cost of Treatment is aggregate of the three regions. NRT = No registered treatment

* No controls applied for webworms in Western Region, # Feeding damage only

4.7 Conclusions on wheat invertebrate pests

Average total cost of treatment for invertebrate pests in wheat nationally is \$77.9 million or \$6 per ha grown. By GRDC region this equates to:

- Northern region: \$3.1 million pa or \$1.19 per hectare of wheat grown.
- Southern region: \$33.5 million pa or \$5.72 per hectare of wheat grown.
- Western region: \$41.3 million pa or \$9.08 per hectare of wheat grown.

Invertebrate pest pressure in the Northern GRDC region is much lower compared to other parts of Australia. This is largely due to the absence in the Northern GRDC region of the important pests, redlegged earth mite and lucerne flea. When ranked in order of potential and present losses, the five major invertebrate pests of wheat are:

TABLE 4.9 Five most important invertebrate pests of wheat by potential and present loss

Rank	By Potential Loss	By Present Loss
1	Locusts (\$114.5 million)	Redlegged earth mite (\$25.0 million)
2	Blue oat mite (\$100.2 million)	Blue oat mite (\$22.5 million)
3	Redlegged earth mite (\$98.4 million)	Locusts (\$19.7 million)
4	Lucerne flea (\$97.3 million)	Lucerne flea (\$18.6 million)
5	Cereal aphids (\$72.5 million)	Slugs (various) (\$18.1 million)

Reference to Table 4.4 shows that the above listed five invertebrate pests of wheat have the potential to cause serious losses. Table 4.5 shows that even with control the above listed five pests cost the wheat industry more than \$100 million annually.

5 BARLEY – INVERTEBRATE PEST COST

5.1 Incidence and severity of invertebrate pests in barley

The following tables report pest presence, incidence and severity using survey data for barley.

TABLE 5.1 Presence of invertebrate pests causing barley damage – GRDC Regions and Australia

Invertebrate pest	Northern	Southern	Western	Australia
Snails				
Snails (various)	N	Y	Y	Y
Slugs				
Slugs (various)	N	Y	Y	Y
Mites				
Redlegged earth mite	N	Y	Y	Y
Blue oat mite	Y	Y	Y	Y
Bryobia (various) / Balaustium mite	N	Y	Y	Y
Brown wheat mite	Y	Y	Y	Y
Wheat curl mite	Y	Y	Y	Y
Springtails				
Lucerne flea	N	Y	Y	Y
Crickets				
Sandgroper	N	N	Y	Y
Locusts				
Locusts (various)	Y	Y	Y	Y
Aphids				
Cereal aphids (various)	Y	Y	Y	Y
Beetles				
Cockchafer (various)	Y	Y	Y	Y
Caterpillars				
Pasture webworms (various)	N	Y	Y	Y
Armyworms (various)	Y	Y	Y	Y
Cutworms (various)	Y	Y	Y	Y
Budworms (various)	Y	Y	Y	Y
Earwigs				
European earwigs	N	Y	Y	Y
Additional Pests				
Slaters	Y	Y	Y	Y

Y: present in region, N: not recorded in region

Notes: If an invertebrate pest is present in any GRDC region, it is recorded as being present in Australia. Slaters are present in both the Northern and Southern Regions but are not rated by entomologists as pests of economic significance.

TABLE 5.2 Incidence of invertebrate pests in barley as a proportion of years when pests occur at economically damaging levels (%) and as a proportion of the whole crop area affected (%) during those years in the GRDC Regions and Australia

Invertebrate pest	Northern		Southern		Western		Australia	
	Years	Area	Years	Area	Years	Area	Years	Area
Snails								
Snails (various)			32.5%	7.5%	70.0%	5.0%	39.6%	5.9%
Slugs								
Slugs (various)			43.3%	4.3%	80.0%	4.0%	49.0%	3.7%
Mites								
Redlegged earth mite			45.0%	30.7%	30.0%	10.0%	35.5%	21.2%
Blue oat mite	4.2%	1.3%	45.0%	27.3%	40.0%	10.0%	38.9%	19.3%
Bryobia (various) / Balaustium mite			45.0%	24.0%	60.0%	10.0%	44.2%	17.2%
Brown wheat mite	6.7%	1.2%	10.0%	2.9%	5.0%	5.0%	8.2%	3.3%
Wheat curl mite	3.3%	0.3%	53.3%	33.6%	20.0%	2.0%	38.0%	20.7%
Springtails								
Lucerne flea			43.3%	22.0%	40.0%	10.0%	37.4%	16.0%
Crickets								
Sandgroper					20.0%	1.0%	5.8%	0.3%
Locusts								
Locusts (various)	4.7%	4.7%	21.7%	30.0%	10.0%	20.0%	16.4%	24.2%
Aphids								
Cereal aphids (various)*	46.7%	30.1%	60.0%	16.7%	60.0%	30.0%	58.5%	22.1%
Beetles								
Cockchafer (various)	4.2%	2.5%	40.0%	2.1%	30.0%	10.0%	33.0%	4.4%
Caterpillars								
Pasture webworms (various)			15.0%	2.3%	50.0%	15.0%	23.4%	5.7%
Armyworms (various)	23.0%	28.8%	28.3%	18.0%	50.0%	15.0%	34.0%	18.4%
Cutworms (various)	13.3%	3.5%	26.7%	7.3%	50.0%	15.0%	31.9%	9.1%
Budworms (various)	24.0%	16.6%	51.7%	12.3%	10.0%	2.0%	36.5%	9.8%
Earwigs								
European earwigs			16.7%	2.9%	100.0%	4.0%	38.8%	2.9%
Additional Pests								
Slaters					100.0%	2.0%	28.9%	0.6%

Note: Australia Years and Area percentages are a weighted average total based on percentage for each Region multiplied by the total crop area average for that region, with the total then divided by the total crop area average for all regions.

* Assessment for feeding damage only

TABLE 5.3 Severity: Estimated potential damage (% yield loss) in the absence of chemical and cultural controls and present levels of damage (% yield loss) with current chemical and cultural control of invertebrate pests in barley (% yield loss) in the GRDC Regions and Australia

Invertebrate pest	Northern		Southern		Western		Australia	
	Potential	Present	Potential	Present	Potential	Present	Potential	Present
Snails								
Snails (various)			30.0%	12.0%	10.0%	5.0%	20.8%	8.60%
Slugs								
Slugs (various)			17.3%	8.7%	10.0%	5.0%	13.2%	6.62%
Mites								
Redlegged earth mite			14.3%	3.7%	5.0%	1.0%	10.0%	2.48%
Blue oat mite	4.4%	0.5%	14.3%	3.7%	20.0%	1.0%	14.8%	2.53%
Bryobia (various) / Balaustium mite			8.0%	1.3%	10.0%	1.0%	7.7%	1.08%
Brown wheat mite	5.2%	0.8%	1.2%	0.4%	5.0%	1.0%	2.7%	0.62%
Wheat curl mite	0.4%	0.3%	3.1%	0.9%	30.0%	0.0%	10.6%	0.59%
Springtails								
Lucerne flea			15.3%	3.3%	20.0%	1.0%	14.9%	2.28%
Crickets								
Sandgroper					30.0%	30.0%	8.7%	8.67%
Locusts								
Locusts (various)	31.3%	9.8%	58.3%	10.0%	15.0%	2.0%	42.7%	7.67%
Aphids								
Cereal aphids (various)	10.2%	2.3%	6.3%	0.7%	20.0%	2.0%	10.7%	1.24%
Beetles								
Cockchafer (various)	13.3%	13.3%	7.0%	6.3%	5.0%	5.0%	7.1%	6.75%
Caterpillars								
Pasture webworms (various)			13.3%	2.7%	20.0%	5.0%	13.7%	3.04%
Armyworms (various)	28.3%	6.8%	37.0%	6.7%	30.0%	2.0%	34.0%	5.34%
Cutworms (various)	15.8%	3.3%	20.3%	5.7%	20.0%	3.0%	19.7%	4.63%
Budworms (various)	6.1%	2.8%	10.3%	3.7%	10.0%	3.0%	9.7%	3.38%
Earwigs								
European earwigs			3.8%	1.1%	10.0%	5.0%	5.1%	2.10%
Additional Pests								
Slaters					10.0%	5.0%	2.9%	1.44%

Note: Australia Potential and Present percentages are a weighted average total based on percentage for each Region multiplied by the total crop area average for that region, with the total then divided by the total crop area average for all regions.

5.2 Potential cost to barley crop – no control of invertebrate pests

The potential economic loss in the absence of cultural and pesticide controls is summarised in Table 5.4. These values take into consideration both the incidence (% years) and severity (% area damaged).

TABLE 5.4 Potential average annual loss (\$/ha and \$ million) from invertebrate pests in barley in the GRDC Regions and Australia

Invertebrate pest	Northern		Southern		Western		Australia	
	\$/ha	\$ million	\$/ha	\$ million	\$/ha	\$ million	\$/ha	\$ million
Snails								
Snails (various)	\$0.00	\$0.000	\$2.57	\$6.796	\$1.46	\$1.875	\$1.95	\$8.671
Slugs								
Slugs (various)	\$0.00	\$0.000	\$1.68	\$4.438	\$1.34	\$1.714	\$1.39	\$6.152
Mites								
Redlegged earth mite	\$0.00	\$0.000	\$14.06	\$37.255	\$0.63	\$0.803	\$8.57	\$38.058
Blue oat mite	\$0.02	\$0.008	\$12.51	\$33.132	\$3.34	\$4.285	\$8.43	\$37.424
Bryobia (various) / Balaustium mite	\$0.00	\$0.000	\$6.11	\$16.191	\$2.51	\$3.214	\$4.37	\$19.404
Brown wheat mite	\$0.04	\$0.019	\$0.01	\$0.029	\$0.05	\$0.067	\$0.03	\$0.115
Wheat curl mite	\$0.00	\$0.000	\$2.53	\$6.696	\$0.50	\$0.643	\$1.65	\$7.339
Springtails								
Lucerne flea	\$0.00	\$0.000	\$9.58	\$25.386	\$3.34	\$4.285	\$6.68	\$29.671
Crickets								
Sandgroper	\$0.00	\$0.000	\$0.00	\$0.000	\$0.25	\$0.321	\$0.07	\$0.321
Locusts								
Locusts (various)	\$0.54	\$0.274	\$15.52	\$41.114	\$1.25	\$1.607	\$9.68	\$42.995
Aphids								
Cereal aphids (various)	\$8.04	\$4.082	\$2.61	\$6.923	\$15.04	\$19.283	\$6.82	\$30.288
Beetles								
Cockchafer (various)	\$0.20	\$0.099	\$0.39	\$1.032	\$0.63	\$0.803	\$0.44	\$1.935
Caterpillars								
Pasture webworms (various)	\$0.00	\$0.000	\$0.18	\$0.479	\$6.26	\$8.034	\$1.92	\$8.514
Armyworms (various)	\$8.53	\$4.332	\$10.39	\$27.515	\$9.40	\$12.052	\$9.89	\$43.899
Cutworms (various)	\$0.35	\$0.178	\$2.27	\$6.025	\$6.26	\$8.034	\$3.21	\$14.238
Budworms (various)	\$1.49	\$0.757	\$3.99	\$10.568	\$0.08	\$0.107	\$2.57	\$11.432
Earwigs								
European earwigs	\$0.00	\$0.000	\$0.09	\$0.247	\$1.67	\$2.143	\$0.54	\$2.390
Additional Pests								
Slaters					\$0.84	\$1.071	\$0.24	\$1.071
Total	\$19.19	\$9.749	\$84.49	\$223.826	\$54.85	\$70.342	\$68.46	\$303.917

Note: Australia \$/ha amounts are a weighted average total based on \$/ha for each Region multiplied by the total crop area average for that region, with the total then divided by the total crop area average for all regions. Australia \$ million is aggregate of the three regions.

5.3 Current cost to barley crop – with control of invertebrate pests

The current cost to the barley industry of invertebrate pests is shown in Table 5.5. These values take into consideration both the incidence (% years) and severity (% area damaged).

TABLE 5.5 Present average annual loss (\$/ha and \$ million) from invertebrate pests in barley in the GRDC Regions and Australia

Invertebrate pest	Northern		Southern		Western		Australia	
	\$/ha	\$ million	\$/ha	\$ million	\$/ha	\$ million	\$/ha	\$ million
Snails								
Snails (various)	\$0.00	\$0.00	\$1.03	\$2.719	\$0.73	\$0.937	\$0.82	\$3.656
Slugs								
Slugs (various)	\$0.00	\$0.000	\$0.84	\$2.219	\$0.67	\$0.857	\$0.69	\$3.076
Mites								
Redlegged earth mite	\$0.00	\$0.000	\$3.60	\$9.530	\$0.13	\$0.161	\$2.18	\$9.691
Blue oat mite	\$0.00	\$0.001	\$3.20	\$8.476	\$0.17	\$0.214	\$1.96	\$8.691
Bryobia (various) / Balaustium mite	\$0.00	\$0.000	\$1.02	\$2.698	\$0.25	\$0.321	\$0.68	\$3.020
Brown wheat mite	\$0.01	\$0.003	\$0.00	\$0.010	\$0.01	\$0.013	\$0.01	\$0.026
Wheat curl mite	\$0.00	\$0.000	\$0.76	\$2.016	\$0.00	\$0.000	\$0.45	\$2.016
Springtails								
Lucerne flea	\$0.00	\$0.000	\$2.08	\$5.519	\$0.17	\$0.214	\$1.29	\$5.733
Crickets								
Sandgroper	\$0.00	\$0.000	\$0.00	\$0.000	\$0.25	\$0.321	\$0.07	\$0.321
Locusts								
Locusts (various)	\$0.17	\$0.086	\$2.66	\$7.048	\$0.17	\$0.214	\$1.66	\$7.348
Aphids								
Cereal aphids (various)	\$1.81	\$0.919	\$0.28	\$0.729	\$1.50	\$1.928	\$0.81	\$3.576
Beetles								
Cockchafer (various)	\$0.20	\$0.099	\$0.35	\$0.934	\$0.63	\$0.803	\$0.41	\$1.837
Caterpillars								
Pasture webworms (various)	\$0.00	\$0.000	\$0.04	\$0.096	\$1.57	\$2.009	\$0.47	\$2.105
Armyworms (various)	\$2.06	\$1.045	\$1.87	\$4.958	\$0.63	\$0.803	\$1.53	\$6.806
Cutworms (various)	\$0.07	\$0.038	\$0.63	\$1.679	\$0.94	\$1.205	\$0.66	\$2.922
Budworms (various)	\$0.70	\$0.354	\$1.42	\$3.750	\$0.03	\$0.032	\$0.93	\$4.136
Earwigs								
European earwigs	\$0.00	\$0.000	\$0.03	\$0.072	\$0.84	\$1.071	\$0.26	\$1.143
Additional Pests								
Slaters					\$0.42	\$0.536	\$0.12	\$0.536
Total	\$5.01	\$2.545	\$19.80	\$52.452	\$9.08	\$11.642	\$15.01	\$66.639

Note: Australia \$/ha amounts are a weighted average total based on \$/ha for each Region multiplied by the total crop area average for that region, with the total then divided by the total crop area average for all regions. Australia \$ million is aggregate of the three regions.

5.4 Value of invertebrate pest controls in barley

The value of invertebrate pest control in barley is estimated by subtracting the potential loss (Table 5.4) from the present loss (Table 5.5).

TABLE 5.6 Value of current control practices (\$/ha and \$ million) by GRDC Region and Australia

Invertebrate pest	Northern		Southern		Western		Australia	
	\$/ha	\$ million	\$/ha	\$ million	\$/ha	\$ million	\$/ha	\$ million
Snails								
Snails (various)	\$0.00	\$0.000	\$1.54	\$4.078	\$0.73	\$0.937	\$1.13	\$5.015
Slugs								
Slugs (various)	\$0.00	\$0.000	\$0.84	\$2.219	\$0.67	\$0.857	\$0.69	\$3.076
Mites								
Redlegged earth mite	\$0.00	\$0.000	\$10.47	\$27.725	\$0.50	\$0.643	\$6.39	\$28.367
Blue oat mite	\$0.01	\$0.007	\$9.31	\$24.656	\$3.17	\$4.071	\$6.47	\$28.734
Bryobia (various) / Balaustium mite	\$0.00	\$0.000	\$5.09	\$13.492	\$2.26	\$2.892	\$3.69	\$16.385
Brown wheat mite	\$0.03	\$0.016	\$0.01	\$0.019	\$0.04	\$0.054	\$0.02	\$0.088
Wheat curl mite	\$0.00	\$0.000	\$1.77	\$4.680	\$0.50	\$0.643	\$1.20	\$5.323
Springtails								
Lucerne flea	\$0.00	\$0.000	\$7.50	\$19.867	\$3.17	\$4.071	\$5.39	\$23.938
Crickets								
Sandgroper	\$0.00	\$0.000	\$0.00	\$0.000	\$0.00	\$0.000	\$0.00	\$0.000
Locusts								
Locusts (various)	\$0.37	\$0.188	\$12.86	\$34.066	\$1.09	\$1.393	\$8.03	\$35.647
Aphids								
Cereal aphids (various)	\$6.23	\$3.163	\$2.34	\$6.195	\$13.53	\$17.354	\$6.02	\$26.712
Beetles								
Cockchafers (various)	\$0.00	\$0.000	\$0.04	\$0.098	\$0.00	\$0.000	\$0.02	\$0.098
Caterpillars								
Pasture webworms (various)	\$0.00	\$0.000	\$0.14	\$0.384	\$4.70	\$6.026	\$1.44	\$6.409
Armyworms (various)	\$6.47	\$3.287	\$8.52	\$22.557	\$8.77	\$11.248	\$8.36	\$37.093
Cutworms (various)	\$0.28	\$0.141	\$1.64	\$4.346	\$5.33	\$6.829	\$2.55	\$11.316
Budworms (various)	\$0.79	\$0.402	\$2.57	\$6.818	\$0.06	\$0.075	\$1.64	\$7.295
Earwigs								
European earwigs	\$0.00	\$0.000	\$0.07	\$0.175	\$0.84	\$1.071	\$0.28	\$1.246
Additional Pests								
Slaters					\$0.42	\$0.536	\$0.12	\$0.536
Total	\$14.18	\$7.204	\$64.69	\$171.374	\$45.77	\$58.700	\$53.45	237.278

5.5 Value of cultural controls in barley

The value of cultural controls for invertebrate pest control in barley is estimated by multiplying the value of invertebrate pest control (Table 5.6) by the proportion of treated area receiving cultural controls.

TABLE 5.6A Percentage of treated area receiving cultural controls and value of current cultural control practices (\$ million) by GRDC Region and Australia

Invertebrate pest	Northern		Southern		Western		Australia
	% treated area	\$ million	% treated area	\$ million	% treated area	\$ million	\$ million
Snails							
Snails (various)	0.00%	\$0.000	40.00%	\$1.631	50.00%	\$0.469	\$2.100
Slugs							
Slugs (various)	0.00%	\$0.000	48.33%	\$1.072	60.00%	\$0.514	\$1.586
Mites							
Redlegged earth mite	0.00%	\$0.000	2.33%	\$0.646	30.00%	\$0.193	\$0.839
Blue oat mite	0.00%	\$0.000	2.33%	\$0.574	30.00%	\$1.221	\$1.795
Bryobia (various) / Balaustium mite	0.00%	\$0.000	2.33%	\$0.314	60.00%	\$1.735	\$2.049
Brown wheat mite	0.00%	\$0.000	0.00%	\$0.000	60.00%	\$0.032	\$0.032
Wheat curl mite	0.00%	\$0.000	52.50%	\$2.457	0.00%	\$0.000	\$2.457
Springtails							
Lucerne flea	0.00%	\$0.000	19.00%	\$3.775	50.00%	\$2.036	\$5.811
Crickets							
Sandgropers					0.00%	\$0.000	\$0.000
Locusts							
Locusts (various)	0.00%	\$0.000	0.67%	\$0.228	0.00%	\$0.000	\$0.228
Aphids							
Cereal aphids (various)	10.00%	\$0.316	35.00%	\$2.168	0.00%	\$0.000	\$2.484
Beetles							
Cockchafters (various)	2.50%	\$0.000	8.67%	\$0.008	0.00%	\$0.000	\$0.008
Caterpillars							
Pasture webworms (various)	0.00%	\$0.000	0.00%	\$0.000	70.00%	\$4.218	\$4.218
Armyworms (various)	8.33%	\$0.274	0.00%	\$0.000	0.00%	\$0.000	\$0.274
Cutworms (various)	6.67%	\$0.009	0.00%	\$0.000	0.00%	\$0.000	\$0.009
Budworms (various)	10.00%	\$0.040	1.67%	\$0.114	0.00%	\$0.000	\$0.154
Earwigs							
European earwigs	0.00%	\$0.000	33.33%	\$0.058	80.00%	\$0.857	\$0.915
Additional Pests							
Slaters					80.00%	\$0.429	\$0.429
Total		\$0.639		\$13.045		\$11.704	\$25.388

5.6 Cost of invertebrate pest controls in barley

Cultivars are not currently tested for relevance to the control of vertebrate pests in barley. The survey revealed limited and unspecified cultural controls for invertebrate pests in barley. Cultural controls are sometimes used on slugs, aphids, cockchafers, armyworms and budworms. Invertebrate pest control in barley is most often achieved with pesticides. Pesticides used and their cost are shown in Table 5.7.

TABLE 5.7 Representative pesticide treatment used and cost – barley

Invertebrate pest	Representative pesticide control	Active ingredient	Chemical cost per ha
Snails			
Snails (various)	baits	metaldehyde	\$12.00
Slugs			
Slugs (various)	baits	metaldehyde	\$12.00
Mites			
Redlegged earth mite	PSPE	bifenthrin	\$1.60
Blue oat mite	PSPE	bifenthrin	\$1.60
Bryobia (various) / Balaustium mite	presowing with knockdown	omethoate	\$1.90
Brown wheat mite	presowing with knockdown	omethoate	\$1.90
Wheat curl mite	no treatment*		
Springtails			
Lucerne flea	post-emergence	omethoate	\$1.90
Crickets			
Sandgroper	no treatment*		
Locusts			
Locusts (various)	fenitrothion	fenitrothion	\$16.00
Aphids			
Cereal aphids (various)	dimethoate	dimethoate	\$6.25
Beetles			
Cockchafers (various)	no treatment*		
Caterpillars			
Pasture webworms (various)	SP	alpha-cypermethrin	\$0.64
Armyworms (various)	SP	alpha-cypermethrin	\$2.04
Cutworms (various)	SP	alpha-cypermethrin	\$0.64
Budworms (various)	SP (West & South for Hp)	alpha-cypermethrin	\$2.04
	methomyl (North for Ha)	methomyl	\$22.00
Earwigs			
European earwigs	no treatment*		
Additional Pests			
Slaters	baits*	metaldehyde	\$8.00

PSP: post sowing pre-emergent, SP: Synthetic pyrethroid, Hp: *Heliothis punctifera*, Ha: *Helicovera armigera*
 * Controls may be permitted under relevant State Pesticide Regulations

TABLE 5.8 Invertebrate pest treatment costs – barley

Invertebrate pest	Northern		Southern		Western		Australia	
	Incidence %	Total cost of treatment \$ million	Incidence %	Total cost of treatment \$ million	Incidence %	Total cost of treatment \$ million	Incidence %	Total cost of treatment \$ million
Snails								
Snails (various)			2.63%	\$0.913	3.50%	\$0.786	2.58%	\$1.698
Slugs								
Slugs (various)			2.97%	\$0.688	3.20%	\$0.718	2.69%	\$1.406
Mites								
Redlegged earth mite			30.12%	\$2.368	3.00%	\$0.449	18.84%	\$2.818
Blue oat mite	0.09%	\$0.000	26.78%	\$1.761	4.00%	\$0.599	17.15%	\$2.360
Bryobia (various) / Balaustium mite			23.45%	\$0.648	6.00%	\$0.917	15.73%	\$1.565
Brown wheat mite	0.18%	\$0.004	0.29%	\$0.001	0.25%	\$0.038	0.27%	\$0.044
Wheat curl mite	0.03%		25.03%		0.40%		15.05%	NRT
Springtails								
Lucerne flea			19.18%	\$2.145	4.00%	\$0.611	12.60%	\$2.756
Crickets								
Sandgroper					0.20%	\$0.000	0.06%	NRT
Locusts								
Locusts (various)	0.44%	\$0.014	8.17%	\$2.279	2.00%	\$0.223	5.50%	\$2.516
Aphids#								
Cereal aphids (various)	20.10%	\$0.531	12.67%	\$0.969	18.00%	\$2.666	15.06%	\$4.166
Beetles								
Cockchafer (various)	0.38%	\$0.000	1.71%	\$0.000	3.00%	\$0.000	1.93%	NRT
Caterpillars								
Pasture webworms (various)			0.42%	\$0.031	7.50%	\$1.049	2.42%	\$1.080
Armyworms (various)	7.69%	\$0.209	8.62%	\$0.984	7.50%	\$0.723	8.19%	\$1.916
Cutworms (various)	0.57%	\$0.027	3.43%	\$0.356	7.50%	\$1.049	4.28%	\$1.432
Budworms (various)	6.29%	\$0.131	11.85%	\$1.180	0.20%	\$0.019	7.85%	\$1.330
Earwigs								
European earwigs			0.76%	\$0.020	4.00%	\$0.386	1.61%	\$0.406
Additional Pests								
Slaters					2.00%	\$0.269	0.58%	\$0.269
Total		\$0.915		\$14.343		\$10.505		\$25.763

Incidence %: Incidence years x Incidence area, # feeding damage only

Note: Australia Incidence % are a weighted average total based on percentage for each Region multiplied by the total crop area average for that region, with the total then divided by the total crop area average for all regions. Australia Total Cost of Treatment is aggregate of the three regions.

NRT: No registered treatment

NOTE: applications of pesticides for control of some pests has combined benefit – i.e. PSPE for mites controls both RLEM and BOM. Also cutworm and webworm control is often achieved in the one spray operation.

5.7 Conclusions on barley invertebrate pests

Average total cost of treatment for invertebrate pests in barley nationally is \$25.7 million or \$5.80 per ha grown. By GRDC region this equates to:

- Northern region: \$0.9 million pa or \$1.80 per hectare of barley grown.
- Southern region: \$14.3 million pa or \$5.41 per hectare of barley grown.
- Western region: \$10.5 million pa or \$8.19 per hectare of barley grown.

The Northern GRDC region enjoys a much lower invertebrate pest pressure compared to other parts of Australia. When ranked in order of potential and present losses, the five major invertebrate pests of barley are:

TABLE 5.9 Five most important invertebrate pests of barley by potential and present loss

Rank	By Potential Loss	By Present Loss
1	Armyworms (various) (\$43.9 million)	Redlegged earth mite (\$9.7 million)
2	Locusts (various) (\$42.9 million)	Blue oat mite (\$8.7 million)
3	Redlegged earth mite (\$38.1 million)	Locusts (various) (\$7.3 million)
4	Blue oat mite (\$37.4 million)	Armyworms (various) (\$6.8 million)
5	Cereal aphids (various) (\$30.3 million)	Lucerne flea (\$5.7 million)

Reference to Table 5.4 shows that the above listed five invertebrate pests of barley have a potential to cause serious losses. Table 5.5 shows that even with control the above listed five pests cost the barley industry more than \$30 million annually

6 OATS – INVERTEBRATE PEST COST

6.1 Incidence and severity of invertebrate pests in oats

The following tables report pest presence, incidence and severity using survey data for oats.

TABLE 6.1 Presence of invertebrate pests causing oats damage – GRDC Regions and Australia

Invertebrate pest	Northern	Southern	Western	Australia
Snails				
Snails (various)	N	Y	Y	Y
Slugs				
Slugs (various)	N	Y	Y	Y
Mites				
Redlegged earth mite	N	Y	Y	Y
Blue oat mite	Y	Y	Y	Y
Bryobia (various) / Balaustium mite	N	Y	Y	Y
Brown wheat mite	Y	Y	Y	Y
Wheat curl mite	Y	Y	Y	Y
Springtails				
Lucerne flea	N	Y	Y	Y
Crickets				
Sandgroper	N	N	Y	Y
Locusts				
Locusts (various)	Y	Y	Y	Y
Aphids				
Cereal aphids (various)	Y	Y	Y	Y
Beetles				
Cockchafer (various)	Y	Y	Y	Y
Caterpillars				
Pasture webworms (various)	N	Y	Y	Y
Armyworms (various)	Y	Y	Y	Y
Cutworms (various)	Y	Y	Y	Y
Budworms (various)	Y	Y	Y	Y
Earwigs				
European earwigs	N	Y	Y	Y
Additional Pests				
Slaters	Y	Y	Y	Y

Y: present in region, N: not recorded in region

Notes: If an invertebrate pest is present in any GRDC region, it is recorded as being present in Australia.

Slaters are present in both the Northern and Southern Regions but are not rated by entomologists as pests of economic significance

TABLE 6.2 Incidence of invertebrate pests in oats as a proportion of years when pests occur at economically damaging levels (%) and as a proportion of the whole crop area affected (%) during those years in the GRDC Regions and Australia

Invertebrate pest	Northern		Southern		Western		Australia	
	Years	Area	Years	Area	Years	Area	Years	Area
Snails								
Snails (various)			32.5%	7.5%	70.0%	5.0%	39.4%	5.6%
Slugs								
Slugs (various)			43.3%	7.7%	80.0%	4.0%	48.4%	5.4%
Mites								
Redlegged earth mite			45.0%	30.7%	30.0%	10.0%	33.7%	19.7%
Blue oat mite	5.0%	1.6%	45.0%	30.7%	45.0%	10.0%	39.1%	19.9%
Bryobia (various) / Balaustium mite			45.0%	17.3%	60.0%	10.0%	43.0%	12.5%
Brown wheat mite	8.3%	0.9%	10.0%	2.9%	5.0%	5.0%	8.2%	3.3%
Wheat curl mite	4.2%	0.7%	53.3%	21.9%	20.0%	2.0%	35.7%	12.6%
Springtails								
Lucerne flea			43.3%	27.0%	45.0%	10.0%	37.5%	17.7%
Crickets								
Sandgroper					20.0%	1.0%	6.2%	0.3%
Locusts								
Locusts (various)	5.7%	2.9%	21.7%	30.0%	10.0%	20.0%	15.7%	22.9%
Aphids*								
Cereal aphids (various)	5.0%	0.8%	60.0%	13.3%	50.0%	15.0%	48.8%	12.0%
Beetles								
Cockchafers (various)	7.5%	2.3%	40.0%	2.1%	30.0%	10.0%	32.1%	4.6%
Caterpillars								
Pasture webworms (various)			15.0%	2.3%	0.0%	0.0%	8.1%	1.3%
Armyworms (various)	10.0%	16.2%	21.7%	3.0%	50.0%	8.0%	28.8%	6.5%
Cutworms (various)	6.7%	4.6%	26.7%	2.3%	50.0%	15.0%	31.0%	6.6%
Budworms (various)	5.0%	0.8%	45.0%	5.7%	10.0%	2.0%	28.2%	3.8%
Earwigs								
European earwigs			16.7%	3.9%	100.0%	4.0%	40.2%	3.4%
Additional Pests								
Slaters					100.0%	2.0%	31.2%	0.6%

Note: Australia Years and Area percentages are a weighted average total based on percentage for each Region multiplied by the total crop area average for that region, with the total then divided by the total crop area average for all regions.

* Assessed for feeding damage only not virus transmission

TABLE 6.3 Severity: Estimated potential damage (% yield loss) in the absence of chemical and cultural controls and present levels of damage (% yield loss) with current chemical and cultural control of invertebrate pests in oats in the GRDC Regions and Australia

Invertebrate pest	Northern		Southern		Western		Australia	
	Potential	Present	Potential	Present	Potential	Present	Potential	Present
Snails								
Snails (various)			30.0%	12.0%	10.0%	5.0%	19.3%	8.05%
Slugs								
Slugs (various)			24.0%	12.0%	10.0%	5.0%	16.1%	8.05%
Mites								
Redlegged earth mite			11.0%	3.7%	5.0%	1.0%	7.5%	2.30%
Blue oat mite	4.8%	0.7%	14.3%	3.7%	20.0%	1.0%	14.7%	2.40%
Bryobia (various) / Balaustium mite			8.0%	1.3%	10.0%	1.0%	7.4%	1.03%
Brown wheat mite	1.0%	0.5%	1.2%	0.4%	5.0%	1.0%	2.3%	0.61%
Wheat curl mite	1.1%	0.7%	1.4%	0.6%	30.0%	0.0%	10.3%	0.42%
Springtails								
Lucerne flea			15.3%	3.3%	20.0%	1.0%	14.5%	2.11%
Crickets								
Sandgroper					30.0%	30.0%	9.4%	9.35%
Locusts								
Locusts (various)	21.7%	9.7%	58.3%	10.0%	15.0%	2.0%	39.4%	7.46%
Aphids								
Cereal aphids (various)	1.3%	0.8%	5.3%	0.7%	5.0%	1.0%	4.6%	0.79%
Beetles								
Cockchafer (various)	6.1%	5.7%	4.3%	2.2%	5.0%	5.0%	4.8%	3.57%
Caterpillars								
Pasture webworms (various)			8.3%	1.7%	0.0%	0.0%	4.5%	0.90%
Armyworms (various)	16.5%	3.7%	32.0%	5.0%	5.0%	2.0%	21.3%	3.88%
Cutworms (various)	16.5%	3.7%	15.3%	4.7%	20.0%	3.0%	17.0%	4.01%
Budworms (various)	1.3%	0.8%	7.0%	1.7%	5.0%	2.0%	5.5%	1.64%
Earwigs								
European earwigs			3.8%	1.1%	10.0%	5.0%	5.2%	2.15%
Additional Pests								
Slaters					10.0%	5.0%	3.1%	1.56%

Note: Australia Potential and Present percentages are a weighted average total based on percentage for each Region multiplied by the total crop area average for that region, with the total then divided by the total crop area average for all regions.

6.2 Potential cost to oat crop – no control of invertebrate pests

The potential economic loss in the absence of cultural and pesticide controls is summarised in Table 6.4. These values take into consideration both the incidence (% years) and severity (% area damaged).

TABLE 6.4 Potential average annual loss (\$/ha and \$ million) from invertebrate pests in oats in the GRDC Regions and Australia

Invertebrate pest	Northern		Southern		Western		Australia	
	\$/ha	\$ million	\$/ha	\$ million	\$/ha	\$ million	\$/ha	\$ million
Snails								
Snails (various)	\$0.00	\$0.000	\$1.90	\$0.980	\$1.22	\$0.361	\$1.41	\$1.341
Slugs								
Slugs (various)	\$0.00	\$0.000	\$3.26	\$1.683	\$1.11	\$0.330	\$2.11	\$2.013
Mites								
Redlegged earth mite	\$0.00	\$0.000	\$8.00	\$4.124	\$0.52	\$0.155	\$4.49	\$4.279
Blue oat mite	\$0.00	\$0.001	\$10.42	\$5.374	\$3.12	\$0.928	\$6.61	\$6.303
Bryobia (various) / Balaustium mite	\$0.00	\$0.000	\$3.24	\$1.672	\$2.08	\$0.619	\$2.40	\$2.290
Brown wheat mite	\$0.00	\$0.000	\$0.01	\$0.004	\$0.04	\$0.013	\$0.02	\$0.017
Wheat curl mite	\$0.00	\$0.000	\$0.66	\$0.342	\$0.42	\$0.124	\$0.49	\$0.466
Springtails								
Lucerne flea	\$0.00	\$0.000	\$8.95	\$4.617	\$3.12	\$0.928	\$5.82	\$5.545
Crickets								
Sandgroper	\$0.00	\$0.000	\$0.00	\$0.000	\$0.21	\$0.062	\$0.06	\$0.062
Locusts								
Locusts (various)	\$0.00	\$0.011	\$11.50	\$5.931	\$1.04	\$0.309	\$6.55	\$6.251
Aphids								
Cereal aphids (various)	\$0.00	\$0.000	\$1.20	\$0.620	\$1.30	\$0.387	\$1.06	\$1.007
Beetles								
Cockchafters (various)	\$0.00	\$0.005	\$0.18	\$0.092	\$0.52	\$0.155	\$0.26	\$0.252
Caterpillars								
Pasture webworms (various)	\$0.00	\$0.000	\$0.08	\$0.043	\$0.00	\$0.000	\$0.05	\$0.043
Armyworms (various)	\$1.07	\$0.150	\$0.61	\$0.312	\$0.69	\$0.206	\$0.70	\$0.669
Cutworms (various)	\$0.11	\$0.015	\$0.35	\$0.178	\$5.21	\$1.547	\$1.83	\$1.740
Budworms (various)	\$0.00	\$0.000	\$0.71	\$0.365	\$0.03	\$0.010	\$0.39	\$0.375
Earwigs								
European earwigs	\$0.00	\$0.000	\$0.10	\$0.050	\$1.39	\$0.412	\$0.48	\$0.462
Additional Pests								
Slaters					\$0.69	\$0.206	\$0.22	\$0.206
Total	\$1.18	\$0.184	\$51.18	\$26.388	\$22.73	\$6.752	\$34.95	\$33.323

Note: Australia \$/ha amounts are a weighted average total based on \$/ha for each Region multiplied by the total crop area average for that region, with the total then divided by the total crop area average for all regions. Australia \$ million is aggregate of the three regions.

6.3 Current cost to oat crop – with control of invertebrate pests

The current cost to the oat industry of invertebrate pests is shown in Table 6.5. These values take into consideration both the incidence (% years) and severity (% area damaged).

TABLE 6.5 Present average annual loss (\$/ha and \$ million) from invertebrate pests in oats in the GRDC Regions and Australia

Invertebrate pest	Northern		Southern		Western		Australia	
	\$/ha	\$ million	\$/ha	\$ million	\$/ha	\$ million	\$/ha	\$ million
Snails								
Snails (various)	\$0.00	\$0.000	\$0.76	\$0.392	\$0.61	\$0.180	\$0.60	\$0.573
Slugs								
Slugs (various)	\$0.00	\$0.000	\$1.63	\$0.842	\$0.56	\$0.165	\$1.06	\$1.007
Mites								
Redlegged earth mite	\$0.00	\$0.000	\$2.67	\$1.375	\$0.10	\$0.031	\$1.48	\$1.406
Blue oat mite	\$0.00	\$0.000	\$2.67	\$1.375	\$0.16	\$0.046	\$1.49	\$1.421
Bryobia (various) / Balaustium mite	\$0.00	\$0.000	\$0.54	\$0.279	\$0.21	\$0.062	\$0.36	\$0.340
Brown wheat mite	\$0.00	\$0.000	\$0.00	\$0.001	\$0.01	\$0.003	\$0.00	\$0.004
Wheat curl mite	\$0.00	\$0.000	\$0.28	\$0.143	\$0.00	\$0.000	\$0.15	\$0.143
Springtails								
Lucerne flea	\$0.00	\$0.000	\$1.95	\$1.004	\$0.16	\$0.046	\$1.10	\$1.050
Crickets								
Sandgroper	\$0.00	\$0.000	\$0.00	\$0.000	\$0.21	\$0.062	\$0.06	\$0.062
Locusts								
Locusts (various)	\$0.00	\$0.005	\$1.97	\$1.017	\$0.14	\$0.041	\$1.11	\$1.063
Aphids								
Cereal aphids (various)	\$0.00	\$0.000	\$0.15	\$0.077	\$0.26	\$0.077	\$0.16	\$0.155
Beetles								
Cockchafer (various)	\$0.00	\$0.005	\$0.09	\$0.046	\$0.52	\$0.155	\$0.21	\$0.206
Caterpillars								
Pasture webworms (various)	\$0.00	\$0.000	\$0.02	\$0.009	\$0.00	\$0.000	\$0.01	\$0.009
Armyworms (various)	\$0.24	\$0.034	\$0.09	\$0.049	\$0.28	\$0.082	\$0.17	\$0.165
Cutworms (various)	\$0.02	\$0.003	\$0.11	\$0.054	\$0.78	\$0.232	\$0.30	\$0.290
Budworms (various)	\$0.00	\$0.000	\$0.17	\$0.087	\$0.01	\$0.004	\$0.10	\$0.091
Earwigs								
European earwigs	\$0.00	\$0.000	\$0.03	\$0.015	\$0.69	\$0.206	\$0.23	\$0.221
Additional Pests								
Slaters					\$0.35	\$0.103	\$0.11	\$0.103
Total	\$0.27	\$0.048	\$13.12	\$6.764	\$5.04	\$1.497	\$8.71	\$8.308

Note: Australia \$/ha amounts are a weighted average total based on \$/ha for each Region multiplied by the total crop area average for that region, with the total then divided by the total crop area average for all regions. Australia \$ million is aggregate of the three regions.

6.4 Value of invertebrate pest controls in oats

The value of invertebrate pest control in oats is estimated by subtracting the potential loss (Table 6.4) from the present loss (Table 6.5) and is shown in Table 6.6.

TABLE 6.6 Value of current control practices (\$/ha and \$ million) by GRDC Region and Australia

Invertebrate pest	Northern		Southern		Western		Australia	
	\$/ha	\$ million	\$/ha	\$ million	\$/ha	\$ million	\$/ha	\$ million
Snails								
Snails (various)	\$0.00	\$0.000	\$1.14	\$0.588	\$0.61	\$0.180	\$0.81	\$0.769
Slugs								
Slugs (various)	\$0.00	\$0.000	\$1.63	\$0.842	\$0.56	\$0.165	\$1.06	\$1.007
Mites								
Redlegged earth mite	\$0.00	\$0.000	\$5.33	\$2.750	\$0.42	\$0.124	\$3.01	\$2.873
Blue oat mite	\$0.00	\$0.001	\$7.76	\$3.999	\$2.97	\$0.882	\$5.12	\$4.882
Bryobia (various) / Balaustium mite	\$0.00	\$0.000	\$2.70	\$1.393	\$1.87	\$0.557	\$2.05	\$1.950
Brown wheat mite	\$0.00	\$0.000	\$0.01	\$0.003	\$0.03	\$0.010	\$0.01	\$0.013
Wheat curl mite	\$0.00	\$0.000	\$0.39	\$0.199	\$0.42	\$0.124	\$0.34	\$0.323
Springtails								
Lucerne flea	\$0.00	\$0.000	\$7.01	\$3.613	\$2.97	\$0.882	\$4.72	\$4.495
Crickets								
Sandgroper	\$0.00	\$0.000	\$0.00	\$0.000	\$0.00	\$0.000	\$0.00	\$0.000
Locusts								
Locusts (various)	\$0.00	\$0.006	\$9.53	\$4.914	\$0.90	\$0.268	\$5.44	\$5.188
Aphids								
Cereal aphids (various)	\$0.00	\$0.000	\$1.05	\$0.542	\$1.04	\$0.309	\$0.89	\$0.852
Beetles								
Cockchafer (various)	\$0.00	\$0.000	\$0.09	\$0.046	\$0.00	\$0.000	\$0.05	\$0.046
Caterpillars								
Pasture webworms (various)	\$0.00	\$0.000	\$0.07	\$0.035	\$0.00	\$0.000	\$0.04	\$0.035
Armyworms (various)	\$0.83	\$0.116	\$0.51	\$0.263	\$0.42	\$0.124	\$0.53	\$0.503
Cutworms (various)	\$0.08	\$0.012	\$0.24	\$0.124	\$4.43	\$1.315	\$1.52	\$1.450
Budworms (various)	\$0.00	\$0.000	\$0.54	\$0.278	\$0.02	\$0.006	\$0.30	\$0.284
Earwigs								
European earwigs	\$0.00	\$0.000	\$0.07	\$0.035	\$0.69	\$0.206	\$0.25	\$0.241
Additional Pests								
Slaters					\$0.35	\$0.103	\$0.11	\$0.103
Total	\$0.91	\$0.136	\$38.06	\$19.624	\$17.69	\$5.255	\$26.24	\$25.015

6.5 Value of cultural controls in oats

The value of cultural controls for invertebrate pest control in oats is estimated by multiplying the value of invertebrate pest control (Table 6.6) by the proportion of treated area receiving cultural controls.

TABLE 6.6A Percentage of treated area receiving cultural controls and value of current cultural control practices (\$ million) by GRDC Region and Australia

Invertebrate pest	Northern		Southern		Western		Australia
	% treated area	\$ million	% treated area	\$ million	% treated area	\$ million	\$ million
Snails							
Snails (various)	0.00%	\$0.000	40.00%	\$0.235	50.00%	\$0.09	\$0.325
Slugs							
Slugs (various)	0.00%	\$0.000	48.33%	\$0.407	60.00%	\$0.099	\$0.506
Mites							
Redlegged earth mite	0.00%	\$0.000	2.33%	\$0.064	30.00%	\$0.037	\$0.101
Blue oat mite	0.00%	\$0.000	2.33%	\$0.932	30.00%	\$1.536	\$2.468
Bryobia (various) / Balaustium mite	0.00%	\$0.000	2.33%	\$0.325	60.00%	\$0.334	\$0.659
Brown wheat mite	0.00%	\$0.000	0.00%	\$0.000	60.00%	\$0.006	\$0.006
Wheat curl mite	0.00%	\$0.000	35.00%	\$0.070	0.00%	\$0.000	\$0.070
Springtails							
Lucerne flea	0.00%	\$0.000	19.00%	\$0.689	50.00%	\$0.441	\$1.130
Crickets							
Sandgropers	0.00%	\$0.000	0.00%	\$0.000	0.00%	\$0.000	\$0.000
Locusts							
Locusts (various)	0.00%	\$0.000	0.67%	\$0.033	0.00%	\$0.000	\$0.033
Aphids							
Cereal aphids (various)	0.00%	\$0.000	35.00%	\$0.190	0.00%	\$0.000	\$0.190
Beetles							
Cockchafer (various)	0.00%	\$0.000	3.67%	\$0.002	0.00%	\$0.000	\$0.002
Caterpillars							
Pasture webworms (various)	0.00%	\$0.000	0.00%	\$0.000	0.00%	\$0.000	\$0.000
Armyworms (various)	0.00%	\$0.000	0.00%	\$0.000	0.00%	\$0.000	\$0.000
Cutworms (various)	10.00%	\$0.001	0.00%	\$0.000	0.00%	\$0.000	\$0.001
Budworms (various)	0.00%	\$0.000	0.67%	\$0.002	0.00%	\$0.000	\$0.002
Earwigs							
European earwigs	0.00%	\$0.000	33.33%	\$0.012	80.00%	\$0.165	\$0.177
Additional Pests							
Slaters					80.00%	\$0.082	\$0.082
Total				\$2.961		\$2.708	\$5.670

6.6 Cost of invertebrate pest controls in oats

Cultivars are not presently tested for relevance to the control of vertebrate pests in oats. The survey revealed limited and unspecified cultural controls for invertebrate pests in oats. Cultural controls are sometimes used on slugs, aphids, cockchafer, armyworms and budworms. Invertebrate pest control in oats is most often achieved with pesticides. Pesticides used and their cost are shown in Table 6.7.

TABLE 6.7 Representative pesticide treatment used and cost – oats

Invertebrate pest	Representative pesticide control	Active ingredient	Chemical cost per ha
Snails			
Snails (various)	baits	metaldehyde	\$12.00
Slugs			
Slugs (various)	baits	metaldehyde	\$12.00
Mites			
Redlegged earth mite	PSPE	bifenthrin	\$0.85
Blue oat mite	PSPE	bifenthrin	\$0.85
Bryobia (various) / Balaustium mite	presowing and knockdown	omethoate	\$1.90
Brown wheat mite	presowing and knockdown	omethoate	\$1.90
Wheat curl mite	no treatment*		
Springtails			
Lucerne flea	post-emergence	omethoate	\$1.90
Crickets			
Sandgroper	no treatment*		
Locusts			
Locusts (various)	fenitrothion	fenitrothion	\$16.00
Aphids			
Cereal aphids (various)	dimethoate	dimethoate	\$6.25
Beetles			
Cockchafer (various)	no treatment*		
Caterpillars			
Pasture webworms (various)	SP	alpha-cypermethrin	\$0.64
Armyworms (various)	SP	alpha-cypermethrin	\$2.04
Cutworms (various)	SP	alpha-cypermethrin	\$0.64
Budworms (various)	SP (WA on Hp)	alpha-cypermethrin	\$2.04
Earwigs			
European earwigs	no treatment*		
Additional Pests			
Slaters	baits*	metaldehyde	\$8.00

PSPE: post sowing pre-emergent, SP: Synthetic pyrethroid, H: *Heliothis punctifera*
 * Controls may be permitted under relevant State Pesticide Regulations

The total cost of pesticide treatment of oats and the area treated is shown in Table 6.8

TABLE 6.8 Invertebrate pest treatment costs – oats

Invertebrate pest	Northern		Southern		Western		Australia	
	Incidence %	Total cost of treatment \$ million	Incidence %	Total cost of treatment \$ million	Incidence %	Total cost of treatment \$ million	Incidence %	Total cost of treatment \$ million
Snails								
Snails (various)			2.63%	\$0.178	3.50%	\$0.156	2.51%	\$0.334
Slugs								
Slugs (various)			5.63%	\$0.254	3.20%	\$0.143	4.04%	\$0.397
Mites								
Redlegged earth mite			30.12%	\$0.461	3.00%	\$0.104	17.23%	\$0.565
Blue oat mite	0.10%	\$0.000	30.12%	\$0.461	4.50%	\$0.156	17.71%	\$0.617
Bryobia (various) / Balaustium mite			16.78%	\$0.090	6.00%	\$0.212	10.95%	\$0.303
Brown wheat mite	0.13%	\$0.000	0.29%	\$0.000	0.25%	\$0.009	0.25%	\$0.009
Wheat curl mite	0.03%	\$0.000	19.19%	\$0.000	0.40%	\$0.000	10.51%	NRT
Springtails								
Lucerne flea			24.18%	\$0.526	4.50%	\$0.159	14.49%	\$0.686
Crickets								
Sandgroper					0.20%	\$0.000	0.06%	NRT
Locusts								
Locusts (various)	0.22%	\$0.000	8.17%	\$0.444	2.00%	\$0.052	5.07%	\$0.496
Aphids								
Cereal aphids (various)	0.04%	\$0.000	9.33%	\$0.139	7.50%	\$0.257	7.39%	\$0.396
Beetles								
Cockchafer (various)	0.37%	\$0.000	1.71%	\$0.000	3.00%	\$0.000	1.91%	NRT
Caterpillars								
Pasture webworms (various)			0.42%	\$0.006	0.00%	\$0.000	0.23%	\$0.006
Armyworms (various)	3.90%	\$0.018	0.78%	\$0.017	4.00%	\$0.089	2.24%	\$0.125
Cutworms (various)	0.40%	\$0.002	0.93%	\$0.018	7.50%	\$0.243	2.90%	\$0.263
Budworms (various)	0.04%	\$0.000	4.18%	\$0.076	0.20%	\$0.004	2.33%	\$0.080
Earwigs								
European earwigs			1.06%	\$0.004	4.00%	\$0.089	1.82%	\$0.093
Additional Pests								
Slaters					2.00%	\$0.062	0.62%	\$0.062
Total		\$0.020		\$2.674		\$1.737		\$4.431

Incidence %: Incidence years x Incidence area

Note: Australia Incidence % are a weighted average total based on percentage for each Region multiplied by the total crop area average for that region, with the total then divided by the total crop area average for all regions.

Australia Total Cost of Treatment is aggregate of the three regions.

NRT: No registered treatment

6.7 Conclusions on oats invertebrate pests

Average total cost of treatment for invertebrate pests in oats nationally is \$4.4 million or \$4.65 per ha grown. By GRDC region this equates to:

- Northern region: \$0.02 million pa or \$0.14 per hectare of oats grown.
- Southern region: \$2.7 million pa or \$5.18 per hectare of oats grown.
- Western region: \$1.7 million pa or \$5.85 per hectare of oats grown.

The Northern GRDC region enjoys a much lower invertebrate pest pressure compared to other parts of Australia. When ranked in order of potential and present losses, the five major invertebrate pests of oats are:

TABLE 6.9 Five most important invertebrate pests of oats by potential and present loss

Rank	By Potential Loss	By Present Loss
1	Blue oat mite (\$6.3 million)	Blue oat mite (\$1.4 million)
2	Locusts (\$6.2 million)	Redlegged earth mite (\$1.4 million)
3	Lucerne flea (\$5.5 million)	Locusts (\$1.1 million)
4	Redlegged earth mite (\$4.3 million)	Lucerne flea (\$1.0 million)
5	Bryobia (various) / Balaustium mite (\$2.3 million)	Slugs (\$1.0 million)

Reference to Table 6.4 shows that the above listed five invertebrate pests of oats have a potential to cause serious losses. Table 6.5 shows that even with control the above listed five pests cost the oat industry more than \$5 million annually.

7 CANOLA – INVERTEBRATE PEST COST

7.1 Incidence and severity of invertebrate pests in canola

The following tables report pest presence, incidence and severity using survey data for canola. Limited responses were received for canola in the Northern GRDC region and those that were received have a Queensland focus. If the invertebrate pest is present in one GRDC region, it is recorded as being present in Australia.

TABLE 7.1 Presence of invertebrate pests causing canola damage – GRDC Regions and Australia

Invertebrate pest	Northern	Southern	Western	Australia
Snails				
Snails (various)	N	Y	Y	Y
Slugs				
Slugs (various)	N	Y	Y	Y
Springtails				
Lucerne flea	N	Y	Y	Y
Mites				
Redlegged earth mite	N	Y	Y	Y
Blue oat mite	N	Y	Y	Y
Bryobia (various) / Balaustium mite	N	Y	Y	Y
Aphids				
Canola aphids (various)	Y	Y	Y	Y
Beetles				
False wireworms (various)	N	Y	Y	Y
Weevils (various)	N	Y	Y	Y
Caterpillars				
Budworms	Y	Y	Y	Y
Diamondback moth	N	Y	Y	Y
Cutworms (various)	N	Y	Y	Y
Weed web moth	N	Y	Y	Y
Bugs				
Rutherglen bug	N	Y	Y	Y
Earwigs				
European earwig	N	Y	Y	Y
Millipedes				
Millipedes	N	Y	N	Y
Additional Pests				
Slaters	N	N	Y	Y

Y: present in region, N: not recorded in region

TABLE 7.2 Incidence of invertebrate pests in canola as a proportion of years when pests occur at economically damaging levels (%) and as a proportion of the whole crop area affected (%) during those years in the GRDC Regions and Australia

Invertebrate pest	Northern		Southern		Western		Australia	
	Years	Area	Years	Area	Years	Area	Years	Area
Snails								
Snails (various)			50.0%	7.5%	70.0%	9.0%	58.4%	8.0%
Slugs								
Slugs (various)			50.0%	7.7%	80.0%	8.0%	63.4%	7.6%
Springtails								
Lucerne flea			48.3%	18.7%	80.0%	30.0%	62.7%	23.7%
Mites								
Redlegged earth mite			56.7%	40.0%	80.0%	60.0%	66.5%	48.7%
Blue oat mite			56.7%	26.7%	50.0%	10.0%	51.5%	17.5%
Bryobia (various) / Balaustium mite			56.7%	10.0%	60.0%	40.0%	56.5%	24.7%
Aphids*								
Canola aphids (various)	3.3%	1.3%	73.3%	26.7%	80.0%	45.0%	74.4%	35.0%
Beetles								
False wireworms (various)			51.7%	7.7%	10.0%	5.0%	29.1%	6.1%
Weevils (various)			47.7%	7.7%	80.0%	15.0%	62.3%	11.1%
Caterpillars								
Budworms	11.7%	16.7%	61.7%	7.0%	80.0%	25.0%	69.3%	16.3%
Diamondback moth			41.7%	15.0%	50.0%	30.0%	44.5%	22.0%
Cutworms (various)			28.3%	6.0%	30.0%	40.0%	28.3%	22.9%
Weed web moth			40.0%	5.0%	20.0%	15.0%	28.7%	9.9%
Bugs								
Rutherglen bug			53.3%	17.0%	60.0%	20.0%	55.0%	18.0%
Earwigs								
European earwig			40.0%	13.3%	90.0%	5.0%	63.8%	8.7%
Millipedes								
Millipedes			23.3%	5.3%			10.9%	2.5%
Additional Pests								
Slaters					90.0%	2.0%	45.1%	1.0%

Note: Australia Years and Area percentages are a weighted average total based on percentage for each Region multiplied by the total crop area average for that region, with the total then divided by the total crop area average for all regions.

* Assessment for feeding damage only not virus transmission

TABLE 7.3 Severity: Estimated potential damage (% yield loss) in the absence of chemical and cultural controls and present levels of damage (% yield loss) with current chemical and cultural control of invertebrate pests in canola in the GRDC Regions and Australia

Invertebrate pest	Northern		Southern		Western		Australia	
	Potential	Present	Potential	Present	Potential	Present	Potential	Present
Snails								
Snails (various)			27.5%	11.0%	20.0%	5.0%	22.9%	7.64%
Slugs								
Slugs (various)			37.0%	11.7%	30.0%	4.0%	32.3%	7.45%
Springtails								
Lucerne flea			14.0%	2.0%	25.0%	2.0%	19.1%	1.94%
Mites								
Redlegged earth mite			36.7%	3.7%	30.0%	2.0%	32.1%	2.71%
Blue oat mite			40.0%	3.7%	5.0%	1.0%	21.2%	2.21%
Bryobia (various) / Balaustium mite			25.0%	5.3%	15.0%	1.0%	19.2%	2.99%
Aphids								
Canola aphids (various)	1.3%	0.8%	4.7%	1.3%	15.0%	3.0%	9.7%	2.15%
Beetles								
False wireworms (various)			35.3%	5.0%	10.0%	5.0%	21.5%	4.84%
Weevils (various)			53.3%	15.0%	10.0%	4.0%	29.9%	9.00%
Caterpillars								
Budworms	40.0%	5.0%	13.3%	2.0%	20.0%	3.0%	17.5%	2.60%
Diamondback moth			25.0%	15.0%	20.0%	10.0%	21.7%	12.01%
Cutworms (various)			20.3%	3.3%	10.0%	2.0%	14.5%	2.56%
Weed web moth			15.0%	2.5%	10.0%	3.0%	12.0%	2.67%
Bugs								
Rutherglen bug			8.3%	2.7%	5.0%	2.0%	6.4%	2.25%
Earwigs								
European earwig			30.3%	13.3%	20.0%	10.0%	24.2%	11.23%
Millipedes								
Millipedes			13.5%	6.7%			6.3%	3.11%
Additional Pests								
Slaters					5.0%	3.0%	2.5%	1.50%

Note: Australia Potential and Present percentages are a weighted average total based on percentage for each Region multiplied by the total crop area average for that region, with the total then divided by the total crop area average for all regions.

7.2 Potential cost to canola crop – no control of invertebrate pests

The potential economic loss in the absence of cultural and pesticide controls is summarised in Table 7.4. These values take into consideration both the incidence (% years) and severity (% area damaged).

TABLE 7.4 Potential average annual loss (\$/ha and \$ million) from invertebrate pests in canola in the GRDC Regions and Australia

Invertebrate pest	Northern		Southern		Western		Australia	
	\$/ha	\$ million	\$/ha	\$ million	\$/ha	\$ million	\$/ha	\$ million
Snails								
Snails (various)	\$0.00	\$0.000	\$4.83	\$3.292	\$6.49	\$4.755	\$5.51	\$8.047
Slugs								
Slugs (various)	\$0.00	\$0.000	\$12.94	\$8.817	\$9.89	\$7.245	\$10.99	\$16.062
Springtails								
Lucerne flea	\$0.00	\$0.000	\$10.29	\$7.015	\$30.91	\$22.641	\$20.30	\$29.656
Mites								
Redlegged earth mite	\$0.00	\$0.000	\$61.95	\$42.224	\$74.18	\$54.339	\$66.09	\$96.563
Blue oat mite	\$0.00	\$0.000	\$40.82	\$27.820	\$1.29	\$0.943	\$19.69	\$28.763
Bryobia (various) / Balaustium mite	\$0.00	\$0.000	\$8.36	\$5.701	\$18.54	\$13.585	\$13.20	\$19.285
Aphids								
Canola aphids (various)	\$0.02	\$0.001	\$5.31	\$3.618	\$27.82	\$20.377	\$16.42	\$23.996
Beetles								
False wireworms (various)	\$0.00	\$0.000	\$9.01	\$6.144	\$0.26	\$0.189	\$4.33	\$6.332
Weevils (various)	\$0.00	\$0.000	\$12.93	\$8.811	\$6.18	\$4.528	\$9.13	\$13.339
Caterpillars								
Budworms	\$30.43	\$1.428	\$4.03	\$2.744	\$20.60	\$15.094	\$13.19	\$19.266
Diamondback moth	\$0.00	\$0.000	\$11.40	\$7.767	\$15.45	\$11.321	\$13.06	\$19.088
Cutworms (various)	\$0.00	\$0.000	\$1.96	\$1.333	\$6.18	\$4.528	\$4.01	\$5.861
Weed web moth	\$0.00	\$0.000	\$1.51	\$1.026	\$1.55	\$1.132	\$1.48	\$2.158
Bugs								
Rutherglen bug	\$0.00	\$0.000	\$4.49	\$3.059	\$3.09	\$2.264	\$3.64	\$5.324
Earwigs								
European earwig	\$0.00	\$0.000	\$8.37	\$5.707	\$4.64	\$3.396	\$6.23	\$9.103
Millipedes								
Millipedes	\$0.00	\$0.000	\$1.03	\$0.700	\$0.00	\$0.000	\$0.48	\$0.700
Additional Pests								
Slaters					\$0.46	\$0.340	\$0.23	\$0.340
Total	\$30.45	\$1.430	\$199.23	\$135.779	\$227.52	\$166.676	\$207.99	\$303.884

Note: Australia \$/ha amounts are a weighted average total based on \$/ha for each Region multiplied by the total crop area average for that region, with the total then divided by the total crop area average for all regions. Australia \$ million is aggregate of the three regions.

7.3 Current cost to canola crop – with control of invertebrate pests

The current cost to the canola industry of invertebrate pests is shown in Table 7.5. These values take into consideration both the incidence (% years) and severity (% area damaged).

TABLE 7.5 Present average annual loss (\$/ha and \$ million) from invertebrate pests in canola in the GRDC Regions and Australia

Invertebrate pest	Northern		Southern		Western		Australia	
	\$/ha	\$ million	\$/ha	\$ million	\$/ha	\$ million	\$/ha	\$ million
Snails								
Snails (various)	\$0.00	\$0.000	\$1.93	\$1.317	\$1.62	\$1.189	\$1.71	\$2.506
Slugs								
Slugs (various)	\$0.00	\$0.000	\$4.08	\$2.780	\$1.32	\$0.966	\$2.56	\$3.746
Springtails								
Lucerne flea	\$0.00	\$0.000	\$1.47	\$1.002	\$2.47	\$1.811	\$1.93	\$2.813
Mites								
Redlegged earth mite	\$0.00	\$0.000	\$6.20	\$4.222	\$4.95	\$3.623	\$5.37	\$7.845
Blue oat mite	\$0.00	\$0.000	\$3.74	\$2.550	\$0.26	\$0.189	\$1.87	\$2.739
Bryobia (various) / Balaustium mite	\$0.00	\$0.000	\$1.78	\$1.216	\$1.24	\$0.906	\$1.45	\$2.122
Aphids								
Canola aphids (various)	\$0.01	\$0.001	\$1.52	\$1.034	\$5.56	\$4.075	\$3.50	\$5.110
Beetles								
False wireworms (various)	\$0.00	\$0.000	\$1.28	\$0.869	\$0.13	\$0.094	\$0.66	\$0.964
Weevils (various)	\$0.00	\$0.000	\$3.64	\$2.478	\$2.47	\$1.811	\$2.94	\$4.289
Caterpillars								
Budworms	\$13.04	\$0.612	\$0.60	\$0.412	\$3.09	\$2.264	\$2.25	\$3.288
Diamondback moth	\$0.00	\$0.000	\$6.84	\$4.660	\$7.73	\$5.660	\$7.06	\$10.321
Cutworms (various)	\$0.00	\$0.000	\$0.32	\$0.219	\$1.24	\$0.906	\$0.77	\$1.124
Weed web moth	\$0.00	\$0.000	\$0.25	\$0.171	\$0.46	\$0.340	\$0.35	\$0.511
Bugs								
Rutherglen bug	\$0.00	\$0.000	\$1.44	\$0.979	\$1.24	\$0.906	\$1.29	\$1.885
Earwigs								
European earwig	\$0.00	\$0.000	\$3.68	\$2.508	\$2.32	\$1.698	\$2.88	\$4.206
Millipedes								
Millipedes	\$0.00	\$0.000	\$0.51	\$0.346	\$0.00	\$0.000	\$0.24	\$0.346
Additional Pests								
Slaters					\$0.28	\$0.204	\$0.14	\$0.204
Total	\$13.06	\$0.613	\$39.27	\$26.764	\$36.37	\$26.641	\$36.97	\$54.018

Note: Australia \$/ha amounts are a weighted average total based on \$/ha for each Region multiplied by the total crop area average for that region, with the total then divided by the total crop area average for all regions. Australia \$ million is aggregate of the three regions.

7.4 Value of invertebrate pest controls in canola

The value of invertebrate pest control in canola is estimated by subtracting the potential loss (Table 7.4) from the present loss (Table 7.5) and is shown in Table 7.6.

TABLE 7.6 Value of current control practices (\$/ha and \$ million) by GRDC Region and Australia

Invertebrate pest	Northern		Southern		Western		Australia	
	\$/ha	\$ million	\$/ha	\$ million	\$/ha	\$ million	\$/ha	\$ million
Snails								
Snails (various)	\$0.00	\$0.000	\$2.90	\$1.975	\$4.87	\$3.566	\$3.79	\$5.541
Slugs								
Slugs (various)	\$0.00	\$0.000	\$8.86	\$6.037	\$8.57	\$6.279	\$8.43	\$12.316
Springtails								
Lucerne flea	\$0.00	\$0.000	\$8.82	\$6.013	\$28.43	\$20.830	\$18.37	\$26.843
Mites								
Redlegged earth mite	\$0.00	\$0.000	\$55.76	\$38.002	\$69.23	\$50.716	\$60.72	\$88.718
Blue oat mite	\$0.00	\$0.000	\$37.08	\$25.270	\$1.03	\$0.755	\$17.81	\$26.024
Bryobia (various) / Balaustium mite	\$0.00	\$0.000	\$6.58	\$4.485	\$17.31	\$12.679	\$11.75	\$17.164
Aphids								
Canola aphids (various)	\$0.01	\$0.000	\$3.79	\$2.584	\$22.25	\$16.302	\$12.93	\$18.886
Beetles								
False wireworms (various)	\$0.00	\$0.000	\$7.74	\$5.274	\$0.13	\$0.094	\$3.67	\$5.369
Weevils (various)	\$0.00	\$0.000	\$9.29	\$6.333	\$3.71	\$2.717	\$6.19	\$9.050
Caterpillars								
Budworms	\$17.39	\$0.816	\$3.42	\$2.332	\$17.51	\$12.830	\$10.94	\$15.979
Diamondback moth	\$0.00	\$0.000	\$4.56	\$3.107	\$7.73	\$5.660	\$6.00	\$8.767
Cutworms (various)	\$0.00	\$0.000	\$1.64	\$1.115	\$4.95	\$3.623	\$3.24	\$4.737
Weed web moth	\$0.00	\$0.000	\$1.25	\$0.855	\$1.08	\$0.792	\$1.13	\$1.648
Bugs								
Rutherglen bug	\$0.00	\$0.000	\$3.05	\$2.080	\$1.85	\$1.358	\$2.35	\$3.439
Earwigs								
European earwig	\$0.00	\$0.000	\$4.69	\$3.198	\$2.32	\$1.698	\$3.35	\$4.896
Millipedes								
Millipedes	\$0.00	\$0.000	\$0.52	\$0.354	\$0.00	\$0.000	\$0.24	\$0.354
Additional Pests								
Slaters					\$0.19	\$0.136	\$0.09	\$0.136
Total	\$17.40	\$0.817	\$159.95	\$109.015	\$191.16	\$140.035	\$171.02	\$249.867

7.5 Value of cultural controls in canola

The value of cultural controls for invertebrate pest control in canola is estimated by multiplying the value of invertebrate pest control (Table 7.6) by the proportion of treated area receiving cultural controls.

TABLE 7.6A Percentage of treated area receiving cultural controls and value of current cultural control practices (\$ million) by GRDC Region and Australia

Invertebrate pest	Northern		Southern		Western		Australia
	% treated area	\$ million	% treated area	\$ million	% treated area	\$ million	\$ million
Snails							
Snails (various)	0.00%	\$0.000	20.00%	\$0.395	50.00%	\$1.783	\$2.178
Slugs							
Slugs (various)	0.00%	\$0.000	45.00%	\$2.717	60.00%	\$3.767	\$6.484
Springtails							
Lucerne flea	0.00%	\$0.000	3.33%	\$0.200	50.00%	\$10.415	\$10.615
Mites							
Redlegged earth mite	0.00%	\$0.000	3.33%	\$1.265	60.00%	\$30.430	\$31.695
Blue oat mite	0.00%	\$0.000	3.33%	\$0.841	60.00%	\$0.453	\$1.294
Bryobia (various) / Balaustium mite	0.00%	\$0.000	3.33%	\$0.149	60.00%	\$7.607	\$7.756
Aphids							
Canola aphids (various)	0.00%	\$0.000	17.33%	\$0.448	50.00%	\$8.151	\$8.599
Beetles							
False wireworms (various)	0.00%	\$0.000	3.33%	\$0.176	30.00%	\$0.028	\$0.204
Weevils (various)	0.00%	\$0.000	1.67%	\$0.106	40.00%	\$1.087	\$1.193
Caterpillars							
Budworms (various)	0.00%	\$0.000	1.67%	\$0.039	0.00%	\$0.000	\$0.039
Diamondback moth	0.00%	\$0.000	2.00%	\$0.062	60.00%	\$3.400	\$3.462
Cutworms (various)	0.00%	\$0.000	0.83%	\$0.009	60.00%	\$2.174	\$2.183
Weed web moth	0.00%	\$0.000	2.50%	\$0.002	60.00%	\$0.475	\$0.477
Bugs							
Rutherglen bug	0.00%	\$0.000	27.50%	\$0.572	60.00%	\$0.815	\$1.387
Earwigs							
European earwigs	0.00%	\$0.000	31.67%	\$1.013	60.00%	\$1.019	\$2.032
Millipedes							
Millipedes	0.00%	\$0.000	31.67%	\$0.112	0.00%	\$0.000	\$0.112
Additional Pests							
Slaters	0.00%	\$0.000	0.00%	\$0.000	50.00%	\$0.068	\$0.068
Total				\$8.106		\$71.672	\$79.778

7.6 Cost of invertebrate pest controls in canola

Cultivars are not presently tested for relevance to the control of vertebrate pests in canola. The survey revealed limited and unspecified cultural controls for invertebrate

pests in canola. Cultural controls are sometimes used on slugs, aphids, cockchafers, armyworms and budworms. Invertebrate pest control in canola is most often achieved with pesticides. Pesticides used and their cost are shown in Table 7.7.

TABLE 7.7 Representative pesticide treatment used and cost – canola

Invertebrate pest	Representative pesticide control	Active ingredient	Chemical cost per ha
Snails			
Snails (various)	baits	metaldehyde	\$12.00
Slugs			
Slugs (various)	baits	metaldehyde	\$12.00
Springtails			
Lucerne flea	post-emergence	omethoate	\$1.90
Mites			
Redlegged earth mite	PSPE	bifenthrin	\$1.60
Blue oat mite	PSPE	bifenthrin	\$1.60
Bryobia (various) / Balaustium mite	presowing and knockdown	omethoate	\$1.90
Aphids			
Canola aphids (various)	dimethoate	dimethoate	\$6.25
Beetles			
False wireworms (various)	SP	alpha-cypermethrin	\$3.40
Weevils (various)	SP	alpha-cypermethrin	\$3.40
Caterpillars			
Budworms	SP	alpha-cypermethrin	\$2.55
Diamondback moth	SP	alpha-cypermethrin	\$3.40
Cutworms (various)	SP	alpha-cypermethrin	\$2.55
Weed web moth	SP	alpha-cypermethrin	\$3.40
Bugs			
Rutherglen bug	SP	alpha-cypermethrin	\$3.40
Earwigs			
European earwig	SP	alpha-cypermethrin	\$3.40
Millipedes			
Millipedes	no treatment*		
Additional Pests			
Slaters	baits*	metaldehyde	\$8.00

PSPE: post sowing pre-emergent, SP: Synthetic pyrethroid

* Controls may be permitted under relevant State Pesticide Regulations

The total cost of pesticide treatment of canola and the area treated is shown in Table 7.8

TABLE 7.8 Invertebrate pest treatment costs – canola

Invertebrate pest	Northern		Southern		Western		Australia	
	Incidence %	Total cost of treatment \$ million	Incidence %	Total cost of treatment \$ million	Incidence %	Total cost of treatment \$ million	Incidence %	Total cost of treatment \$ million
Snails								
Snails (various)			3.50%	\$0.268	6.30%	\$0.923	4.79%	\$1.191
Slugs								
Slugs (various)			6.97%	\$0.554	6.40%	\$0.938	6.46%	\$1.492
Springtails								
Lucerne flea			14.65%	\$0.644	24.00%	\$2.095	18.87%	\$2.740
Mites								
Redlegged earth mite			33.67%	\$3.015	48.00%	\$4.620	39.77%	\$7.635
Blue oat mite			20.33%	\$1.821	5.00%	\$0.428	11.99%	\$2.249
Bryobia (various) / Balaustium mite			6.67%	\$0.508	24.00%	\$2.095	15.14%	\$2.603
Aphids								
Canola aphids (various)	0.27%	\$0.000	22.67%	\$0.397	36.00%	\$3.554	28.63%	\$3.950
Beetles								
False wireworms (various)			5.08%	\$0.275	0.50%	\$0.030	2.62%	\$0.305
Weevils (various)			4.83%	\$0.261	12.00%	\$1.009	8.27%	\$1.270
Caterpillars								
Budworms	11.67%	\$0.043	6.02%	\$0.266	20.00%	\$1.367	13.21%	\$1.675
Diamondback moth			9.08%	\$0.558	15.00%	\$1.081	11.76%	\$1.640
Cutworms (various)			1.92%	\$0.080	12.00%	\$0.719	6.91%	\$0.799
Weed web moth			2.00%	\$0.022	3.00%	\$0.216	2.44%	\$0.239
Bugs								
Rutherglen bug			10.73%	\$0.320	12.00%	\$0.721	11.02%	\$1.041
Earwigs								
European earwig			5.50%	\$0.174	4.50%	\$0.270	4.82%	\$0.444
Millipedes								
Millipedes			1.52%	\$0.023			0.71%	\$0.023
Additional Pests								
Slaters					1.80%	\$0.194	0.90%	\$0.194
Total		\$0.043		\$9.186		\$20.261		\$29.489

Incidence %: Incidence years x Incidence area

Note: Australia Incidence % are a weighted average total based on percentage for each Region multiplied by the total crop area average for that region, with the total then divided by the total crop area average for all regions.

Australia Total Cost of Treatment is aggregate of the three regions.

NRT: No registered treatment

7.7 Conclusions on canola invertebrate pests

Average total cost of treatment for invertebrate pests in canola nationally is \$29.5 million or \$20.18 per ha grown. By GRDC region this equates to:

- Northern region: \$0.04 million pa or \$0.91 per hectare of canola grown.
- Southern region: \$9.2 million pa or \$13.47 per hectare of canola grown.
- Western region: \$20.2 million pa or \$27.64 per hectare of canola grown.

The Northern GRDC region enjoys a much lower invertebrate pest pressure compared to other parts of Australia. When ranked in order of potential and present losses, the five major invertebrate pests of canola are:

TABLE 7.9 Five most important invertebrate pests of canola by potential and present loss

Rank	By Potential Loss	By Present Loss
1	Redlegged earth mite (\$96.6 million)	Diamondback moth (\$10.3 million)
2	Lucerne flea (\$29.7 million)	Redlegged earth mite (\$7.8 million)
3	Blue oat mite (\$28.8 million)	Canola aphids (various) (\$5.1 million)
4	Canola aphids (various) (\$24.0 million)	Weevils (various) (\$4.3 million)
5	Bryobia (various) / Balaustium mite (\$19.3 million)	European earwig (\$4.2 million)

Reference to Table 7.4 shows that the above listed five invertebrate pests of canola have a potential to cause serious losses. Table 7.5 shows that even with control the above listed five pests cost the canola industry more than \$30 million annually.

8 LUPINS – INVERTEBRATE PEST COST

8.1 Incidence and severity of invertebrate pests in lupins

The following tables report pest presence, incidence and severity using survey data for lupins. No responses were received for lupins in the Northern GRDC region.

TABLE 8.1 Presence of invertebrate pests causing lupin damage – GRDC Regions and Australia

Invertebrate pest	Northern	Southern	Western	Australia
Snails				
Snails (various)		Y	Y	Y
Mites				
Redlegged earth mite		Y	Y	Y
Blue oat mite		Y	Y	Y
Bryobia (various) / Balaustium mite		Y	Y	Y
Springtails				
Lucerne flea		Y	Y	Y
Aphids				
Aphids (various)		Y	Y	Y
Caterpillars				
Etiella moth		Y	U	Y
Budworms		Y	Y	Y
Cutworms (various)		Y	Y	Y
Weed web moth		Y	Y	Y
Beetles				
Weevils (various)		Y	Y	Y
Earwigs				
European earwigs		Y	Y	Y
Additional Pests (N/A)				

Y: present in region, N: not recorded in region, U: unknown status
 Note: If invertebrate pest is present in any GRDC region, it is recorded as being present in Australia.

TABLE 8.2 Incidence of invertebrate pests in lupins as a proportion of years when pests occur at economically damaging levels (%) and as a proportion of the whole crop area affected (%) in the GRDC Regions and Australia

Invertebrate pest	Northern		Southern		Western		Australia	
	Years	Area	Years	Area	Years	Area	Years	Area
Snails								
Snails (various)			40.0%	10.0%	70.0%	5.0%	61.3%	6.0%
Mites								
Redlegged earth mite			65.0%	25.0%	80.0%	50.0%	74.4%	42.9%
Blue oat mite			65.0%	20.0%	50.0%	5.0%	52.1%	8.3%
Bryobia (various) / Balaustium mite			65.0%	22.5%	60.0%	20.0%	59.5%	20.0%
Springtails								
Lucerne flea			57.5%	17.5%	80.0%	10.0%	72.7%	11.5%
Aphids*								
Aphids (various)			55.0%	25.0%	60.0%	40.0%	57.3%	35.5%
Caterpillars								
Etiella moth			70.0%	12.0%	5.0%	7.0%	19.8%	8.0%
Budworms			80.0%	23.3%	90.0%	30.0%	85.3%	27.7%
Cutworms (various)			27.5%	6.5%	40.0%	20.0%	36.1%	16.4%
Weed web moth			20.0%	10.0%	20.0%	15.0%	19.5%	13.5%
Beetles								
Weevils (various)			30.0%	7.3%	80.0%	20.0%	66.4%	16.6%
Earwigs								
European earwigs			35.0%	8.8%	80.0%	3.0%	67.5%	4.2%
Additional Pests (N/A)								

Note: Australia Years and Area percentages are a weighted average total based on percentage for each Region multiplied by the total crop area average for that region, with the total then divided by the total crop area average for all regions.

* Assessment for feeding damage only not virus transmission

TABLE 8.3 Severity: Estimated potential damage (% yield loss) in the absence of chemical and cultural controls and present levels of damage (% yield loss) with current chemical and cultural control of invertebrate pests in lupins in the GRDC Regions and Australia

Invertebrate pest	Northern		Southern		Western		Australia	
	Potential	Present	Potential	Present	Potential	Present	Potential	Present
Snails								
Snails (various)			50.0%	20.0%	10.0%	5.0%	18.9%	8.3%
Mites								
Redlegged earth mite			37.5%	2.0%	20.0%	1.0%	23.5%	1.2%
Blue oat mite			35.0%	1.5%	5.0%	1.0%	11.7%	1.1%
Bryobia (various) / Balaustium mite			40.0%	8.0%	5.0%	1.0%	12.9%	2.6%
Springtails								
Lucerne flea			12.5%	2.0%	15.0%	1.0%	14.0%	1.2%
Aphids								
Aphids (various)			7.0%	2.5%	15.0%	5.0%	12.8%	4.3%
Caterpillars								
Etiella moth			22.5%	3.5%	20.0%	20.0%	20.0%	15.7%
Budworms			33.3%	3.0%	20.0%	3.0%	22.5%	2.9%
Cutworms (various)			30.0%	3.5%	5.0%	1.0%	10.6%	1.5%
Weed web moth			5.0%	1.0%	5.0%	2.0%	4.9%	1.7%
Beetles								
Weevils (various)			16.7%	5.3%	8.0%	3.0%	9.8%	3.5%
Earwigs								
European earwigs			37.5%	16.0%	20.0%	5.0%	23.5%	7.4%
Additional Pests (N/A)								

Note: Australia Potential and Present percentages are a weighted average total based on percentage for each Region multiplied by the total crop area average for that region, with the total then divided by the total crop area average for all regions.

8.2 Potential cost to lupin crop – no control of invertebrate pests

The potential economic loss in the absence of cultural and pesticide controls is summarised in Table 8.4. These values take into consideration both the incidence (% years) and severity (% area damaged).

TABLE 8.4 Potential average annual loss (\$/ha and \$ million) from invertebrate pests in lupins in the GRDC Regions and Australia

Invertebrate pest	Northern		Southern		Western		Australia	
	\$/ha	\$ million	\$/ha	\$ million	\$/ha	\$ million	\$/ha	\$ million
Snails								
Snails (various)			\$5.90	\$0.980	\$0.95	\$0.510	\$2.06	\$1.490
Mites								
Redlegged earth mite			\$19.37	\$3.216	\$21.62	\$11.649	\$20.52	\$14.866
Blue oat mite			\$13.43	\$2.230	\$0.34	\$0.182	\$3.33	\$2.412
Bryobia (various) / Balaustium mite			\$22.43	\$3.725	\$1.62	\$0.874	\$6.35	\$4.598
Springtails								
Lucerne flea			\$4.01	\$0.666	\$3.24	\$1.747	\$3.33	\$2.414
Aphids								
Aphids (various)			\$3.62	\$0.600	\$9.73	\$5.242	\$8.07	\$5.843
Caterpillars								
Etiella moth			\$4.52	\$0.750	\$0.19	\$0.102	\$1.18	\$0.852
Budworms			\$18.36	\$3.049	\$14.59	\$7.863	\$15.07	\$10.913
Cutworms (various)			\$1.66	\$0.276	\$1.08	\$0.582	\$1.18	\$0.858
Weed web moth			\$0.30	\$0.049	\$0.41	\$0.218	\$0.37	\$0.267
Beetles								
Weevils (various)			\$1.28	\$0.212	\$3.46	\$1.864	\$2.87	\$2.076
Earwigs								
European earwigs			\$4.43	\$0.735	\$1.30	\$0.699	\$1.98	\$1.434
Additional Pests (N/A)								
Total	0.00	0.000	\$99.29	\$16.488	\$58.51	\$31.534	\$66.30	\$48.022

Note: Australia \$/ha amounts are a weighted average total based on \$/ha for each Region multiplied by the total crop area average for that region, with the total then divided by the total crop area average for all regions. Australia \$ million is aggregate of the three regions.

8.3 Current cost to lupin crop – with control of invertebrate pests

The current cost to the lupins industry of invertebrate pests is shown in Table 8.5. These values take into consideration both the incidence (% years) and severity (% area damaged).

TABLE 8.5 Present average annual loss (\$/ha and \$ million) from invertebrate pests in lupins in the GRDC Regions and Australia

Invertebrate pest	Northern		Southern		Western		Australia	
	\$/ha	\$ million	\$/ha	\$ million	\$/ha	\$ million	\$/ha	\$ million
Snails								
Snails (various)			\$2.36	\$0.392	\$0.47	\$0.255	\$0.89	\$0.647
Mites								
Redlegged earth mite			\$1.03	\$0.172	\$1.08	\$0.582	\$1.04	\$0.754
Blue oat mite			\$0.58	\$0.096	\$0.07	\$0.036	\$0.18	\$0.132
Bryobia (various) / Balaustium mite			\$4.49	\$0.745	\$0.32	\$0.175	\$1.27	\$0.920
Springtails								
Lucerne flea			\$0.64	\$0.107	\$0.22	\$0.116	\$0.31	\$0.223
Aphids								
Aphids (various)			\$1.29	\$0.214	\$3.24	\$1.747	\$2.71	\$1.962
Caterpillars								
Etiella moth			\$0.70	\$0.117	\$0.19	\$0.102	\$0.30	\$0.219
Budworms			\$1.65	\$0.274	\$2.19	\$1.180	\$2.01	\$1.454
Cutworms (various)			\$0.19	\$0.032	\$0.22	\$0.116	\$0.21	\$0.149
Weed web moth			\$0.06	\$0.010	\$0.16	\$0.087	\$0.13	\$0.097
Beetles								
Weevils (various)			\$0.41	\$0.068	\$1.30	\$0.699	\$1.06	\$0.767
Earwigs								
European earwigs			\$1.89	\$0.314	\$0.32	\$0.175	\$0.67	\$0.488
Additional Pests (N/A)								
Total	\$0.00	\$0.000	\$15.29	\$2.540	\$9.78	\$5.271	\$10.78	\$7.811

Note: Australia \$/ha amounts are a weighted average total based on \$/ha for each Region multiplied by the total crop area average for that region, with the total then divided by the total crop area average for all regions. Australia \$ million is aggregate of the three regions.

8.4 Value of invertebrate pest controls in lupins

The value of invertebrate pest control in lupins is estimated by subtracting the potential loss (Table 8.4) from the present loss (Table 8.5) and is shown in Table 8.6.

TABLE 8.6 Value of current control practices (\$/ha and \$ million) by GRDC Region and Australia

Invertebrate pest	Northern		Southern		Western		Australia	
	\$/ha	\$ million	\$/ha	\$ million	\$/ha	\$ million	\$/ha	\$ million
Snails								
Snails (various)			\$3.54	\$0.588	\$0.47	\$0.255	\$1.16	\$0.843
Mites								
Redlegged earth mite			\$18.33	\$3.045	\$20.53	\$11.067	\$19.48	\$14.112
Blue oat mite			\$12.85	\$2.134	\$0.27	\$0.146	\$3.15	\$2.280
Bryobia (various) / Balaustium mite			\$17.94	\$2.980	\$1.30	\$0.699	\$5.08	\$3.679
Springtails								
Lucerne flea			\$3.37	\$0.560	\$3.03	\$1.631	\$3.02	\$2.191
Aphids								
Aphids (various)			\$2.32	\$0.386	\$6.48	\$3.495	\$5.36	\$3.881
Caterpillars								
Etiella moth			\$3.81	\$0.633	\$0.00	\$0.000	\$0.87	\$0.633
Budworms			\$16.71	\$2.775	\$12.40	\$6.684	\$13.06	\$9.459
Cutworms (various)			\$1.47	\$0.244	\$0.86	\$0.466	\$0.98	\$0.709
Weed web moth			\$0.24	\$0.039	\$0.24	\$0.131	\$0.24	\$0.170
Beetles								
Weevils (various)			\$0.87	\$0.144	\$2.16	\$1.165	\$1.81	\$1.309
Earwigs								
European earwigs			\$2.54	\$0.421	\$0.97	\$0.524	\$1.31	\$0.946
Additional Pests (N/A)								
Total	0.00	0.000	\$84.00	\$13.949	\$48.73	\$26.262	\$55.51	\$40.211

8.5 Value of cultural controls in lupins

The value of cultural controls for invertebrate pest control in lupins is estimated by multiplying the value of invertebrate pest control (Table 8.6) by the proportion of treated area receiving cultural controls.

TABLE 8.6A Percentage of treated area receiving cultural controls and value of current cultural control practices (\$ million) by GRDC Region and Australia

Invertebrate pest	Northern		Southern		Western		Australia
	% treated area	\$ million	% treated area	\$ million	% treated area	\$ million	\$ million
Snails							
Snails (various)			15.00%	\$0.088	50.00%	\$1.128	\$1.216
Mites							
Redlegged earth mite			2.00%	\$0.061	30.00%	\$3.320	\$3.381
Blue oat mite			2.00%	\$0.043	60.00%	\$0.088	\$0.131
Bryobia (various) / Balaustium mite			3.33%	\$0.099	60.00%	\$0.419	\$0.518
Springtails							
Lucerne flea			2.33%	\$0.013	50.00%	\$0.816	\$0.829
Aphids							
Aphids (various)			3.33%	\$0.013	60.00%	\$2.097	\$2.110
Caterpillars							
Etiella moth			0.67%	\$0.004	20.00%	\$0.000	\$0.004
Cutworms (various)			0.67%	\$0.018	0.00%	\$0.000	\$0.018
Budworms (various)			0.33%	\$0.001	60.00%	\$4.010	\$4.011
Weed web moth			0.50%	\$0.000	60.00%	\$0.079	\$0.079
Beetles							
Weevils (various)			1.67%	\$0.002	40.00%	\$0.466	\$0.468
Earwigs							
European earwigs			1.67%	\$1.007	80.00%	\$0.419	\$1.426
Additional Pests (N/A)							
Total				\$1.349		\$12.842	\$14.191

8.6 Cost of invertebrate pest controls in lupins

Cultivars are not presently tested for relevance to the control of vertebrate pests in lupins. The survey revealed limited and unspecified cultural controls for invertebrate pests in lupins. Cultural controls are sometimes used on slugs, aphids, cockchafer, armyworms and budworms. Invertebrate pest control in lupins is most often achieved with pesticides. Pesticides used and their cost are shown in Table 8.7.

TABLE 8.7 Representative pesticide treatment used and cost – lupins

Invertebrate pest	Representative pesticide control	Active ingredient	Chemical cost per ha
Snails			
Snails (various)	baits	metaldehyde	\$12.00
Mites			
Redlegged earth mite	PSPE	bifenthrin	\$1.60
Blue oat mite	PSPE	bifenthrin	\$1.60
Bryobia (various) / Balaustium mite	presowing and knockdown	omethoate	\$1.90
Springtails			
Lucerne flea	PSPE	omethoate	\$1.90
Aphids			
Aphids (various)	dimethoate	dimethoate	\$6.25
Caterpillars			
Etiella moth	SP	alpha-cypermethrin	\$2.55
Budworms	SP	alpha-cypermethrin	\$2.55
Cutworms (various)	SP	alpha-cypermethrin	\$0.64
Weed web moth	SP	alpha-cypermethrin	\$2.55
Beetles			
Weevils (various)	SP	alpha-cypermethrin	\$0.85
Earwigs			
European earwigs	no treatment*		
Additional Pests (N/A)			

PSPE: post sowing pre-emergent, SP: Synthetic pyrethroid

* Controls may be permitted under relevant State Pesticide Regulations

The total cost of pesticide treatment of lupin and the area treated is shown in Table 8.8

TABLE 8.8 Invertebrate pest treatment costs – lupin

Invertebrate pest	Northern		Southern		Western		Australia	
	Incidence %	Total cost of treatment \$ million	Incidence %	Total cost of treatment \$ million	Incidence %	Total cost of treatment \$ million	Incidence %	Total cost of treatment \$ million
Snails								
Snails (various)			4.00%	\$0.066	3.50%	\$0.236	3.52%	\$0.302
Mites								
Redlegged earth mite			17.50%	\$0.170	40.00%	\$2.518	33.77%	\$2.688
Blue oat mite			13.00%	\$0.121	2.50%	\$0.157	4.84%	\$0.278
Bryobia (various) / Balaustium mite			19.00%	\$0.211	12.00%	\$0.771	13.28%	\$0.982
Springtails								
Lucerne flea			10.88%	\$0.076	8.00%	\$0.064	8.45%	\$0.140
Aphids								
Aphids (various)			17.50%	\$0.103	24.00%	\$1.494	21.87%	\$1.597
Caterpillars								
Etiella moth			6.80%	\$0.050	0.35%	\$0.021	1.82%	\$0.070
Budworms			18.67%	\$0.313	27.00%	\$1.584	24.37%	\$1.897
Cutworms (various)			1.88%	\$0.009	8.00%	\$0.412	6.38%	\$0.421
Weed web moth			2.00%	\$0.001	3.00%	\$0.176	2.69%	\$0.177
Beetles								
Weevils (various)			2.60%	\$0.018	16.00%	\$0.717	12.50%	\$0.735
Earwigs								
European earwigs			4.00%	\$0.019	2.40%	\$0.042	2.70%	\$0.061
Additional Pests (N/A)								
Total		\$0.000		\$1.158		\$8.191		\$9.349

Incidence %: Incidence years x Incidence area

Note: Australia Incidence % are a weighted average total based on percentage for each Region multiplied by the total crop area average for that region, with the total then divided by the total crop area average for all regions.

Australia Total Cost of Treatment is aggregate of the three regions.

NRT: No registered treatment

8.7 Conclusions on lupin invertebrate pests

Average total cost of treatment for invertebrate pests in lupins nationally is \$9.3 million or \$12.91 per ha grown. By GRDC region this equates to:

- Northern region: N/A (insufficient area of lupins grown to obtain data for survey).
- Southern region: \$1.2 million pa or \$6.98 per hectare of lupins grown.
- Western region: \$8.2 million pa or \$15.20 per hectare of lupins grown.

When ranked in order of potential and present losses, the five major invertebrate pests of lupins are:

TABLE 8.9 Five most important invertebrate pests of lupins by potential and present loss

Rank	By Potential Loss	By Present Loss
1	Redlegged earth mite (\$14.9 million)	Aphids (various) (\$2.0 million)
2	Budworms (\$10.9 million)	Budworms (\$1.4 million)
3	Aphids (various) (\$5.8 million)	Bryobia (various) / Balaustium mite (\$0.9 million)
4	Bryobia (various) / Balaustium mite (\$4.6 million)	Weevils (various) (\$0.8 million)
5	Lucerne flea (\$2.4 million)	Redlegged earth mite (\$0.7 million)

Reference to Table 8.4 shows that the above listed five invertebrate pests of lupin have a potential to cause serious losses. Table 8.5 shows that even with control the above listed five pests cost the lupins industry more than \$6 million annually.

9 GRAIN SORGHUM – INVERTEBRATE PEST COST

9.1 Incidence and severity of invertebrate pests in sorghum

The following tables report pest presence, incidence and severity using survey data for sorghum. Most grain sorghum in Australia is produced in the Northern GRDC region. As a consequence no survey responses were received for the Southern and Western GRDC regions.

TABLE 9.1 Presence of invertebrate pests causing sorghum damage – GRDC Regions and Australia

Invertebrate pest	Northern	Southern	Western	Australia
Beetles				
False wireworms (various)	Y			Y
Caterpillars				
Budworms (corn earworm)	Y			Y
Flies				
Sorghum midge	Y			Y
Bugs				
Rutherglen bug	Y			Y
Locusts				
Locusts (various)	Y			Y
Additional Pests				
Earwigs	Y			Y
Beetles (scarab / cockchafer)	Y			Y

Y: present in region, N: not recorded in region

Note: If invertebrate pest is present in any GRDC region, it is recorded as being present in Australia.

TABLE 9.2 Incidence of invertebrate pests in sorghum as a proportion of years when pest occurs (%) and as a proportion of the crop area affected (%) when the pest develops in the GRDC Regions and Australia

Invertebrate pest	Northern		Southern		Western		Australia	
	Years	Area	Years	Area	Years	Area	Years	Area
Beetles								
False wireworms (various)	58.5%	24.3%					58.1%	24.1%
Caterpillars								
Budworms (corn earworm)	95.0%	56.7%					94.4%	56.3%
Flies								
Sorghum midge	95.8%	28.8%					95.2%	28.6%
Bugs								
Rutherglen bug	30.5%	19.5%					30.3%	19.4%
Locusts								
Locusts (various)	6.8%	8.1%					6.8%	8.1%
Additional Pests								
Earwigs	16.7%	6.7%					16.6%	6.6%
Beetles (scarab / cockchafer)	5.0%	0.7%					5.0%	0.7%

Note: Australia Years and Area percentages are a weighted average total based on percentage for each Region multiplied by the total crop area average for that region, with the total then divided by the total crop area average for all regions.

TABLE 9.3 Potential and present severity of invertebrate pests in sorghum (% yield loss) in the GRDC Regions and Australia

Invertebrate pest	Northern		Southern		Western		Australia	
	Potential	Present	Potential	Present	Potential	Present	Potential	Present
Beetles								
False wireworms (various)	40.0%	3.2%					39.7%	3.1%
Caterpillars								
Budworms (corn earworm)	46.7%	5.7%					46.4%	5.6%
Flies								
Sorghum midge	64.2%	8.2%					63.8%	8.1%
Bugs								
Rutherglen bug	23.8%	3.8%					23.7%	3.8%
Locusts								
Locusts (various)	35.0%	6.7%					34.8%	6.6%
Additional Pests								
Earwigs	6.7%	0.8%					6.6%	0.8%
Beetles (scarab / cockchafer)	16.7%	8.3%					16.6%	8.3%

Note: Australia Potential and Present percentages are a weighted average total based on percentage for each Region multiplied by the total crop area average for that region, with the total then divided by the total crop area average for all regions.

9.2 Potential cost to sorghum crop – no control of invertebrate pests

The potential economic loss in the absence of cultural and pesticide controls is summarised in Table 9.4.

TABLE 9.4 Potential average annual loss (\$/ha and \$ million) from invertebrate pests in sorghum in the GRDC Regions and Australia

Invertebrate pest	Northern		Southern		Western		Australia	
	\$/ha	\$ million	\$/ha	\$ million	\$/ha	\$ million	\$/ha	\$ million
Beetles								
False wireworms (various)	\$47.02	\$33.094					\$46.72	\$33.094
Caterpillars								
Budworms (corn earworm)	\$168.17	\$118.369					\$167.10	\$118.369
Flies								
Sorghum midge	\$121.67	\$85.635					\$120.89	\$85.635
Bugs								
Rutherglen bug	\$8.61	\$6.058					\$8.55	\$6.058
Locusts								
Locusts (various)	\$2.05	\$1.442					\$2.04	\$1.442
Additional Pests								
Earwigs	\$2.96	\$2.081					\$2.94	\$2.081
Beetles (scarab / cockchafer)	\$0.22	\$0.156					\$0.22	\$0.156
Total	\$350.69	\$246.836					\$350.69	\$246.836

Note: Australia \$/ha amounts are a weighted average total based on \$/ha for each Region multiplied by the total crop area average for that region, with the total then divided by the total crop area average for all regions. Australia \$ million is aggregate of the three regions.

9.3 Current cost to sorghum crop – with control of invertebrate pests

The current cost to the sorghum industry of invertebrate pests is shown in Table 9.5.

TABLE 9.5 Present average annual loss (\$/ha and \$ million) from invertebrate pests in sorghum in the GRDC Regions and Australia

Invertebrate pest	Northern		Southern		Western		Australia	
	\$/ha	\$ million	\$/ha	\$ million	\$/ha	\$ million	\$/ha	\$ million
Beetles								
False wireworms (various)	\$3.72	\$2.620					\$3.70	\$2.620
Caterpillars								
Budworms (corn earworm)	\$20.42	\$14.373					\$20.29	\$14.373
Flies								
Sorghum midge	\$15.48	\$10.899					\$15.39	\$10.899
Bugs								
Rutherglen bug	\$1.38	\$0.974					\$1.38	\$0.974
Locusts								
Locusts (various)	\$0.39	\$0.275					\$0.39	\$0.275
Additional Pests								
Earwigs	\$0.37	\$0.260					\$0.37	\$0.260
Beetles (scarab / cockchafer)	\$0.11	\$0.078					\$0.11	\$0.078
Total	\$41.88	\$29.480	0.00	0.000	0.00	0.000	\$41.88	\$29.480

Note: Australia \$/ha amounts are a weighted average total based on \$/ha for each Region multiplied by the total crop area average for that region, with the total then divided by the total crop area average for all regions. Australia \$ million is aggregate of the three regions.

9.4 Value of invertebrate pest controls in sorghum

The value of invertebrate pest control in sorghum is estimated by subtracting the potential loss (Table 9.4) from the present loss (Table 9.5) and is shown in Table 9.6.

TABLE 9.6 Value of current control practices (\$/ha and \$ million) by GRDC Region and Australia

Invertebrate pest	Northern		Southern		Western		Australia	
	\$/ha	\$ million	\$/ha	\$ million	\$/ha	\$ million	\$/ha	\$ million
Beetles								
False wireworms (various)	\$43.30	\$30.474					\$43.02	\$30.474
Caterpillars								
Budworms (corn earworm)	\$147.75	\$103.995					\$146.81	\$103.995
Flies								
Sorghum midge	\$106.18	\$74.736					\$105.51	\$74.736
Bugs								
Rutherglen bug	\$7.22	\$5.084					\$7.18	\$5.084
Locusts								
Locusts (various)	\$1.66	\$1.168					\$1.65	\$1.168
Additional Pests								
Earwigs	\$2.59	\$1.821					\$2.57	\$1.821
Beetles (scarab / cockchafer)	\$0.11	\$0.078					\$0.11	\$0.078
Total	\$308.81	\$217.356					\$308.81	\$217.356

9.5 Value of cultural controls in sorghum

The value of cultural controls for invertebrate pest control in sorghum is estimated by multiplying the value of invertebrate pest control (Table 9.6) by the proportion of treated area receiving cultural controls.

TABLE 9.6A Percentage of treated area receiving cultural controls and value of current cultural control practices (\$ million) by GRDC Region and Australia

Invertebrate pest	Northern		Southern		Western		Australia
	% treated area	\$ million	% treated area	\$ million	% treated area	\$ million	\$ million
Beetles							
False wireworms (various)	25.83%	\$7.871					\$7.871
Caterpillars							
Budworms (corn earworm)	8.33%	\$8.663					\$8.663
Flies							
Sorghum midge	53.33%	\$39.857					\$39.857
Bugs							
Rutherglen bug	8.33%	\$0.423					\$0.423
Locusts							
Locusts (various)	0.00%	\$0.000					\$0.000
Additional Pests							
Earwig	0.00%	\$0.000					\$0.000
Beetles (scarab / cockchafer)	20.00%	\$0.016					\$0.016
Total		\$56.830					\$56.830

9.6 Cost of invertebrate pest controls in sorghum

Plant breeding has been a major contributor towards improved control of invertebrate pests in sorghum (Franzmann *et al.* 2008). Midge resistant sorghum is a global success story demonstrating the adoption of host plant resistance and survey responses have been based on additional pesticide use on top of a breeding outcome. The current resistant varieties are not 'immune' to midge, but timely plantings of midge-resistant varieties mostly escape midge sprays. Early planting lowers the risk of midge attack, but in some seasons later and staggered plantings are unavoidable. Without resistant varieties, a majority (say 55%) of sorghum crops would receive midge pesticide sprays. With 96% incidence across 55% of the area, an incidence of 52.8% would almost double the current control cost of this pest. Representative pesticide sprays used and their cost are shown in Table 9.7.

of planted sorghum seed is seed treated for the suite of establishment pests that includes false wireworms and BFE. In severe cases, growers may apply baits for BFE, but usually the seed dressing provides sufficient protection.

TABLE 9.7 Representative pesticide treatment used and cost – sorghum

Invertebrate pest	Preferred chemical control	Active ingredient	Chemical cost per ha
Beetles			
False wireworms (various)	seed dressing	imidacloprid or thiomethoxam	\$8.00
Caterpillars			
Budworms (corn earworm)	NPV	NPV	\$20.40
Flies			
Sorghum midge	SP	alpha-cypermethrin	\$1.70
Bugs			
Rutherglen bug	SP	alpha-cypermethrin	\$3.40
Locusts			
Locusts (various)	fenitrothion	fenitrothion	\$12.80
Additional Pests			
Earwigs	seed dressing	imidacloprid or thiomethoxam	\$8.00
Beetles (scarab / cockchafer)	No treatment		

NPV: nucleopolyhedrovirus, SP: Synthetic pyrethroid

Table 9.7 does not include data for beetles (scarab / cockchafer) as these pests are considered relatively minor and localised problems sometimes associated with conservation farming practices. There are no chemical control options for scarabs in grain sorghum. Scarabs were only identified as 'Additional Pests' in a single survey response.

Black field earwigs (BFE) are a major pest of maize, particularly on the heavier black cracking clay soils. BFE tend to be less of a problem with sorghum, in part because the plant population (9 to 12 plants per row metre) is much higher than maize, and losing a small number of sorghum seedlings does not impact greatly on yield. Also, sorghum sends up tillers (secondary plants) that potentially compensate for any plant losses when growing conditions are good. With maize, there are normally only three or four plants per row metre; these do not tiller, and losing one or two plants per row metre to seedling pests can have a much more profound effect on yield. Additionally, the control of BFE now relies mostly on seed dressing, and over 80%

TABLE 9.8 Invertebrate pest treatment costs – sorghum

Invertebrate pest	Northern		Southern		Western		Australia	
	Incidence %	Total cost of treatment \$ million	Incidence %	Total cost of treatment \$ million	Incidence %	Total cost of treatment \$ million	Incidence %	Total cost of treatment \$ million
Beetles								
False wireworms (various)	17.67%	\$2.107					17.56%	\$2.107
Caterpillars								
Budworms (corn earworm)	54.17%	\$8.701					53.82%	\$8.701
Flies								
Sorghum midge	28.50%	\$0.682					28.32%	\$0.682
Bugs								
Rutherglen bug	5.43%	\$0.060					5.39%	\$0.060
Locusts								
Locusts (various)	0.88%	\$0.055					0.87%	\$0.055
Additional Pests								
Earwigs	6.67%	\$0.591					6.62%	\$0.591
Beetles (scarab / cockchafer)	0.20%	NRT					0.20%	\$0.000
Total		\$12.196		\$0.000		\$0.000		\$12.196

Incidence %: Incidence years x Incidence area

Note: Australia Incidence % are a weighted average total based on percentage for each Region multiplied by the total crop area average for that region, with the total then divided by the total crop area average for all regions. Australia Total Cost of Treatment is aggregate of the three regions.

NRT: No registered treatment

9.7 Conclusions on sorghum invertebrate pests

Average total cost of treatment for invertebrate pests in sorghum nationally is \$12.2 million or \$17.23 per ha grown.

By GRDC region this equates to:

- Northern region: \$12.2 million pa or \$17.32 per hectare of sorghum grown.
- Southern region: N/A (insufficient area of sorghum grown to obtain data for survey).
- Western region: N/A (insufficient area of sorghum grown to obtain data for survey).

The Northern GRDC region is the major production area of grain sorghum in Australia. When ranked in order of potential and present losses, the three major invertebrate pests of sorghum are:

TABLE 9.9 Three most important invertebrate pests of sorghum by potential and present loss

Rank	By Potential Loss	By Present Loss
1	Budworms (corn earworm) (\$118.4 million)	Budworms (corn earworm) (\$14.4 million)
2	Sorghum midge (\$85.6 million)	Sorghum midge (\$10.9 million)
3	False wireworms (various) (\$33.1 million)	False wireworms (various) (\$2.6 million)

Reference to Table 9.4 shows that the above listed three invertebrate pests of sorghum have the potential to cause serious losses. Table 9.5 shows that even with control the above listed three pests cost the sorghum industry more than \$20 million annually.

Henzell *et al.* (1996) estimated the annual cost to production for sorghum midge in Australia was \$10 million. Similarly, Adamson *et al.* (1997) estimated budworm cost the Australian sorghum industry \$14 million annually in control costs and production loss.

10 GENERAL DISCUSSION

Various cultural controls are widely adopted in grain crops and deliver substantial benefits for invertebrate pest management. Despite the contribution of cultural controls, many of the pests regularly require intervention for their management, and this intervention is invariably pesticide-based.

When a pesticide is applied for the control of one pest, it may offer control of other pests, and thus lower the overall cost of control for each of the pests controlled. For this reason, pesticide control costs for a pest may be over-estimated. For example, PSPE sprays for mites control both RLEM and BOM, and possibly some other pests during the germination/seedling phase. Similarly, cutworm and webworm control is often achieved in the one spray operation. Because of the difficulty of accurately apportioning costs of the same treatment to different pests, full control costs were assigned separately to each pest.

Estimates of control pesticides are based on a single (representative) product selection, whereas in practice various registered options may be available and alter the value of estimated control costs. Product selection may depend on personal preference, efficacy, cost, spectrum of pest activity and compatibility.

For many pests, application costs are higher than the cost of the pesticide alone, and combining pesticides targeting invertebrate pests with herbicide or fungicide sprays is one means of lowering the real cost of pest management. For example, pesticides to control redlegged earth mite in canola are mixed with herbicides in knockdown or after-sowing pre-emergence sprays because they are cost-effective strategies to control pests before the vulnerable seedling stage (Ridsdill-Smith *et al.* 2008). In our estimates, costs have not been apportioned in line with possible combined treatments. Full application costs were assigned separately to each pest/pesticide treatment.

In all GRDC Regions, armyworms and budworms sometimes occur concurrently in maturing wheat and barley crops. SP insecticides will effectively control armyworms and budworm species that occur in Southern and Western Regions. However, the presence of pyrethroid-resistant budworms (corn earworm, *Helicoverpa armigera*) in the Northern Region (Forrester *et al.* 1993) means that much higher priced alternatives may be needed if budworms also require control.

SP products figure prominently in invertebrate pest management in several grain crops. Their selection is based on relatively low cost, high efficacy, residual activity and broad spectrum of target pest activity. These very attributes may lead to other problems which include overuse, disruption of beneficial arthropods and development of resistance to pesticides.

Our estimates of control costs for aphids in wheat, barley and oats are based on foliar sprays applied to reduce

aphid-feeding damage later in the crop's growth. Aphids also vector BYDV, where infection during early growth phases can lead to major losses in high-yielding crops. Seed dressing treatments have been shown to reduce the incidence of aphids and BYDV (Edwards *et al.* 2008), but follow-up foliar SP sprays seven weeks after crop emergence are recommended. We have not estimated the costs of seed dressing treatments where use has increased in recent years. The estimated value of pesticides for control of BYDV in Australia was \$8 million for wheat (Murray and Brennan 2009c) and \$4 million for barley (Murray and Brennan 2010). While there are no wheat varieties resistant to BYDV, there is good resistance available in barley and some tolerance available in oats (Edwards *et al.* 2008).

11 CONCLUSIONS

Invertebrate pests represent a major threat to grain production in Australia with the capacity to decrease the value of the industry by more than \$1.5 billion. Summary data for invertebrate pest losses in six major Australian grain crops are presented in Murray *et al.* (2013). Invertebrate pests are generally well controlled at present and the industry is highly reliant on pesticides to achieve this control.

Pests of economic significance are relatively uniform across the cereals (wheat, barley and oats), with redlegged earth mite, blue oat mite and lucerne flea being among the most important. Redlegged earth mite is also an important pest of canola and lupins. Potential management problems are flagged for redlegged earth mite as this pest has developed resistance to some pesticides (Ridsdill-Smith *et al.* 2008). Another canola pest, diamondback moth, has developed resistance to some broad spectrum pesticides and potential management problems are flagged (Furlong *et al.* 2008). Budworm, sorghum midge and false wireworms are important to the economic production of grain sorghum.

A number of pests are identified as having no registered treatment. For some of these pests efforts should be directed towards obtaining registration of effective products. Pesticide regulations in some States allow the use of a product registered against another pest on the crop at an existing rate and use pattern that may be effective against a non-listed pest.

However, for some pests, for example cockchafers, there are currently limited effective options for consideration as broadacre pesticide treatments. Efforts should be directed towards obtaining registration of effective products to meet these minor uses where appropriate.

Aggregated across the six major Australian grain crops, the estimated present annual loss due to invertebrate pests totalled \$359.8 million. Present cultural and pesticide controls of invertebrate pests effectively reduced losses by \$1,366.1 million.

The GRDC has an on-going project addressing minor uses of this nature.

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