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Project Code	
Project Type	

FINAL REPORT 2018

PROJECT CODE :	S1217

PROJECT TITLE
Enhancing diagnostics and extension for Khapra Beetle to secure trade

PROJECT DURATION

Project Start date	1 July 2017					
Project End date	30 June 2018					
SAGIT Funding Request	2015/16	$	2016/17	$	2017/18	

PROJECT SUPERVISOR CONTACT DETAILS

Title:	**First Name:**	**Surname:**
Ms	Nancy	Cunningham

Organisation:

South Australian Research and Development Institute (a Division of Primary Industries and Regions)

Mailing address:

Telephone:	**Facsimile:**	**Mobile:**	**Email:**

ADMINISTRATION CONTACT DETAILS

Title:	First Name:	Surname:
Mrs	Adrienne	Twisk

Organisation:

South Australian Research and Development Institute (a Division of Primary Industries and Regions)

Mailing address:

Telephone:	Facsimile:	Mobile:	Email:

PROJECT REPORT

Executive Summary

The 'Enhancing diagnostics and extension for Khapra Beetle to secure trade' project aimed to leverage existing surveillance programs in order to increase South Australia's diagnostic capability. The project aimed to provide future resources should another incursion happen again and extension material on other species of dermestid, particularly *Trogoderma* that could be mistaken for khapra beetle.

During the sampling process

- A wide variety of dermestids were found amongst samples from grain growing/grain related locations in South Australia.
- From this, many species of native Trogoderma were found and no further evidence of the exotic khapra beetle discovered.
- The Waite Insect and Nematode Collection has widened its voucher specimens of dermestids.
- SARDI entomologists have increased reference material for diagnostics.
- The collection was used in a recent biosecurity enquiry on dermestid pests of grain.

Extension was carried out through SARDI and Biosecurity and included workshops for farmers and biosecurity staff, information brochures, seminars and a dermestid technical fact sheet.

Project Objectives

Biosecurity SA is currently running a mandatory surveillance program to ensure the absence of Khapra Beetle in the emergency response incursion areas. This project will leverage the current surveillance programs to provide outcomes for SA grain producers through:

- Improving accuracy of diagnostics to ensure the grain industry can provide faster resolution to trade issues if they arise.

- Understanding of closely related dermestids found in grain growing regions (that could easily be misdiagnosed as Khapra Beetle).
- Provision of a database of stored product pests collected that will be accessible to the grains industry and can be used as part of proof of absence requirements for important trading partners.
- Providing further analysis and better understanding of general stored product pests (including information on new species and closely related native species) and collect voucher specimens of non-pests from by-catch data provided through the current surveillance programs.

In addition the project will:

- Provide awareness training and extension for grains industry producers/specialists/other associated industry stakeholders.
- Assess the appropriateness of traps and current surveillance methods.

Overall Performance

Over 173 (330 individual insect specimens) were curated into the Waite Insect and Nematode Collection. A Fact sheet on the different dermestids found during sample analysis was produced and will be delivered to South Australian grain growers and advisers in spring. A database of all information from over 1200 samples was created with information on by-catch as well as dermestids. In addition to this, the collection has already contributed to further investigation into possible invasive dermestid species.

Information of Staff who contributed to the project:
Ms Nancy Cunningham, Senior Research Officer, WAITE
Ms Judy Bellati, Grains Biosecurity Officer, Biosecurity SA, GLENSIDE
Mr Ian Campbell Senior Plant Biosecurity Officer, Biosecurity SA, GLENSIDE
Dr Richard Glatz, Entomologist, D'Estrees Entomology

In addition to this awareness and training was carried out throughout the program:

- awareness training (Stored grain awareness workshops);
- face-to- face 'hands on' awareness training;
- program exposure and general awareness (producers, other industry personal);
- specific dermestid identification training;
- several presentations.

Key Performance Indicators (KPI)

KPI	*Achieved (Y/N)*	*If not achieved, please state reason.*
Collection and curation of invertebrates relevant to the grains industry through samples collected through the Khapra beetle surveillance programs	Y	
Diagnostics of samples/specimens	Y	

By-catch data analysis	Y	
Extension of project outcomes through workshops/field days and other relevant grains focused activities/events	Y	

Technical Information

Results

Sample numbers

From the general non-targeted surveillance, 1056 samples were collected between 2016 and 2018. From the Kangaroo Island surveillance, 180 pre-sorted samples were provided to SARDI from D'Estrees Entomology.

The number of samples containing insects were: general non-targeted surveillance- 591, Kangaroo Island surveillance – 180.

Total number individual dermestids specimens (adult and larvae) curated into Waite Insect and Nematode Collection in the last 12 months – 330.

The vast majority of insects collected were from dome traps, followed by sieve sampling. Only a small percentage of insects were caught using other methods (wall traps, vacuum, sweeping and visual sampling).

Dermestids

From the dermestids found in the general targeted surveillance and from Kangaroo Island – 173 samples were curated into the Waite Insect and Nematode Collection (330 individual insect specimens). These were further sorted into genus before curation. Break down of genus and details can be seen in appended report.

The majority of the native *Trogoderma* found were adults, with only a few larvae amongst samples. The larvae of native species are morphological easy to discern from other dermestid species, with basket shaped hairs – 'fiscisitae' compared with other genera which have hair-like setae and barbed 'hastisetae'. In some instances, specimens of adult and larval *Trogoderma* were identified to species (the exotic *Trogoderma variable*).

By-catch data

More than half of the general non-targeted samples had insects/arthropods. The majority of these were not dermestids but a substantial amount were insects often associated with stored grain. From this, the most abundant was a variety of non-stored pest insects from the order Coleoptera. Amongst other grain pests, the most common genus found was *Tribolium* spp.

(see detailed report appended to document)

Conclusions Reached &/or Discoveries Made

The inclusion of a range of new specimens into the Waite Insect and Nematode Collection (176 new voucher specimens of dermestids) has led to a valuable diagnostic tool now available to researchers and industry. In addition to this, a number of non-dermestid genera were also identified.

All dermestid beetles curated into the WINC were classified to genus. The majority of dermestids were adults, given that most samples were collected during the summer and the pheromone lures used in some trapping methods were meant to attract adult stages, this was expected. The most common genus found was *Anthrenocerus*, followed by *Orphinus* and *Trogoderma* (non khapra beetle). Further examination of the *Trogoderma* genus ruled out the presence of *Trogoderma granarium* (no khapra beetle was found during this sub-sampling process). No adult or larval *Trogoderma* were found in sieve samples, only in dome and wall traps despite sieving being the second most common method for insect sampling. Within the *Trogoderma* genus, the exotic species *Trogoderma variable* was found but the majority of species were native *Trogoderma*. In some instances, exuviae (larval castings of mostly the *Anthrenocerus* genus) were found and placed into WINC.

Overall, the surveys collected a range of insects, including dermestid beetles. The most common insects found other than dermestid were other Coleoptera adult beetles – and from this the majority of grain-related beetles were flour beetles (*Tribolium* spp.) saw-tooth grain beetles (*Oryzaephilus* sp.), and weevils (*Sitophilus* spp.).

A data base of samples (including all samples curated into WINC, has been collated. The dermestid samples have also been added as reference to the Atlas of Living Australia database.

Exposure and extension activities included a variety of delivery mechanisms (refer to report added which has a comprehensive list of extension activities).

There was face-to-face extension to industry stakeholders, media coverage, and higher diagnostic training and extension. Exposure of the program was also gained at two international conferences to professional research and extension audiences. Oral presentations conducted through the South Australian Grains Biosecurity Officer, Judy Bellati, highlighted the significance of the program's support to the SA general surveillance program, recognising the unique opportunity it provided for extension of the SAGIT enhancing diagnostics for khapra beetle project.

In addition, informal discussions with stored product and entomological specialists and the wider industry at events also occurred throughout the project.

In addition to these extension activities, a fact sheet identifying these dermestids will come out shortly (see attached report and draft fact sheet) and will be readily available to producers and relevant industry personnel once printed.

Intellectual Property

n/a

Application / Communication of Results

The 'Enhancing diagnostics and extension for Khapra Beetle to secure trade' project further examined over one thousand samples taken from South Australian grain related sites over 2016-2018. From this:

- almost one hundred and eighty dermestid samples (330 individual specimens) were curated into the Waite Insect and Nematode Collection (WINC) a working insect collection used specifically for insect diagnostics;
- a collection of *trogoderma* (non-khapra beetle) were curated into the collection as reference material;
- a database of stored product pests (part of a general surveillance program in South Australia) is now established and accessible through the Grains Biosecurity Program run through Biosecurity SA;
- SARDI diagnosticians gained knowledge of morphological characteristics of various native *Trogoderma* species;
- the composition of stored grain pests from by-catch data indicated dominant genera;
- voucher dermestid specimens added to WINC have already been used to assist with biosecurity measures.

Through the extension side of the program several activities have occurred during the life of the program:

- stored grain awareness workshops (Biosecurity SA);
- field days and insect ID day (SARDI);
- program exposure through general market access workshops (Biosecurity SA);
- specific Dermestidae ID training/Khapra beetle from SARDI diagnosticians for DAWR and Grains Biosecurity officers (SARDI);
- media articles on the WINC (SARDI/Biosecurity SA);
- a fact sheet about identifying common dermestids was created through the program and will be available shortly (SARDI).

A full list of extension activities can be seen in the appended report – including a draft copy of the Dermestid fact sheet.

POSSIBLE FUTURE WORK

The general surveillance sampling created a database which collected information in a number of areas:

- location
- trap type
- host material (commodity)
- host habitat (eg silo or building)
- genera of stored grain pest

Further analysis of this data could help improve sampling methodology and assist in improving risk profiles and target groups for surveillance.

Reference material could be further extended from both surveillance programs and shared widely with other biosecurity groups. Voucher specimens of *Trogoderma variable* have been provided to Queensland researchers.

AUTHORISATION	
Name:	Dr Tim Sutton
Position:	Acting Research Chief, Sustainable Systems
Signature:	
Date:	28 August 2018

Enhancing diagnostics and extension for Khapra Beetle to secure trade

July 2018

N.M. Cunningham[1], J. Bellati[2], I. Campbell[2].

[1]SARDI Entomology, Waite Campus, Urrbrae, SA

[2]Biosecurity SA, Glenside, SA

Introduction

Khapra beetle (KB) (*Trogoderma granarium*) is a devastating exotic pest of grains and seed products around the world (Lindgren et al, 1955). In the top one hundred most invasive species, KB is one of fourteen insect species to make the list (Global Invasive Species Database, 2013). In March 2016, an incursion of khapra beetle occurred in South Australia. In response, Biosecurity SA (PIRSA) began an emergency response eradication program on affected properties under the Emergency Plant Pest Response Deed (EPPRD) and other potential risk sites identified during a trace forward and trace back program. The deployment of pheromone specific traps and other sampling methods generated a large number of samples for proof of eradication and area freedom purposes.

In addition to this emergency response, a general non-targeted surveillance program began to investigate properties in South Australia. The aim of the general targeted program was to survey a range of stakeholders in the grains sector and other potential risk target groups at various locations throughout grain growing areas in South Australia to support proof of absence of khapra beetle (KB).

This wealth of samples from grain-associated (and other) properties had the potential to improve understanding of stored product insects, particularly those that closely resemble *Trogoderma granarium.*

Biosecurity SA has undertaken the servicing and collection of traps throughout SA (mainly on Kangaroo Island and Adelaide metropolitan high-risk areas) under the emergency response program and a joint effort between the national Grains Farm Biosecurity Program and Biosecurity SA for the general targeted surveillance program. The Entomology Unit of the South Australian Research and Development Institute provided diagnostic capability that included sorting and visual identification of samples from programs. This recent KB pest incursion and subsequent response and surveillance programs provided a unique one-off opportunity to assist the grains industry to better understand and manage current and possible future incursions by this significant exotic pest. The project sought to provide fundamental capacity building for the South Australian grains sector beyond what the current biosecurity programs can provide. The main objectives of the enhancing post-farm gate diagnostics and extension for khapra beetle program were:

- improving accuracy of diagnostics to ensure the grain industry can provide faster resolution to trade issues if they arise;
- understanding of closely related dermestids found in grain growing regions (that could easily be misdiagnosed as khapra beetle);

- provision of a database of stored product pests collected that will be accessible to the grains industry and can be used as part of proof of absence requirements for important trading partners;
- providing further analysis and better understanding of general stored product pests (including information on new species and closely related native species) and collect voucher specimens of non-pests from by-catch data provided through the current surveillance programs.

In addition, the project covered several extension activities:

- provide awareness training and extension for grains industry producers/specialists/other associated industry stakeholders;
- assess the appropriateness of traps and current surveillance methods.

Methods

Sampling and sites

The program sourced dermestid beetles from a number of sites throughout South Australia. The aim of sampling was to assess sites for:

1. Presence/absence insects
2. Presence/absence dermestids

Over the period 2016-2018, samples came from ninety six sites throughout South Australia (general non-targeted program), and in addition to this, samples came from forty one sites on Kangaroo Island. Unlike samples from the general non-targeted program, all Kangaroo Island samples were pre-sorted so that every sample provided had insects. Sites for the general non-targeted program are listed in Appendix 1.

Samples came predominantly from dome traps, which can be rapidly assessed (see Figure 1) and sieving. Other traps/collection methods used included wall traps using wheat germ as bait, sweepings and vacuum samples from grain.

Diagnostics

Diagnostic protocols developed through the khapra beetle emergency response program were utilised to examine samples from non-quarantine locations.

Protocols for diagnostics involved assessment of the sticky section of the dome trap (containing a specific lure for dermestids) with initial identification of insects using a stereo microscope. All the insects found in traps were placed in alcohol, and then sub-sampled for dermestids. The two most common traps used were dome and wall traps which can be seen in Figures 1 and 2. Sieved samples were also used for general grain insect collection.

Samples of dermestids were identified using morphological features and official taxonomic keys (ISPM 27). Genera of adult specimens identified were:

- Trogoderma
- Anthrenocerus
- Anthrenus
- Orphinus
- Attagenus
- Dermestes

Larval identification was similar – however at the time of the project, no key for orphinus genus larvae was available and as the lure used is for adults, the majority of specimens collected were adult dermestids.

Curation

All dermestids collected from samples were curated into the Waite Insect and Nematode Collection (WINC) and either pinned (glued using a carding method) or for larval specimens, stored in vials of alcohol (80%)

Collation

Information on by-catch was also collected and collated from samples from all locations surveyed. Specimens found and recorded in samples were:

- *Oryzaephilus* (saw-toothed grain beetle)
- *Sitophilus* (Weevils)
- *Ptinus* (Spider beetle)
- *Triboliuim* (Flour beetle)
- *Cryptolestes* (Flat grain beetle)
- *Rhyzopertha* (Lesser grain borer)
- *Ahasverus* (Foreign grain beetle)
- *Stegobium* (Drugstore beetle)
- *Lasioderma* (Cigarette beetle)
- *Carpophilus* (Dried fruit beetle)

In addition to these genera, other arthropods/insects were also recorded including:

- Coleoptera (non-stored grain pests)
- Psocoptera (Psocids)
- Dermaptera (Earwigs)
- Hymenoptera (Ants and wasps)
- Diptera (Flies)
- Collembola (Springtails)
- Lepidoptera (Moths)
- Blatteodea (Cockroaches)
- Hemiptera (Bugs)
- Diplopoda (Milipedes)
- Pseudoscorpiones (False scorpions)
- Isopods (Slaters)

Figure 1: Dome trap with lure.

Figure 2: Wall trap with lure.

Results

Sample numbers

From the general non-targeted surveillance, 1056 samples were collected between 2016 and 2018. From the Kangaroo Island surveillance, 180 pre-sorted samples were provided to SARDI from D'Estrees Entomology.

The number of samples containing insects and dermestids can be seen in Table 1 and 2.

Total number individual dermestid specimens (adult and larvae) curated into Waite Insect and Nematode collection in the last 12 months – 330.

The vast majority of insects collected were from dome traps, followed by sieve sampling. Only a small percentage of insects were caught using other methods (Table 3).

Table 1: Samples collected with insects present.

Program	Number of samples with insects
General Non-targeted surveillance	591 (n=1056)
Kangaroo Island surveillance	180 (n=180)

*Samples submitted were pre-sorted (contained insects)

Table 2: Samples collected with dermestids present.

Program	Number of samples with dermestids
General Non-targeted surveillance	139† (n= 591, samples with insects; n = 1056)
Kangaroo Island surveillance	6

†173 samples curated – several samples had more than one genus and were curated separately

Table 3: Number of samples processed using different methods for general non-targeted surveillance.

Type	Processed total	Number of samples with insects	Number of dermestids curated	Percentage of total traps with insects
Dome	560	418	130	
Wall	27	10	4	
Sieve	378	140	29	
Vacuum	87	20	10	
Sweepings	3	2	-	
Visual	1	1	-	
Grand Total	1056	591	173	55.9 (591/1056)

Dermestids

From the dermestids found in the general targeted and Kangaroo Island – 173 samples were curated into the Waite Insect and Nematode collection (330 individual insects specimens). The largest number (and percentage of total samples) of dermestids were found in dome traps.

The majority of the native *Trogoderma* found were adults, with only a few larvae found. The larvae of native species are morphologically easy to discern from other dermestid species, with basket shaped hairs - 'fiscisitae' (Figure 3) compared with other genera which have hair-like setae and barbed 'hastisetae' (Figure 4). In some instances, specimens of adult and larvae *Trogoderma* were identified to species (*Trogoderma variable*).

A snap shot of the adult species found amongst samples compared with *Trogoderma granarium* (Figure 5) are in Figures 6 to 16.

Figure 3: Native Trogoderma larvae showing fiscisitae.

Figure 4: Other common dermestid species larvae showing the barbed hastisetae.

Figure 5: *Trogoderma granarium*

Figure 6: *Trogoderma variable*

Figure 7: Native *Trogoderma spp*

Figure 8: Native *Trogoderma* spp

Figure 9: Native *Trogoderma* spp

Figure 10: Native *Trogoderma* spp

Figure 11: *Anthrenus verbasci*

Figure 12: *Anthrenocerus spp*

Figure 13: *Attagenus* spp

Figure 14: *Anthrenocerus* spp

Figure 15: *Attagenus spp*

Figure 16: *Orphinus* spp

The breakdown of genera for dermestids found in the survey is shown in Table 4 below.

Table 4: Number of dermestids seen in general non-targeted sampling.

Program	**General Non-targeted**		**Kangaroo Island**	
	Adult	Larvae	Adult	Larvae
Anthrenus	10	15		
Anthrenocerus	47	14		1
Attagenus	4	0		
Orphinus	35	0		
Trogoderma	32	6	4	1
Unidentified	2	1		
Dermestes	1	0		

By-catch

More than half the general non-targeted samples had insects/arthropods. The majority of these were not dermestids but a substantial amount were insects often associated with stored grain. From this, the most abundant was a variety of non-stored pest insects from the order Coleoptera. Amongst other grain pests, the most common genus found was *Tribolium* spp.

Table 5: Insect/arthropods

Insect/Arthropod	**Number of samples**	
	General Non-targeted	Kangaroo Island
Oryzaephilus	91	13
Sitophilus	82	21
Ptinus	45	52
Triboliuim	126	7
Cryptolestes	67	2
Rhyzopertha	71	1
Ahasverus	25	6
Stegobium	5	0
Lasioderma	37	0
Coleoptera gen	177	62
Psocoptera	76	25

Dermaptera	63	37
Hymenoptera	54	20
Diptera	28	55
Collembola	19	25
Lepidoptera	35	19
Other	103	7

Extension

Program exposure and extension activities

Exposure and extension activities included a variety of delivery mechanisms (refer to individual activities in Table 6.)

There were face-to-face extension to industry stakeholders, media coverage, and higher diagnostic training and extension. Exposure of the program was also gained at two international conferences to professional research and extension audiences. Oral presentations conducted through the South Australian Grains Biosecurity Officer, Judy Bellati, highlighted the significance of the programs support to the SA general surveillance program, recognising the unique opportunity it provided for extension of the SAGIT enhancing diagnostics for khapra beetle project.

In addition, informal discussions with stored product and entomological specialists and the wider industry at events also occurred throughout the project.

In addition to these extension activities, a fact sheet identifying these dermestids will come out shortly and be available to grain growers once printed. (See draft in Appendix 2).

Table 6: Extension activities relating to enhancing diagnostics and extension for khapra beetle;

Activity (date)	Delivery type and target audience(s)	Comments
2 x Stored Grain awareness Workshops **(Brinkworth, Straun, 22nd – 24th Aug)**	Face-to- face on-farm awareness training Producers plus other stakeholders e.g. consultants, agri-resellers (Straun only)	• Awareness training related to grain storage. Topics included; phosphine usage, stored grain insects and HPPs (e.g. khapra beetle) and hygiene practices. • 1st time workshops included 'live specimens' of *Trogoderma variable* for participants to look at. • Workshops supported by NSGEP, SA GFBP, GPSA and Koolunga CRT (supplied bbq) 

Activity (date)	Delivery type and target audience(s)	Comments
HART – Insect ID day **(Hart, 24th Aug 2017)**	Face-to- face 'hands on' awareness training Producers	• SARDI Entomologists H. Brodie and N. Cunningham facilitated the day (with a local agronomist). • Workshop format was a modified NIPI insect ID workshop with a grain storage component specifically dedicated to khapra beetle. • NIPI 'I Spy' support resource manual for the training workshops and the GFBP monitoring storage booklet was used. • Feedback: Very engaging group who were switched onto learning the entire day. Having live specimens (e.g. *T. variable* and RWA) was very good. • HART group organized and funded the event.
HART Field Day **(Hart, 19th Sept)**	General Awareness Producers and other grains industry stakeholders	• SA GBO shared display stand with GPSA (peak state grower group) at this grain focused event 
GPSA / SAGMAG – Market Access and Snail Workshop **(YP - Kadina 22nd Sept 2017)**  	Program exposure and general awareness (producers, other industry personal)  	• Awareness event around market access. Topics covered included: Chinese government barley importing requirements, feedback from customers and importing Governments, R&D update on Russian wheat aphid, snails and emerging barley issues: Glyphosate use on barley, khapra beetle survey update. • Good for participants in the SA surveillance program to hear about the complete program and their contribution (as a data point). Two participants came up after and stated that they really enjoyed seeing/hearing the bigger picture. • SAGIT and GPSA also tweeted the event 

Activity (date)	Delivery type and target audience(s)	Comments
Dermestidae identification training / Khapra beetle survey training **(27-29th Nov)**	In-house 	• Valuable training and Information / knowledge exchange related to all Dermestidae diagnostics and surveillance. • SA GBO, NSW GBO, SARDI entomologists on the khapra projects, plus Dr R. Glatz (Independent specialist) and N. Luke (DAWR) present.
Science Protecting Plant Health Conference **(Brisbane, 25th – 28th Sept)**	Oral Presentation	• "Enhancing surveillance for exotic pests of stored grain using a partnership approach with industry and government." • Food Security and Challenges to Stored Product Protection Section 
GRDC Ground Cover Jan-Feb 2018 Edition	Media article	• Surveillance turns to khapra look-alikes • Focus of Article: SA surveillance program and SAGIT grant for further curation and lodgement of Dermestidae into WINC 
General extension programs	Knowledge and understanding	• National Grains Farm Biosecurity Program http://www.planthealthaustralia.com.au/national-programs/grains-farm-biosecurity-program/ • National Grains Storage Extension Project http://storedgrain.com.au/about-us/
Berlin, Oct 2018	Extended and abstract submission and oral presentation	• Title: Enhancing surveillance for exotic stored pests in the Australian grains industry using a partnership approach with industry and government.

Abbreviations: GBO: Grains Biosecurity Officer, DAWR: GFBP: Grains Farm Biosecurity Program, NGSEP: National Grain Storage Extension Program, GPSA: Grain Producers SA, SAGMAG: South Australian Grain Market Access Group

Discussion

The incursion of khapra beetle into South Australia affected a number of properties both on Kangaroo Island and in metropolitan Adelaide. The response to the incursion was unprecedented, with a large number of properties potentially affected. The main aim of the emergency response program, initiated by Biosecurity SA, was to survey high-risk areas in order to establish freedom from khapra beetle after the eradication program. In addition to this program, Biosecurity SA, through the grains farm biosecurity program, ran a wide spread general non-targeted program, collecting samples from grain related premises throughout the state.

In response to the large number of samples collected, an opportunity arose to give researchers and industry improved understanding of grain-associated insects that may affect market access. The project, 'Enhancing diagnostics and extension for khapra beetle to secure trade', allowed further examination of samples beyond the resources of the larger programs and allowed extension of information gained through the sampling process to be released to grain growers in South Australia.

The general targeted surveillance program and the khapra beetle emergency response surveillance program did not record any khapra beetle amongst samples. Both these programs ran over a two-year period, from May 2016 to May 2018. The samples contained a range of insect species, including other stored product pest beetles from the same family (Dermestidae) as khapra beetle. The enhanced diagnostics program ran from 1st July – 30th June 2018 and during that time, processed and sampled specimens from both larger programs, curated dermestids into the Waite Insect and Nematode Collection, created a database of insects found in trap samples and provided extension materials and resources for biosecurity officers working in grains.

The majority of samples collected were from the general non-targeted surveillance program; however, a number of samples that came from Kangaroo Island were associated with the emergency response program. Samples were collected and processed from ninety-six locations (non-quarantine restricted) throughout South Australia and used a variety of methods: wall and dome traps, sieves and vacuumed samples as well as sweepings and visual analysis. The sites varied in type and included grain areas on-farm, storage facilities (silos on and off farm) as well as metropolitan commercial wholesaler properties. Common host materials included stockfeed, hay, general stored grain produce and in general sweepings – within spider webs.

The inclusion of a range of new specimens into the Waite Insect and Nematode Collection (176 new voucher specimens of dermestids) has led to a valuable diagnostic tool now available to researchers and industry. In addition to this, a number of non-dermestid genera were also identified.

All dermestid beetles curated into the WINC were classified to genus. The majority of dermestids were adults and, given that most samples were collected during the summer and that the pheromone lures used in some trapping methods were meant to attract adult stages, this was expected. The most common genus found was *Anthrenocerus*, followed by *Orphinus* and *Trogoderma* (non khapra beetle). Further examination of *Trogoderma* genera ruled out the presence of *Trogoderma granarium* (no khapra beetle was found during this sub-sampling process). No adult or larval *Trogoderma* were found in sieve samples, only in dome and wall traps despite sieving being the second most common method for insect sampling. Amongst the *Trogoderma* genera, the exotic species *Trogoderma variable* was found but the majority were native *Trogoderma*. In some instances, exuviae (larval castings of mostly *Anthrenocerus* genera) were found and placed into WINC.

Overall, the surveys collected a range of insects, including dermestid beetles. The most common insects found other than dermestid were other Coleoptera adult beetles – and from this the majority of grain-related beetles were flour beetles (*Tribolium* spp.) saw-tooth grain beetles (*Oryzaephilus* sp.), and weevils (*Sitophilus* spp.).

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Appendix 1

Name	Town/suburb	Region
Coomandook Area School	Coomandook	Mallee
Hansen Farm	Coomandook	Mallee
Inglebrae Proprieters	Rockleigh	Adelaide Hills
Balco Australia	Bowmans	Northern Adelaide Plains
AGT Foods & Ingredients	Bowmans	Northern Adelaide Plains
Peter Cousins	Crystal Brook	Southern Flinders
AG & P Greg	Crystal Brook	Southern Flinders
Kerin Agencies	Crystal Brook	Southern Flinders
Brenton Harris	Cleve	Central Eyre Peninsula
Modra Seeds	Ungarra	Eyre Peninsula
Cummins Milling Company	Cummins	Eyre Peninsula
Mark Modra	Hawson	Eyre Peninsula
Jeff Big	Wudinna	Central Eyre Peninsula
GH Phillips & Sons	Karcultaby	Eyre Peninsula
GH Phillips & Sons	Karcultaby	Eyre Peninsula
Minnipa Research Centre (SARDI)	Minnipa	Eyre Peninsula
Dean Willmont	Koongawa	Eyre Peninsula
Waringa Plains	Willowie	Southern Flinders Ranges
Northern Ag	Booleroo Centre	Southern Flinders Ranges
Woodleigh	Booleroo Centre	Southern Flinders Ranges
BJ Woolford Trust	Murray Town	Mid North
Australian Growers Direct	Balaklava	Mid North
Shane Weckert	Brinkworth	Mid North
Victoria Park	Crystal Brook	Southern Flinders
Ned Kelly	Narridy	Mid North
Phillip Wilsdon	Gulnare	Mid North
Hornsdale Proprieters	Hornsdale	Mid North
Michael Noonan	Hornsdale	Mid North

Clarke Brothers	Mannanarie	Mid North
Jims Place	Mannanarie	Mid North
LK Moore	Caltowie	Mid North
Kerin Landmark Rural	Jamestown	Mid North
Stott Ag Services	Haines	Kangaroo Island
Mills Farming	Seddon	Kangaroo Island
DL Halloran	Newland	Kangaroo Island
Caleb Pratt	Stokes Bay	Kangaroo Island
Lloyd & Christine Berry	Macgillivray	Kangaroo Island
Bellevista	Menzies	Kangaroo Island
Richard & Jenny Stanton	Stokes Bay	Kangaroo Island
GC & JSL Lutze & Sons P/L	Coonalpyn	Mallee
James Jaeschke	Culburra	Mallee
Cox Rural	Tintinara	Mallee
Cox Rural	Coonalpyn	Mallee
Chris Heath	Lameroo	Mallee
Hayward Proprieters	Lameroo	Mallee
Craig Needs	Lameroo	Mallee
Clampata	Lameroo	Mallee
Pocock	Lameroo	Mallee
Lou Flohr	Lameroo	Mallee
Shane Adams	Sunnyvale	Yorke Peninsula
Bill Moloney	Aurthurton	Yorke Peninsula
J & D Southwood	Maitland	Yorke Peninsula
Tingara	Wauraltee	Yorke Peninsula
Mathew Pointon	Curramulka	Yorke Peninsula
Ilara Park	Curramulka	Yorke Peninsula
Richard Way	Ramsey	Yorke Peninsula
Temana	Yorktown	Yorke Peninsula
Martin Collins	Yorktown	Yorke Peninsula

Julie Page	Warooka	Yorke Peninsula
Bronte Blythe	Brentwood	Yorke Peninsula
Pontifex Farming	Paskeville	Yorke Peninsula
AG Schilling & Co	Cunliffe	Yorke Peninsula
Nigel Baum	Auburn	Mid North
AW Vater & Co	Saddleworth	Mid North
Mona Vale Farms	Tarlee	Mid North
Four Leaf Milling	Tarlee	Mid North
WCT Rural	Wudinna	Eyre Peninsula
Platinum Ag Services	Kimba	Eyre Peninsula
GA & CR Johnson	Netherton	Mallee
Kongolia Farms	Punthari	Murray Lands
Kim Blenkiron	Springton	Adelaide Hills
Persian Supermarket	Thebarton	Adelaide Metropolitan
Asian Food Wholesaler	Woodville 5011	Adelaide Metropolitan
African Supermarket	Salisbury	Adelaide Metropolitan
Usha Importer Pty Ltd	Salisbury	Adelaide Metropolitan
Seed Genetics	Wingfield	Adelaide Metropolitan
Thuan Phat Supermarket	Croydon Park	Adelaide Metropolitan
Khukasan Supermarket	Kilburn	Adelaide Metropolitan
Afghan Supermarket	Kilburn	Adelaide Metropolitan
FP AG (Victor Harbour)	Victor Harbour	Adelaide Metropolitan
FP AG (Yankalilla)	Yankalilla	Adelaide Metropolitan
Yankalilla Seeds	Wattle Flat	Adelaide Metropolitan
FP AG (Mt Compass)	Mount Compass	Adelaide Metropolitan
Top Range Feeds	Willunga	Adelaide Metropolitan
Walkers Stockfeeds, Saddlery and pet supplies	McLaren Vale	Adelaide Metropolitan
AVO Fine Food Distributors	Holden Hill	Adelaide Metropolitan

Appendix 2

FACTSHEET

DERMESTIDS IN SOUTHERN AUSTRALIA

SOUTH AUSTRALIAN RESEARCH & DEVELOPMENT INSTITUTE
PIRSA

Thursday, 28 June 2018

Nancy Cunningham SARDI Entomology Unit—8429 0933

Why identify dermestids?

Dermestid beetles, commonly known as carpet or skin beetles, belong to the family Dermestidae and are common insect scavengers that feed on dry animal or plant material. The *Trogoderma* genus of Dermestidae are known pests of stored grain and *Trogoderma granarium*— the khapra beetle— not present in Australia— is listed in the top 100 Global Invasive Species Database (2004). An incursion of this exotic species into Australia could mean severe economic losses and market access issues for producers. It is important that we are able to clearly identify the differences between the various commonly found dermestids, including our native *Trogoderma* species and the exotic khapra beetle.

This fact sheet aims to show the major differences between Dermestidae genera found in South Australia and to discuss the differences between common dermestids and some of our native *Trogoderma* species as well as pest/exotic species that are not found in Australia.

3mm

Figure 1: Dermestidae Adult

7mm

Figure 2: Dermestidae Larvae

Key features of Dermestidae

Vary in size between 1-12mm

Adults (Figure 1)
- Oval shaped bodies
- Covered in scales or setae (Genus dependent)
- Clubbed antennae often situated within a 'groove' on the underside of the head cavity

Larvae (Figure 2)
- Numerous setae and 'hairy' or 'fluffy' appearance
- Obvious head capsule with chewing mouthparts
- Well developed legs
- Often found on dried commodities/foodstuff

Research supported through:

South Australian Grains Industry Trust
South Australian Research and Development Institute
PIRSA http://www.pir.sa.gov.au/

Acknowledgements:

Peter Taverner, Judy Bellati and Rebecca Hamdorf

SAGIT

SOUTH AUSTRALIA

Government of South Australia
Primary Industries and Regions SA

SARDI
RESEARCH AND DEVELOPMENT INSTITUTE

DRAFT

Genus *Anthrenocerus*

Adult features

Covered with hair (setae)

Antennal cavity closed behind

Antennae has a distinct club like formation and well defined

Distinct 3 segment club of adult *Anthrenocerus*

Genus *Anthrenus*

Adult features

Covered with scale like hair (setae)

Antennal cavity filled by antennae

Antennae visible from anterior viewpoint

Filled antennal cavity of Adult *Anthrenus*

Genus *Attager*

Adult features

Covered with hair (setae)

Antennal cavity open behind

First segment of hind tarsus shorter than first segment

Adult *Attagenus* tarsus First segment shorter to second segment

Genus *Orphin*

Adult features

Covered with hair (setae)

Antennal cavity filled by antennae

Antennal club circular and two segmented

Orphinus Antennal cavity and two segmented club

Genus *Trogoderma*

Adult features

Covered with hair (setae)

First segment of hind tarsus equal or as long as second segment

Antennal 'club' - segments taper

There are over 120 species of *Trogoderma* throughout the world. Research has reported there are up to 52 species of native *Trogoderma* in Australia and at least one exotic species (*Trogoderma variable*).

Trogoderma adults have similar morphologically features and require specialist training to distinguish from other dermestid genera. There are diagnostic keys available in order to identify several of the known exotic *Trogoderma* species and to separate them from native species. These keys are used by diagnosticians to differentiate from other exotic *Trogoderma*.

***Trogoderma granarium* (Everts) - note variation in size and colour of adult beetles**

Native species

There are many species of native *Trogoderma*. The adults have similar distinguishing features as exotic *Trogoderma*, with some variations. For example, many native species have thicker coarse hairs (setae) than those of exotic species. Differences in native larvae vs exotic larvae can be seen in Figure 3 and 4 on the next page.

Exotic species

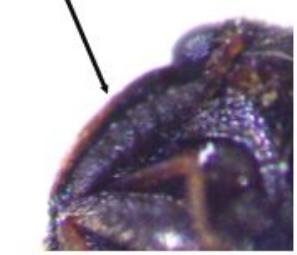
Currently listed as absent from Australia—*Trogoderma granarium, Trogoderma glabrum, Trogoderma inclusum, Trogoderma simplex*.

Listed as present: *Trogoderma variable*.

Trogoderma Variable

Adult *Trogoderma* tarsus
First segment never shorter than second segment

Adult *Trogoderma* antenna and cavity - notice tapered antenna



Native *Trogoderma*

Dermestidae Larvae

Dermestidae larvae are common in stored grain produce and are covered in various lengths of hair (setae) making them appear 'fluffy' to the naked eye. They have a hardened (sclerotized) head capsule and three sets of legs as well as pair of appendages at the end of the abdomen. They are

The larvae of some native *Trogoderma* species are morphological easy to discern from other dermestid species, with basket shaped hairs - (fiscisitae, Figure 3) compared with other genus which have hair-like setae with barbs at the end (hastisetae, Figure 4).

Larval specimens can be identified as *Trogoderma* but in order to differentiate species— a dissection is required.

If enough material is left intact, larval castings (exuviae) left after moulting can be used to identify the genus.

However, identification of dermestid larvae needs to be conducted by skilled diagnosticians.

Figure 3: Native *Trogoderma* larvae showing basket shaped hairs

Figure 4: Other common dermestid species larvae showing the barbed hairs

Diagnostic keys

There are a number of diagnostic keys that can be used to identify dermestid species and are listed in the references below.

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