COGGO Council of Grain Grower Organisations Limited ACN 091 122 039	**Final Report** **COGGO Research Fund for 2020 projects** **A project completion report covering the project. The acceptance of a satisfactory report against the objectives of the project, and agreement on the sharing of any commercial returns and/or IP will trigger payment within 4 weeks, by COGGO for any outstanding payments.**

This Final Report should be completed with reference to the Research and Intellectual Property Agreement (the Research Agreement) signed between the proponent and COGGO Pty Ltd.

1. Project information

Project title	Impact of stubble management on small conical snail mortality
Commencement Date	15th March 2020
Completion Date	31st January 2022

Name of Proponent	Stirlings to Coast Farmers Inc.
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COGGO Use Only

Project Number	
Date Received	

## 2. Project results	This section provides a final report against the Project Aim and the Planned Outputs for the Project.

Achievement of the Project Aim	Brief statement of achievement in relation to the aim of the project

Objectives:

- Provide growers with a clear percentage of the effect of three stubble management techniques (cabling, stubble crunching and speed tillage) on small conical snail mortality.
- Introduce more 'tools' into growers' repertoire to control snails and reduce the current reliance on snail baiting.
- Demonstrate 'GrainCam' 's effectiveness in identifying snail hot spots in paddocks and map their distribution for targeted management.

1. The project results provided a percentage control of snail mortality from each stubble treatment. However, the stubble treatments failed to consistently reduce snail numbers in the wheat crop compared to the Nil control. Snail mortality was measured with three separate metrics after the stubble treatments were applied, and none of the treatments effectively controlled small conical snails compared to the Nil control.
2. Based on the nil results for the stubble treatments, we could not introduce more 'tools' for growers to effectively control small conical snails in the southern region of WA. Nevertheless, the research needed to be completed to show the treatments didn't work in south WA on small conical snails.
3. The effectiveness of GrainCam was demonstrated by John Moore and the DPIRD researchers, which built on existing research data. GrainCam was able to effectively identify small conical snails in the wheat sample in 2020. However, John noted that the accuracy was not as high as previous research, which was thought to be due to the smaller than average size of the snails. The artificial intelligence database needs more images of the smaller sized conical snails to improve its accuracy. The GrainCam concept can be used to identify other grain pests such as insect or weed seed identification.

Project Outputs		Please provide a report on the achievement, or otherwise, of the project outputs as per the planned outputs provided in the Project Proposal.
1	-	Output 1 (from revised project outline) Fact sheet giving percentage effect of cabling, speed tillage and stubble crunching on mortality of small conical snails and best practice advice.
		The concept of providing a fact sheet communicating the percentage control from the three different stubble management techniques was devised on the hypothesis that each treatment would provide some level of control compared to the Nil. None of the three stubble treatments provided consistent control of small conical snails above the nil treatment. It was decided that producing a fact sheet outlining a nil result for the stubble treatments would not value growers. A full report on the project results and conclusions was included in the Stirlings to Coast Farmers Trials Review Booklet 2020.
2	-	Output 2 (from revised project outline) Use of 'GrainCam' to produce snail density maps of paddocks that allow growers to target snail management.
		The 'GrainCam' was successfully utilised to identify snails in grain samples and provided data to produce snail density maps on a paddock scale. Counting snails manually is not a viable option for grain growers or even researchers doing trial work due to being very labour intensive. The use of the GrainCam to estimate snail density could be a valuable system for detecting other

		pests in grain samples. GrainCam could easily be deployed to test for other grain contaminants such as bedstraw, skeleton weed, or insects.
3	-	Output 3 (from revised project outline) Report estimated costs of each stubble management technique ($/ha)
		The grower hosts have estimated the estimated costs for each stubble management treatment in this trial. The original idea of obtaining treatment costs was to compile a fundamental cost-benefit analysis of each stubble management tactics effect on snail mortality. Given the nil results for all three stubble treatments, the estimated costs are not necessarily relevant. However, the estimated prices of applying the stubble treatments are listed below, highlighting the potential value that could have been generated from any reduction in small conical snail numbers. A) Speed Tiller $50/ha B) Stubble Cruncher $30/ha C) Cabling $5/ha

Project results

The project aimed to evaluate if stubble management techniques used in South Australia on 'White Italian' or 'Vineyard' Snails would work on the much smaller conical snails found in Southern WA. Total control was not expected; however, we hypothesised that snail numbers would decrease after the stubble management treatments were applied. Our results show that none of the stubble management strategies significantly reduced snail numbers compared to the untreated control.

We completed three separate measurements to quantify the effects of our stubble management techniques. All three results showed no significant differences between any treatments in the trial, including the nil control.

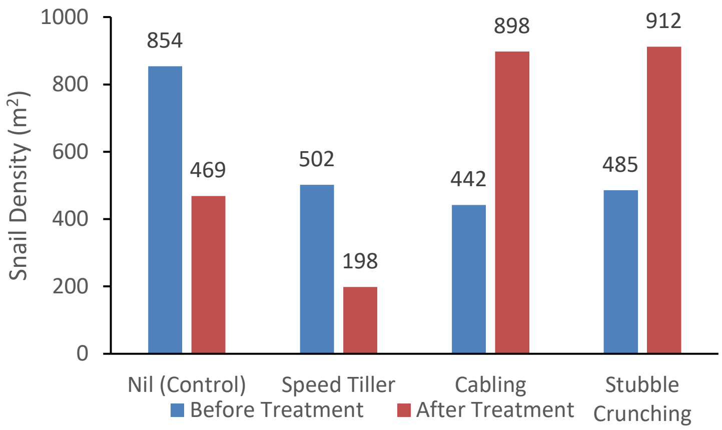

Figure 1: The number of small conical snails (per m^2) counted before and after the stubble treatments in March 2020.

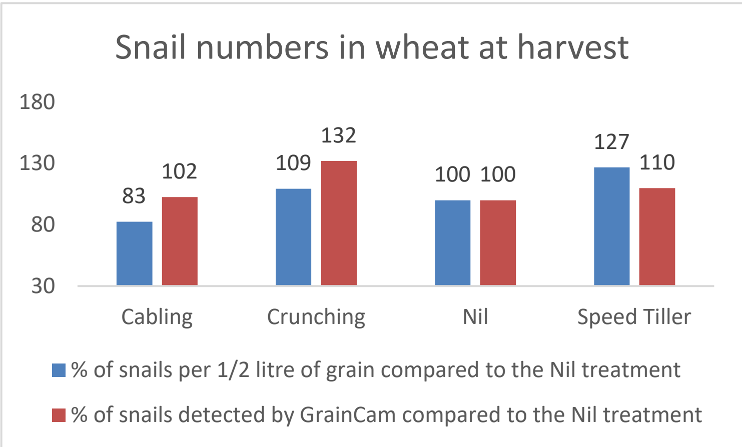

Figure 2: The percentage of small conical snails counted in the grain sample and detected by GrainCam and artificial intelligence compared to the Nil Control.

The data presented in figure one shows the cabling and stubble crunching treatments had increased snail numbers compared to the pre-treatment snail counts. The speed tiller treatments reduced snail numbers; however, the nil control also recorded lower snail numbers after the treatment applications. The variable snail counts meant that we could not obtain a significant difference between any of the treatments.

	The snail counts were variable because the snails were not evenly distributed across the paddock and the snail numbers were very high. Despite deploying adequate project resources to conduct the physical snail counts, a significant difference was not determined. Researcher observations during the snail counts concluded the stubble cruncher and cabling treatments were less likely to affect the small conical snails because the soil and stubble disturbance was minimal. Most of the snails were found below ground in the seeding furrow in large clusters during the snail counting process. The stubble cruncher and cabling treatments only affected the stubble and soil surface. The speed tiller treatment appeared to have the most impact on the environment where most of the snails were found pre-treatment. The speed tiller disturbed soil down to 10cm, which impacted last year's seeding furrow where the snails were located. This might have explained why fewer snails were found after the speed tilling treatment was applied. However, the snail counts in the untreated control were also lower, making it impossible to conclude the reduction was because of the treatment effects. Researchers thought that it was also possible that the speed tiller relocated the small conical snails, distributing them throughout the soil rather than living in clusters. This meant that fewer snails were counted. It was hoped that the data collected at harvest time would be more conclusive, especially since the overall aim is to reduce small conical snail contamination in grain samples. The snail infestations were determined by counting snails in 166-grain samples of approximately 266g/sample and analysing 3,486 GrainCam images. The comprehensive data sets were unable to determine a significant difference in treatments compared to the nil control. The correlation between the snails counted in samples and snails detected by artificial intelligence (GrainCam) was 0.55, which is significant at $p<0.05$. Retraining of the program would improve this. (See full DPIRD report attached). The three data sets indicated no short or long-term benefits from the stubble management techniques used in this trial. The original project methodology was to conduct the same treatments again in 2021 to see if the treatments had compounding benefits. Unfortunately, we could not do this because the grower could not seed through the thick wheat stubble from the 2020 crop. The only way the grower could seed through the crop with his seeder was to burn the stubble. Unfortunately, burning the stubble would compromise our stubble treatments, so the decision was made to conclude the trial after one season of data. On a more positive note, the trial demonstrated another successful application of the GrainCam concept designed by DPIRD researcher John Moore. GrainCam showed a significant correlation to the physical grain samples collected and counted from the 2020 harvest. John notes in his report that the snails in 2020 were much smaller than average and the images used to train the artificial intelligence (AI) software. Providing more images or 'training' for the AI software would likely improve the correlation between the snails detected by GrainCam and the actual counts. Counting snails manually is not a viable option for grain growers or even researchers doing trial work due to being very labour intensive. The use of the GrainCam to estimate snail density is, therefore, a valuable system for detecting pests in grain samples. GrainCam could easily be deployed to test for other grain contaminants such as bedstraw, skeleton weed, insects etc. John Moore believes it would be possible to utilise the camera systems already used in the modern harvesters to 'run' GrainCam to detect snails (or other contaminants) rather than a mobile phone used

	in this trial. The concept needs considerable resources and funding to take the idea from the prototype stage to the market application. The snail mortality results from the stubble treatments are disappointing because we hoped to find an alternative solution to controlling small conical and conical snails that would complement baiting. Stubble management is relatively cheap and is also completed for other agronomic benefits. The project hoped to show a significant benefit from the common treatments to help bring overall snail numbers down. The main industry benefit from the project is communicating what we tried and that it was not an effective as a small conical snail control method. Our recommendations for the next steps beyond this project are to pitch the GrainCam concept to the appropriate machinery or precision agricultural businesses that can develop the idea further. The non-result from the stubble treatments has been and will continue to be available to the whole industry through the SCF and online farm trials websites. Our trial was completed on canola stubble, with a wheat crop planted after the stubble treatments were installed. To test the hypothesis further, it would be beneficial to repeat the trial on a cereal stubble to complement the results we obtained on canola stubble. The most challenging aspect of the trial process was accurately counting snails in the field. Given the natural variation in the paddock and the high numbers, this was always going to be a challenge. Before starting the fieldwork, we consulted DPIRD biometrician Andrew Van Burgel, who advised us how many counts we should take per plot and what statistical analysis we should do. We completed the snail counts with six staff members working together to collect as much data as possible. Despite the dedication to the project, we were still unable to determine statistically significant differences between treatments. In some ways, this result highlighted the benefit of a system like GrainCam, where tremendous amounts of data can be analysed using artificial intelligence. Another significant difficulty encountered in this project was having the proper environmental conditions to ensure snail mortality. Knock to the ground methods of snail management require daytime temperatures above 35 degrees for three consecutive days. During this project, this presented as an issue and will be an issue for snail management in the APZ, particularly on the coastal fringe where summer temperatures are mild. On top of this, running machinery on sweltering days in the middle of summer poses a substantial fire threat risk that many growers would not be willing to take for snail control.

This section should cover aspects identified in *Section 7.3* of the Research Agreement

- the results of the Project, including discoveries made and other achievements (including any Project IP and Project Confidential Information);

- the potential application of the outputs of the Project to the Western Australian grains industry and broader community;
- the actual or potential economic benefits flowing to the Western Australian grains industry and broader community from the Project;
- the difficulties encountered;
- the conclusions reached;
- the Researcher's recommendations for any further research;
- a list of scientific papers or publications resulting from the Project; and
- attach copies of any photos, diagrams or other artworks (including, if requested by COGGO, negatives, bromides or the like) which the Researcher has and which may be of assistance to COGGO in the dissemination of information concerning the Project to COGGO's stakeholders.

## 3. Project resources	This section describes use of the funding listed in the initial plan and any refunds due to COGGO

Expenditure of funds requested from COGGO	$ Total funds budgeted	$ Total funds expended (actual)	$ Total funds requested from COGGO*	$ Total COGGO funds expended	$ Refund due to COGGO of any unexpended COGGO funds
Salary/Contractors	$75,000	$64,610	$60,000	$49,610	
Operating costs	$44,750	$47,883	$20,000	$23,133	
Capital	$0.00	$0.00	$0.00	$0.00	
TOTAL	**$119,750**	**$112,493**	**$80,000**	**$72,743**	**$7,257**

*Funding provided by COGGO.

IMPORTANT: Return of unused funds to COGGO is required as per *Clause 3.3* of the Research Agreement.

## 4. Commercialisation	Insert details of the proposed commercialisation process,as applicable, with reference back to the planned commercialisation plan in the project proposal) for any outputs from the project. This should include recommendations for the commercialisation of the results of the project and the registration or other protection of Project IP and Project Confidential Information as per the Research Agreement.

GrainCam remains the intellecutal property of the Department of Primary Industries and Regional Development.

The stubble treatment data is free to be shared publicly.

It is understood that this may require further discussion and agreement with COGGO via its' agent GIWA, as per the undertakings given and terms agreed, in the project proposal. This can be the subject of an appended letter and attachments. In all cases such discussion and subsequent agreements need to be governed by *Section 8 Project IP, Improvements and Project Confidential information* of the Research Agreement.

## 5. Communication/ Extension	Insert details of how the communication and extension of the project outcomes has been achieved to date and recommendations for future activities to disseminate and promote adoption of the results of the Project.

Extension activities were undertaken as part of this project to communicate the activities and outcomes of the trial effectively.

The project trial activities and results were distributed to SCF members in both an electronic and physical form. The trial results were disseminated with the focus of maximising the reach of the project, both among SCF members and the wider farming and agricultural science community. The SCF trials review booklet published a report detailing the trial activities and outcomes and distributed it among SCF members and sponsors. The trial results were also published online on the SCF website and added to the GRDC's online farm trials platform to ensure that the trial information was made widely available to researchers, farmers, agronomists, and other interested parties.

A trial review video was created as part of the extension activities. This allowed us to communicate with an audience that would not necessarily be reached through traditional sources. This video was published on YouTube as well as the SCF website to ensure maximum reach.

A social media campaign was run as part of the communication strategy to boost awareness of the trial activities and results as they were being undertaken. This aimed to extend the reach of the trial results to stakeholders outside the SCF membership base and Albany Port Zone.

Snails R&D page on the SCF website

https://www.scfarmers.org.au/snails-rd

Project review YouTube video

https://www.youtube.com/watch?v=GuyWxh_sdz0

Trails Review eBooklet

https://static1.squarespace.com/static/5c00a4b3620b859f65cfa797/t/609ccbe26dc12d7b622bc564/1620888600908/SCF_Trials+Review+Booklet_2020_F2S2_S2.pdf

Note: As per *Clause 7.3 (b) (ii)* of the Research Agreement COGGO may require the Researcher to produce an edition of the Final Report in a form suitable for general distribution. If so required by COGGO, the Researcher must produce a non-confidential version of the Final Report within 28 days of receiving a request to that effect from COGGO.

6. Certification

The Project Supervisor and the Research Organisation certify that all information contained in, and forming part of, this final project report is complete and accurate. The project supervisor and research organisation further warrant that the project complied with all the relevant guidelines affecting the conduct of research, for example in relation to ethics, bio-safety, environmental legislation, GMAC or National Health and Medical Research Council Codes.

Project Supervisor's signature ________________________________

Name (in Capitals)

________________________________ Date:

Research Organisation signature ________________________________

Name and title of authorised signatory (in Capitals)

____

________________________________Date:

Completed Final Project reports

Email to or mail to
COGGO Research Fund, GIWA, PO Box 1081, Bentley DC, WA 6983

For any further enquiries please email questions to coggoresearchfund@giwa.org.au

Or phone (08) 6262 2128

COGGO representative

For the purpose of this Project agreement contract, COGGO will be represented by Grains Industry Association of Western Australia (GIWA), or such other representative that is nominated by COGGO as authorised to operate on behalf of COGGO.

PROJECT SYNOPSIS SUITABLE FOR GENERAL PUBLICITY AND COGGO WEBSITE

Impact of stubble management on small conical snail mortality

This project aimed to assess the impact of summer stubble management to control small conical snail populations in the Albany Port Zone (APZ) of Western Australia. Small conical snails have become a serious problem in WA over the last 20 years, causing damage to grain crops, pasture and downgrading grain quality. Current snail management techniques involve burning windrows, removing green bridges, and baiting during the growing season. The best option for removing small conical snails from grain is to put the grain through a specially designed snail rolling machine before delivering to bulk handling depots.

The project idea was based on management practices utilised in South Australia, where snails are knocked onto the ground from stubble on hot days (>35 degrees) to dehydrate and die. This project aimed to test cabling, stubble crunching, and speed tilling because these methods are widely available options to growers within the APZ. Growers have very few low-cost snail control options, and this trial wanted to address that need.

Researchers collected three separate datasets from the treatment effects on small conical snail numbers. These were:

1. Physical small conical snail counts before and after the treatments were applied in Match 2020 (pre-sowing of the wheat crop)
2. The physical collection of 166-grain samples while harvesting the trial and then counting the snails in the grain samples later in the laboratory. (December 2020)
3. Analysis of 3,486 photo images taken by GrainCam while harvesting the farm-scale trial plots by artificial intelligence software. (February-March 2021)

The physical snail counts from the harvested grain sample were used to validate the results obtained from the GrainCam imagery and subsequent analysis using artificial intelligence software. The correlation between the snails counted in samples and snails detected by artificial intelligence (GrainCam) was 0.55, which is significant at $p<0.05$. The three data sets showed no short or long-term reduction of small conical snail numbers from the stubble management techniques used in this trial.

On a positive note, the trial demonstrated a successful application of the GrainCam concept designed by DPIRD researcher John Moore. The DPIRD report states that the snails in 2020 were much smaller than average, and the images used to train the artificial intelligence (AI) software. Providing more images or 'training' for the AI software would likely improve the correlation between the snails detected by GrainCam and the actual counts.

Counting snails manually is not a viable option for grain growers or even researchers doing trial work due to being very labour intensive. The use of the GrainCam to estimate snail density is, therefore, a valuable system for detecting pests in grain samples. GrainCam could easily be deployed to test for other grain contaminants such as bedstraw, skeleton weed, insects etc.

John Moore believes it would be possible to utilise the camera systems already used in modern harvesters to 'run' GrainCam for detecting snails (or other contaminants) rather than a mobile phone as was used in this trial. The concept needs considerable resources and funding to take the idea from the prototype stage to the market application.

The snail mortality results from the stubble treatments are disappointing because we hoped to find an alternative solution to controlling small conical and conical snails that would complement baiting. Stubble management is relatively cheap and is also completed for other agronomic benefits. The main industry benefit from the project is communicating what we tried and that it was not an effective small conical snail control method for use in the Albany Port Zone.

Snails Grain Camm Data

Snails GrainCamm
Report (DPIRD).pdf

Stirlings to Coast Inc.

Impact of Stubble Management on Small Conical Snail Mortality.

Prepared by John Moore and Carlos Babativa Rodriguez, March 18, 2021.

Harvest results

Plots were harvested on 23/12/2020.

The snail infestations were determined by counting snails in 166 grain samples of approximately 266g/sample and analysis of 3486 GrainCam images.

The number of snails per half litre of grain for the four treatments are shown in table 1.

Table 1: The number of snails per half litre of grain following various treatments.

Treatment	Snails per half litre
Cabling	2.93
Stubble Crunching	3.88
Speed Tiller	4.50
Nil (Control)	3.55

l.s.d. ($p<0.05$) =1.15

The data was analysed using Genstat and the output is shown in Appendix 1. The data was analysed initially as a one way anova using the 4 replicates and then re analysed using a spatial analysis taking account of the replicate position as well as the distance down the treatment plot. This improved the probability of treatment effects from p=0.063 to p=0.060. Based on the l.s.d. the speed tiller had greater snail infestation then the cabling treatments and all treatments were not significantly different to the control.

Genstat was used to create a map of the density of snails across the whole site and is shown in figure 1. This shows that the snails occurred in patches over the site but were not significantly influenced by the treatments applied.

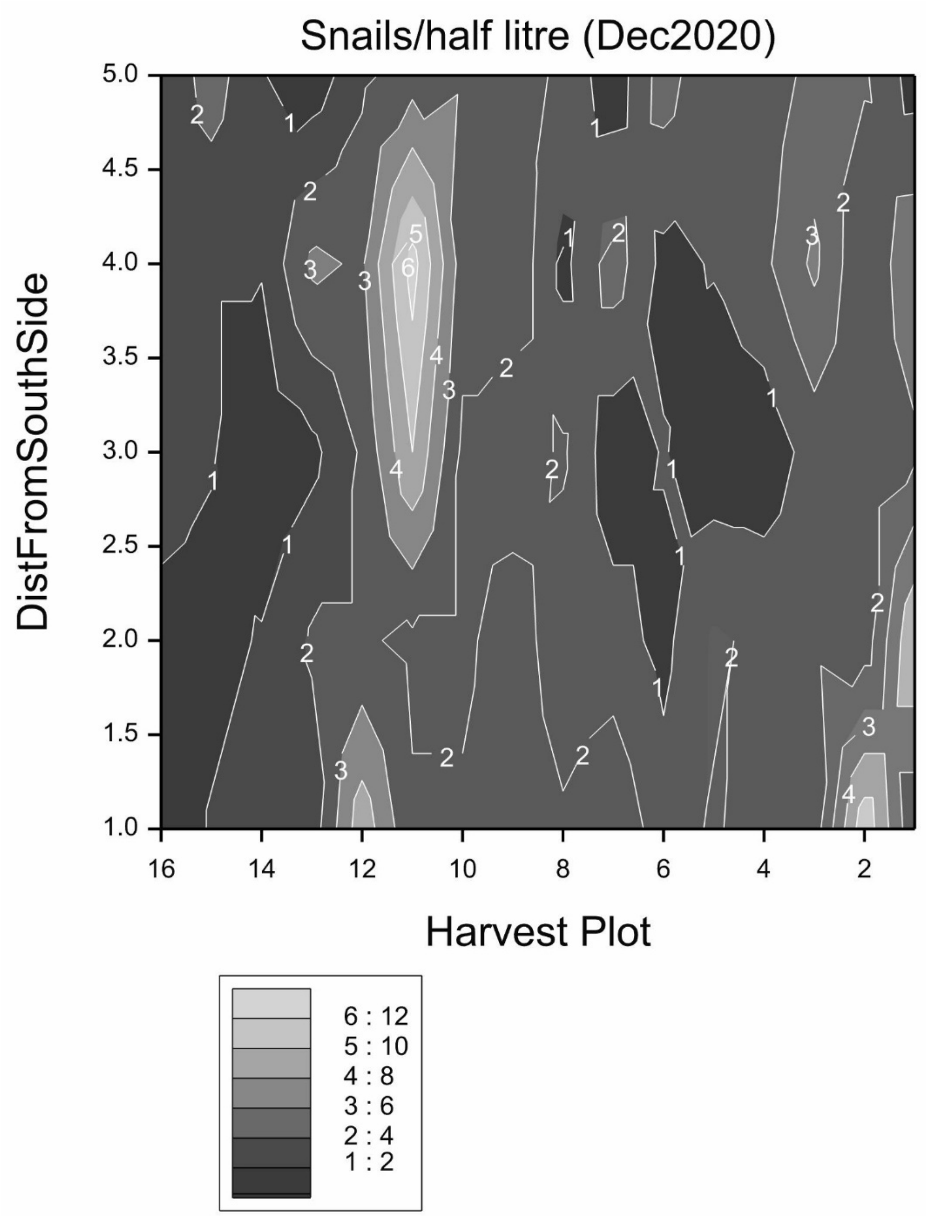

Figure 1: The numbers of snails present in the grain samples taken from the trial site.

Image analysis Results

The GrainCam is a device that is attached to the bubble auger on a harvester so that images of the grain may be taken during harvest. Images are then downloaded and passed through an artificial intelligence inference program. This scans the images and detects snails or snail like objects and records them.

The inference program is made by using images that have snails mapped in images of grain and these are passed through a neural network training program. In this case, we used YOLO3 as the training network. Training takes a long time and requires a large number of labelled images and significant computing power. Much of the data for training was taken from a previous DPIRD R4R project supervised by Micic and Moore in collaboration with UWA. The inference program produced is quite small and runs very fast and the final goal is to have this running on a mobile phone on the GrainCam so snail detections may be made in real time.

The snails harvested in this project in 2020 were much smaller than snails in previous years and this resulted in some loss of accuracy. Some retraining with the small snails would improve the accuracy.

A typical image with a detect snails is shown in figure 2 together with a false positive. The numbers indicate the probability that the detection was really a snail. The fact that the false positive was 0.96 whereas the actual snail was 1.00 indicates that with further training of the model these can be eliminated. Increasing the threshold to 0.95 resulted in missing too many snails (e.g. those what were small, misshapen or partially covered).

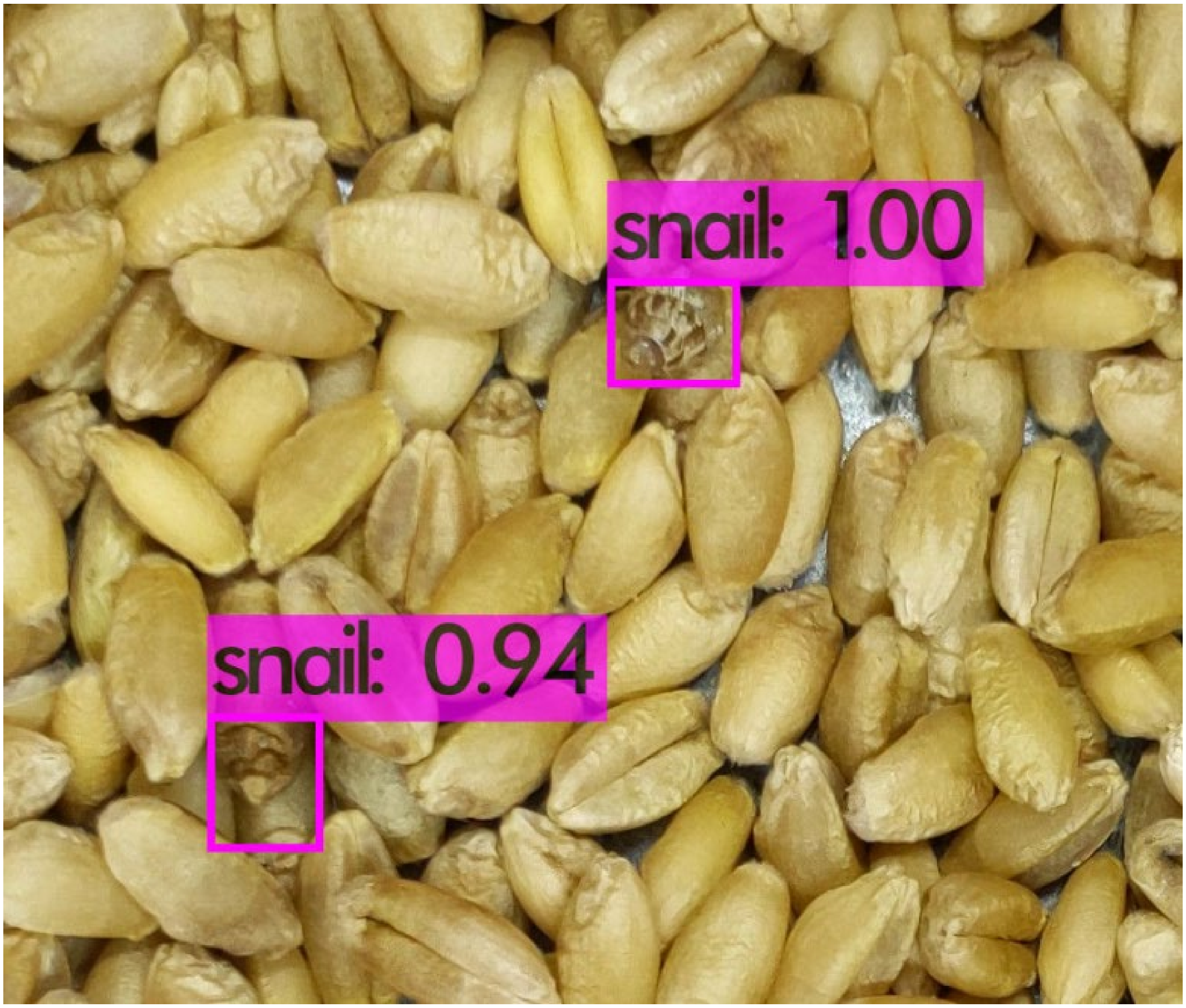

Figure 2: Typical snail detection and false positive with associated probabilities.

The grain at the site also had staining that resulted in some false positives as shown in Figure 3.

Figure 3: Grain defects that were misclassified as snails.

The correlation between the snails actually counted in samples compared to snails detected by AI was 0.55 which is actually significant at $p<0.05$. Retraining would improve this.

Table 2 versus Table 3 shows the numbers of snails counted compared to the number detected by artificial intelligence. In table 3 the high number in Rep3 result form more grain staining in these plots which was misinterpreted as snails. The overall larger numbers come from snails being counted more than once as the same snail may occur in an image and also in the subsequent image if the grain flow is slow.
There were no significant differences between treatments in the number of “snails” detected (see Appendix 2).

Table 2: The number of snails per half litre counted in samples.

Treatment	Rep1	Rep2	Rep3	Rep4	Average
Cabling	2.71	2.57	4.43	2.00	2.93
Crunching	4.93	3.29	4.71	2.57	3.88
Nil	4.07	2.71	5.43	2.00	3.55
Tiller	4.71	3.00	7.14	3.14	4.50
Average	**4.11**	**2.89**	**5.43**	**2.43**	**3.71**

Table 3: The number of "snails" detected by artificial intelligence and the GrainCam

Treatment	Rep1	Rep2	Rep3	Rep4	Average
Cabling	0.80	9.60	13.40	4.60	7.10
Crunching	5.08	13.80	12.90	4.80	9.15
Nil	0.82	0.20	18.20	8.50	6.93
Tiller	1.38	9.70	17.60	1.80	7.62
Average	**2.02**	**8.33**	**15.53**	**4.93**	**7.70**

Conclusions.

Cabling, crunching and tiller treatments had no significant effects on the number of snails that contaminated the grain at harvest. This season the snails were very small compared to last season indicating that they were younger and possibly less affected by treatments applied in autumn.

The GrainCam and artificial intelligence programs showed good potential for measuring snail contamination but require further development of the training algorithms to increase accuracy and reduce the number of false positives. These methods are much faster than counting snails in samples if large numbers of samples need or be processed or maps of contamination are required.

Appendix 1: Statistical analysis of snails counted in grain samples

Genstat 64-bit Release 20.1 (PC/Windows 8-10) 19 January 2021 10:21:43
Copyright 2019, VSN International Ltd.
Registered to: Agriculture Western Australia

Genstat Twentieth Edition
Genstat Procedure Library Release PL28.1

```
   1  SET [WORKINGDIRECTORY='C:/Users/moorej/Documents'; DIAGNOSTIC=messages]
   2  "Data taken from file: '\
  -3  C:/Users/moorej/Documents/SnailsSlugs/S2C/ImagesGrainCam/Mt Barker
grain samples imaging times.xlsx\
  -4  '"
   5  DELETE [REDEFINE=yes] _stitle_: TEXT _stitle_
   6  READ [PRINT=*; SETNVALUES=yes] _stitle_
  10  PRINT [IPRINT=*] _stitle_; JUST=left
```

Data imported from Excel file: C:\Users\moorej\Documents\SnailsSlugs\S2C\ImagesGrainCam\Mt Barker grain samples imaging times.xlsx
on: 19-Jan-2021 10:22:08
taken from sheet "GenstatSpatial", cells A2:I161

```
  11  DELETE [REDEFINE=yes]
Plot,Col,Rep,Treat,No_snails_found,Snail_HalfLitre,\
  12  Time_collected,RepCol
  13  UNITS [NVALUES=*]
  14  VARIATE [NVALUES=160] Plot
  15  READ Plot
```

Identifier	Minimum	Mean	Maximum	Values	Missing
Plot	1.000	8.500	16.00	160	0

```
  22  FACTOR [MODIFY=no; NVALUES=160; LEVELS=5; LABELS=*; REFERENCE=1] Col
  23  READ Col; FREPRESENTATION=ordinal
```

Identifier	Values	Missing	Levels
Col	160	0	5

```
  29  FACTOR [MODIFY=no; NVALUES=160; LEVELS=4; LABELS=*; REFERENCE=1] Rep
  30  READ Rep; FREPRESENTATION=ordinal
```

Identifier	Values	Missing	Levels
Rep	160	0	4

```
  36  FACTOR [MODIFY=no; NVALUES=160; LEVELS=4;
LABELS=!t('Cabling','Crunching',\
  37  'Nil','Tiller'); REFERENCE=1] Treat
  38  READ Treat; FREPRESENTATION=ordinal
```

Identifier	Values	Missing	Levels
Treat	160	0	4

```
  44  VARIATE [NVALUES=160] No_snails_found
  45  READ No_snails_found
```

Identifier	Minimum	Mean	Maximum	Values	Missing	
No_snails_found	0.0000	2.600	12.00	160	0	Skew

```
  51  VARIATE [NVALUES=160] Snail_HalfLitre; DECIMALS=2
  52  READ Snail_HalfLitre
```

Identifier	Minimum	Mean	Maximum	Values	Missing	
Snail_HalfLitre	0.0000	3.714	17.14	160	0	Skew

```
  89  VARIATE [NVALUES=160] Time_collected; DREP=36
  90  READ Time_collected
```

Identifier	Minimum	Mean	Maximum	Values	Missing	
Time_collected	109513	109731	144315	160	0	Skew

```
 131  FACTOR [MODIFY=no; NVALUES=160; LEVELS=20; LABELS=*; REFERENCE=1]
RepCol
 132  READ RepCol; FREPRESENTATION=ordinal
```

Identifier	Values	Missing	Levels
RepCol	160	0	20

```
 139  %PostMessage 1129; 0; 10000001 "Sheet update completed"
 140  "One-way design in randomized blocks"
 141  DELETE [REDEFINE=yes] _ibalance
 142  A2WAY [PRINT=aovtable,information,means; TREATMENTS=Treat; BLOCKS=Rep;
FPROB=yes;\
 143   PSE=diff,lsd; LSDLEVEL=5; PLOT=*; COMBINATIONS=present;
EXIT=_ibalance] Snail_HalfLitre;\
 144   SAVE=_a2save
```

Analysis of variance

Variate: Snail_HalfLitre

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Rep stratum	3	216.837	72.279	10.45	
Rep.*Units* stratum					
Treat	3	51.454	17.151	2.48	0.063
Residual	153	1058.036	6.915		
Total	159	1326.327			

Information summary

All terms orthogonal, none aliased.

Message: the following units have large residuals.

Rep 1 *units* 7	8.59	s.e. 2.57
Rep 1 *units* 15	12.25	s.e. 2.57
Rep 3 *units* 22	9.50	s.e. 2.57
Rep 3 *units* 28	8.07	s.e. 2.57

Tables of means

Variate: Snail_HalfLitre

Grand mean 3.71

Treat	Cabling	Crunching	Nil	Tiller
	2.93	3.88	3.55	4.50

Standard errors of differences of means

Table	Treat
rep.	40
d.f.	153
s.e.d.	0.588

Least significant differences of means (5% level)

Table	Treat
rep.	40
d.f.	153
l.s.d.	1.162

```
SET [IN=*]
"One-way design in randomized blocks"
DELETE [REDEFINE=yes] _ibalance
A2WAY [PRINT=aovtable,information,means; TREATMENTS=Treat; BLOCKS=RepCol; FPROB=yes;\
 PSE=diff,lsd; LSDLEVEL=5; PLOT=*; COMBINATIONS=present; EXIT=_ibalance] Snail_HalfLitre;\
 SAVE=_a2save
```

Appendix 2: GrainCam images.

The 3486 images are on the attached USB memory stick

Analysis of variance

Variate: Snail_HalfLitre

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
RepCol stratum	19	345.714	18.195	2.68	
RepCol.*Units* stratum					
Treat	3	51.454	17.151	2.53	0.060
Residual	137	929.158	6.782		
Total	159	1326.327			

Information summary

All terms orthogonal, none aliased.

Message: the following units have large residuals.

RepCol 14	3.61	s.e. 1.47
RepCol 1 *units* 3	11.00	s.e. 2.41
RepCol 2 *units* 2	7.70	s.e. 2.41
RepCol 13 *units* 6	8.32	s.e. 2.41
RepCol 14 *units* 5	7.61	s.e. 2.41

Tables of means

Variate: Snail_HalfLitre

Grand mean 3.71

Treat	Cabling	Crunching	Nil	Tiller
	2.93	3.88	3.55	4.50

Standard errors of differences of means

Table	Treat
rep.	40
d.f.	137
s.e.d.	0.582

Least significant differences of means (5% level)

Table	Treat
rep.	40

d.f.	137
l.s.d.	1.152

Appendix 2: Statistical analysis of snails detected by AI in grain samples

Genstat 64-bit Release 20.1 (PC/Windows 8-10) 18 March 2021 12:48:12

Registered to: Agriculture Western Australia

Genstat Twentieth Edition
Genstat Procedure Library Release PL28.1

```
   1  SET [WORKINGDIRECTORY='C:/Users/moorej/Documents'; DIAGNOSTIC=messages]
   2  "Data taken from file: '\
  -3  C:/Users/moorej/OneDrive - Department of Primary Industries and
Regional Development/Documents/SnailsSlugs/S2C/ImagesGrainCam/S2CMt Barker
grain samples.xlsx\
  -4  '"
   5  DELETE [REDEFINE=yes] _stitle_: TEXT _stitle_
   6  READ [PRINT=*; SETNVALUES=yes] _stitle_
  10  PRINT [IPRINT=*] _stitle_; JUST=left
```

Data imported from Excel file: C:\Users\moorej\OneDrive - Department of Primary Industries and Regional Development\Documents\SnailsSlugs\S2C\ImagesGrainCam\S2CMt Barker grain samp
on: 18-Mar-2021 12:50:45
taken from sheet "Genstat", cells A2:F17

```
  11  DELETE [REDEFINE=yes]
Plot,Rep,Treat,Snails_266gSample,Snails_HalfLitre,\
  12  AISnails
  13  UNITS [NVALUES=*]
  14  VARIATE [NVALUES=16] Plot
  15  READ Plot
```

Identifier	Minimum	Mean	Maximum	Values	Missing
Plot	1.000	8.500	16.00	16	0

```
  17  FACTOR [MODIFY=no; NVALUES=16; LEVELS=4; LABELS=*; REFERENCE=1] Rep
  18  READ Rep; FREPRESENTATION=ordinal
```

Identifier	Values	Missing	Levels
Rep	16	0	4

```
  20  FACTOR [MODIFY=no; NVALUES=16; LEVELS=4;
LABELS=!t('Cabling','Crunching',\
  21  'Nil','Tiller'); REFERENCE=1] Treat
  22  READ Treat; FREPRESENTATION=ordinal
```

Identifier	Values	Missing	Levels
Treat	16	0	4

```
  24  VARIATE [NVALUES=16] Snails_266gSample; DECIMALS=2
  25  READ Snails_266gSample
```

Identifier	Minimum	Mean	Maximum	Values	Missing
Snails_266gSample	1.400	2.567	5.000	16	0

```
  27  VARIATE [NVALUES=16] Snails_HalfLitre; DECIMALS=2
  28  READ Snails_HalfLitre
```

Identifier	Minimum	Mean	Maximum	Values	Missing
Snails_HalfLitre	2.000	3.668	7.143	16	0

```
  33  VARIATE [NVALUES=16] AISnails; DECIMALS=1
  34  READ AISnails
```

Identifier	Minimum	Mean	Maximum	Values	Missing
AISnails	0.2000	7.699	18.20	16	0

```
  37  %PostMessage 1129; 0; 10000001 "Sheet update completed"
  38  "One-way design in randomized blocks"
  39  DELETE [REDEFINE=yes] _ibalance
  40  A2WAY [PRINT=aovtable,information,means; TREATMENTS=Treat; BLOCKS=Rep;
FPROB=yes;\
  41   PSE=diff,lsd; LSDLEVEL=5; PLOT=*; COMBINATIONS=present;
EXIT=_ibalance] AISnails;\
  42   SAVE=_a2save
```

Analysis of variance

Variate: AISnails

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Rep stratum	3	406.27	135.42	8.37	
Rep.*Units* stratum					
Treat	3	12.20	4.07	0.25	0.858
Residual	9	145.56	16.17		
Total	15	564.03			

Information summary

All terms orthogonal, none aliased.

Message: the following units have large residuals.

Rep 2 *units* 1	-7.4	s.e. 3.0

Tables of means

Variate: AISnails

Grand mean 7.7

Treat	Cabling	Crunching	Nil	Tiller
	7.1	9.1	6.9	7.6

Standard errors of differences of means

Table	Treat
rep.	4
d.f.	9
s.e.d.	2.84

Least significant differences of means (5% level)

Table	Treat
rep.	4
d.f.	9
l.s.d.	6.43

```
SET [IN=*]
```