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SAGIT

FINAL REPORT 2022

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PROJECT CODE	S-UA1420
PROJECT TITLE	
Caught Red-Handed: Revealing invertebrate species and conditions causing seedling damage in field settings.	

PROJECT DURATION			
Project start date	**1/07/2020**		
Project end date	**30/06/2022**		
SAGIT Funding	**2020/2021**	**2021/2022**	**(year)**

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PROJECT REPORT

Executive Summary

Observations of invertebrates attacking crop seedlings were done using night camera observations with infrared flash and pitfall trapping in six different paddocks in SA (3 in 2020/2021, 3 in 2021/2022), both before and after sowing, and using seven different crop seedlings (Barley, wheat/oat, canola, chickpea, faba bean, lentil, vetch).

Paddocks had vastly different invertebrate communities with 12-18 different taxa distinguishable in videos and 25 in pitfall traps.

European earwigs were clearly the most important species attacking seedlings, followed by red legged earth mites. High numbers of these combined with a high feeding ratio resulted in clear crop damage. Other species like millipedes, slaters, slugs and snails were much lower in populations, but also had a low or very low feeding ratio and would rarely cause significant damage.

Crop preference exists in some species, for example, earwigs and weevils preferred faba bean whereas red legged earth mites preferred vetch.

Few beneficials were observed, mainly ants, carabid beetles and spiders with large differences among paddocks.

Pitfall trapping suggested very different invertebrate communities (species diversity and populations) to those observed in the night camera footage at the same sites. If only pitfall data were used to determine the cause of crop damage, there could be an erroneous interpretation of which invertebrate would damage the crop.

This night camera methodology shows potential for a more accurate quantification of invertebrate damage to seedlings. It showed that the farmer/agronomist perception of damaging populations was sometimes incorrect. For example, at one site the cameras revealed no slaters damaging crops and very few millipedes feeding on crops, even though huge numbers of both species were present and there was the incorrect perception that these pests were causing significant damage. More structured observations are required to get a better understanding of the actual in-field invertebrates causing damage to seedlings, and the possible link to agricultural management.

Project objectives

A range of different arthropods (Micic et al 2008) can attack germinating grain crops. Portuguese millipedes, European earwigs or slaters are often blamed when loss of seedlings occurs. Because these are mainly night active and hidden underground during the day, there is often no clear proof which organism has been damaging the germinating plants. Here we aim to identify the organisms involved through:

1. Observation of seedling damage developing *in the field,* to identify which organisms (slaters, millipedes, earwigs, others) damage the seedlings of which crops and under which pedo-climatic conditions and at which arthropod physiological state.
2. Quantify the population size, dynamics, possible migration events and life history of European earwigs, slaters, and millipedes in broad-acre paddocks and surrounding landscape.
3. Develop observation methods and decision rules for growers to adapt management to avoid seedling damage by these organisms in their paddocks.

Overall Performance
The project was largely successful in developing a night-time camera setup, providing a large set of good quality data and new insight into the organisms causing actual crop damage on seedlings. Some technical and practical issues occurred, especially around the sowing period and time-consuming image analysis. Overall, an excellent dataset was collected and analysed, providing new insights in crop damage by invertebrates.

KEY PERFORMANCE INDICATORS (KPI)

KPI	Achieved	If not achieved, please state reason.
1. Development and testing of camera, light and seedling setup 02/21	Yes ☒ No ☐	
2. Selection of paddocks and testing of trapping/sampling methodology 01/21	Yes ☒ No ☐	
3. Installation of cameras and weather stations; Traps for long term monthly monitoring. 03/21	Yes ☒ No ☐	
4. Results of seedling damage trials in first sowing season, adaptation of protocols (if needed) for 2022 sowing period 07/21	Yes ☒ No ☐	
5. First full year of ecology data for each species (population dynamics, developmental stages, activity levels, migration) 03/22	Yes ☒ No ☐	
6. Extension/Communication activities (workshops, field days, SAGIT research meetings) 2022	Yes ☒ No ☐	Limited communication so far (SARDI Pestfacts), but will continue when opportunities arise
7. Results of seedling damage trials in second sowing season 08/22	Yes ☒ No ☐	
8. Final report (this report)	Yes ☒ No ☐	

TECHNICAL INFORMATION

(Please also see full report with figures attached)

The first and most important result of this project is that this methodology, designed for night observation of invertebrates damaging seedlings, is giving some excellent results using simple and low-cost equipment. Camera observations are valuable as they visually confirm the species that actively feed on seedlings and do not depend on assumptions about night time seedling damage from day time observations of the pest. Camera observations of actual feeding are clearly adding value compared to a trapping or other sampling approaches.

The 6 paddocks were located in Finniss, Riverton, Rhynie (2020) and Reeves Plains, Halbury and Yorke Valley (2021). Observations and trapping were done both pre and post sowing.
The video images and analysis by direct visual observation on the computer screen was time consuming but feasible with sufficiently trained staff. A 2-week recording period could take up to 3 days to analyse when many organisms were present in the images. A total of 16,645 individual invertebrate observations occurred in the images we analysed.

OVERALL COMMUNITY
Video images showed quite different communities from the pitfalls with very large differences between communities at different sites. Earwigs (Rhynie, Finniss, Riverton), millipedes (Finniss,

Riverton), red legged earth mites (Halbury), ants (Reeves Plains) and slaters (Yorke Valley) were the most abundant species per site.

Main organisms involved:

- We have clearly established that earwigs are the main invertebrate 'culprit' attacking seedlings when present (as was observed in several paddocks).
    - Earwig captures were low in the pitfalls but were recorded in high numbers on the images.
    - Not only are they often numerous, but they also showed a feeding ratio of 63% over all cases (feeding ratio = feeding events / number of observations).
- Portuguese millipedes, even when present in high numbers, showed a relatively low feeding ratio.
    - The Portuguese millipede (*Ommatoiulus moreleti*) is mostly a detritivore and might not be that attracted to healthy living plants.
    - The fact that this ratio appears to be larger in paddocks with high populations of earwigs or red legged earth mites suggests that initial damage (for example by earwigs in Finniss and red legged earth mites in Halbury) is needed before millipedes will feed on seedlings.
- The red legged earth mites in Halbury were also very numerous and damaged the seedlings.
- Weevils, rarely reported for damaging seedlings, were present in higher numbers than expected and were regularly seen attacking crops.
- Snails (and slugs) were not present in high numbers in any of the paddocks, so data are not sufficient to be able to interpret their impact in this study.
- Slaters (presumed the main pest in the Yorke Valley paddock), did not cause damage in the paddocks we studied.
    - Slaters were identified as *Australiodillo bifrons.*
    - This is the species most often reported as doing damage to seedlings.
    - Even with a high population observed, the *feeding ratio* of these slaters was very low.
    - It may be that other slater species do more damage to crops, but they were not recorded in this study.

The experimental design with seedlings of 7 different crops enabled the observation of preferences of particular invertebrates for feeding on certain crops in a 'choice' situation in a paddock. If only a single crop had been sown (a non-choice situation), the result could be slightly different. For example, with no other food options available, some invertebrates may feed upon a plant species that would normally rarely form part of their diet.

- With only six paddocks (2 years x 3 sites) monitored and with a single setup per paddock the large differences between paddocks cannot be confidently explained. Soil type, preceding crop, chemical history, surrounding landscape, weather conditions, weed communities (Norris and Kogan, 2005) etc. will all influence the populations of invertebrates and their appetite for crops. This study was a preliminary investigation. With additional resources, a more rigorous experimental design utilising this camera methodology, and finer scale data collection (eg. multiple set-ups per paddock), scientific and agronomic interpretation of these differences would be possible.

- The setup was not successful for quantifying 'damage' as feeding impact is very different per species, with mice sometimes raiding all seedlings in a very short time, while other organisms (earwigs) lopped some seedlings and others (mites) would only cause small feeding spots. The impact of this damage on final yield would also need to be considered.

The observed differences between pre and post sowing frequencies are not easy to explain since several effects were probably involved and interacting.

- Weather conditions (temperature, moisture) will influence the behaviours of invertebrates e.g. reduced mobility when it is colder.
- Some organisms (such as red legged earth mites) will hatch around sowing time, explaining their much higher observation rate after sowing.
- During the pre-sowing period the trays with seedlings are the only green vegetation present in the fields.

    - This can attract some very mobile species, such as mice, from a large distance to the seedlings due to visual or olfactory cues.
    - The patch of green can 'intercept' randomly moving mobile invertebrates when (random) encounters occur and then retain the invertebrate in the area while feeding, thus accumulating numbers over time.
- After sowing, with the crop emerging
    - Populations of organisms might be strongly reduced by the sowing (and associated possible pre-sowing chemical applications).
    - The movement of invertebrates will often be hampered due to the presence of crop plants and disturbed soil.
    - Visual and olfactory attraction to the tray of seedlings will be reduced.
    - The crop is providing food if it is a suitable feeding host for the organism.

Beneficials

This experiment has revealed the presence of a range of 'beneficials' (carabid beetles, spiders, ants, etc). Populations were again very different among observation points (paddocks) and generally quite low. However, the Reeves Plains observations with a very high number of ants shows very few invertebrates damaging the seedlings.

More information on the presence of beneficials, their role in regulating some of the potential pests and the impact of agricultural management on them is needed.

Some work has been done recently on pesticides and beneficials in the Australian context through Hort Innovation (2020) and GRDC (2022). However, these laboratory studies provide limited understanding of the effect of agricultural management practices; not just insecticides, but all seeding and harvesting operations, pesticides, rotations, fertilizers etc on the presence of beneficials or their contribution to pest management.

The infrared camera observations do make it possible to monitor the presence of nocturnal beneficials that often go unnoticed (such as carabid beetles).

Just as the trays with seedlings, camera observation of the action of natural enemies using 'sentinel' prey (such as aphids on a plant) could be used to increase knowledge on the importance of beneficials.

CONCLUSIONS REACHED &/OR DISCOVERIES MADE

1. The camera setup with sentinel plants provides a simple and effective method for observation of nocturnal invertebrates in a field situation.
2. Results confirmed that the 'suspected' (visible) arthropods are not always the ones doing the damage.
3. In these experiments earwigs were the main invertebrate damaging seedlings. Millipedes and slaters did much less damage than expected, but this requires confirmation in future studies.
4. This camera setup opens opportunities for more scientific and experimental approaches in a field setting, for example to:
    a. Gain a better understanding of establishment pests through observations on a wider range of paddocks with other communities present (slugs, snails, cutworms etc)
    b. Link populations of invertebrates (phytophagous and beneficials) to historical management practices
    c. Quantify the effect of (nocturnal) beneficials on pests (using sentinel prey)
    d. Experimentally test the effect of agronomic practices on invertebrate communities
5. Knowledge of actual populations of invertebrates damaging seedlings ('establishment pests') would provide a better understanding of the link between management and damage, and possibly the role of certain beneficials. This would allow farmers to adapt their management towards a real IPM approach (IOBC 2018), which should include the monitoring of beneficials, and would allow to avoid prophylactic pre-sowing applications using wide spectrum insecticides such as Chlorpyrifos and others.

INTELLECTUAL PROPERTY

N/A

APPLICATION / COMMUNICATION OF RESULTS

This camera setup is currently being used in another GRDC project (UOA2112-001RTX: Quantifying the diversity and abundance of pest and beneficial invertebrates associated with harvest weed-seed controlled systems in southern Australia.

Communication of results at meetings and field days has been limited due to COVID restrictions, but some results have been reported through Pestfacts SA and IPMforGrains workshops. Communication will continue, especially in the pre-sowing period of next season.

POSSIBLE FUTURE WORK

In this project we observed 6 different locations with no specific selection of paddocks or problem areas in paddocks. The main aim was to develop and validate the observation system. Now that has been done, the system could be applied for multiple research projects (see conclusions).

A more structured approach, for example selecting specific paddock histories (rotation, treatments), would allow greater and better insight in invertebrate communities during crop establishment. This could also be used to validate the influence of certain practices (for example pre-sowing and post sowing insecticide applications).

Results emphasise the need for more research into the management of earwigs in the higher rainfall areas where they are an abundant and important establishment pest.