What's hiding in your stored grain?

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ON-FARM grain storage has become a significant component of many Australian cropping operations. Grain producers are acutely aware from past experience that it is not safe, to simply store and forget grain held in storage for future sales, stockfeed or planting seed.

Recent field trials conducted at the Hermitage Research Facility in southern Queensland highlighted a feature of storage pests that can cost us dearly due to the old problem of 'out of sight out of mind'.

The four key strategies that tend to provide successful grain storage results are:

- Regular monthly monitoring;
- Good storage hygiene;
- Well managed aeration cooling; and,
- Effective fumigations when pests are found.

One of the enduring rewards from managing storage facilities well, is establishing a 'good reputation' over time as a reliable supplier of quality grain. This leads to both formal or informal preferred-supplier partnerships with grain buyers and traders, providing tangible and profitable benefits.

Grain sales are not the only rewards. Looking after planting seed in storage, to maintain seed germination and vigour, will always provide rewards through improved crop establishment in the paddock.

So keeping a close eye on what is going on with grain in storage, both in terms of grain quality and potential problems with insect pests, is crucial for all grain producers.

The lesser grain borer is fast and destructive

While there are six or seven common storage pests found throughout Australia, the lesser grain borer (*Rhyzopertha dominica*) has a reputation as a hidden, destructive pest, rapidly destroying grain in storage.

The lesser grain borer has a reputation for causing serious damage to stored grain.

The small 3 mm long, dark brown adult beetle lives for two to three months and is known to be a strong flier capable of travelling more than one or two kilometres.

Each female beetle lays 200–400 tiny eggs in the grain, only 0.6 mm long and 0.2 mm in diameter. The life cycle – from egg, larvae, pupae through to adult beetle – is completed in as little as four weeks when grain temperatures in storage are around 30 to 35°C. These temperatures are not uncommon during our warm harvest time conditions.

Both larvae (grub stage) and adult beetles eat out the inside of each grain leaving hollow shells and grain dust.

Storage pest behaviour

"I can see weevils in my grain" is a statement we are all familiar with. But what is hiding in your grain is what we don't see! Understanding a bit about storage pest behaviour helps us out here.

Under some conditions, storage pests can be fairly easy to see. If they are in very large numbers and ambient conditions

The natural habitat of flat grain beetles (pictured) and lesser grain borers is to stay hidden in grain. Unless we sieve the grain and use insect probe traps, we can be completely unaware we have an infestation.

are warm, pests will be actively moving over the grain surface or crawling over grain handling equipment. We may see them while augering grain into a truck.

Some storage pests have the ability to climb out of grain up vertical smooth surfaces. Rice weevils (*Sitophilus oryzae*), saw-toothed grain beetles (*Oryzaephilus surinamensis*) and bruchids such as the cowpea weevils (Callosobruchus spps.) have a habit of doing this.

While the rust-red flour beetles (*Tribolium castaneum*) cannot climb a smooth vertical surface, it can often be seen moving over the grain surface, particularly when it is warm.

For some of our storage pests in grain this behaviour helps us see we have a problem. Unfortunately, when we can easily see them like this, it is often far too late. By this stage, the grain is usually heavily infested with pests.

Two of our common storage pests, the lesser grain borer and flat grain beetles (Cryptolestes spps.) – which includes the rusty grain beetle – have behaviours that are completely different.

Their natural habit is to stay hidden in grain. Unless we sieve the grain and use insect probe traps, we can be completely unaware we have large numbers of them in our stored grain.

The hidden life cycle

Often when we use an insect sieve or probe trap and find one or two beetles or weevils in our sample, we have completely forgotten about the other parts of the insect's life cycle.

How many tiny eggs did that single female lesser grain borer lay in the grain? The answer is possibly 200 to 400 eggs. And how many undetected larvae and pupae are also there?

In a recent experiment, 15 grain samples were taken from each of four 30 tonne silos of wheat while augering from one silo to another.

These samples were taken back to the laboratory and all the adult lesser grain borer beetles were counted and then removed.

Grain samples from Silo 1 gave an adult lesser grain borers density of 588 per tonne.

In Silo 2, there were 250 beetles per tonne.

But in silos 3 and 4 there were no adult beetles found in the wheat sample (see Table 1).

The wheat samples were then incubated in the laboratory under warm conditions to allow time for the undetected eggs, larvae and pupae to develop into beetles over a number of weeks.

Following this incubation period, the second counting of adult lesser grain borers now showed how many immatures (egg, larvae, pupae) were hiding in the wheat that we could not see.

A pest density of nearly 60,000 per tonne in Silo 1 was hidden from detection as immature stages. This is compared to a density of 588 adult beetles we could see.

In Silos 3 and 4, we initially detected no adult beetles. The experiment showed there was in fact the start of an infestation

TABLE 1: Numbers of beetles versus undetected immatures (eggs, larvae or pupae) in four 30 tonne wheat silos

Silo	Insects per tonne	
	Beetles	Immatures*
1	588	59,413
2	250	21,913
3	0	4,220
4	0	15,533

*Samples were incubated in the laboratory until any eggs, larvae or pupae developed into beetles.

occurring with densities of 4220 and 15,533 immature stages respectaely per tonne of wheat.

This indicates that sieving and trapping adult beetles can greatly underestimate infestation levels in grain because of the undetected immatures' life stages.

Slowing or stopping the pest breeding life cycle

In the experiment above (Table 1), to hatch those very large numbers of beetle pests from the immature stages (eggs, larvae and pupae) we placed the wheat samples in special rooms in the laboratory when provided continuous, warm, high humidity conditions. This was ideal for incubating the insect life cycle.

But what realistic numbers of pests could we expect to build up in on-farm grain storages under normal day and night ambient temperatures?

In a second experiment, recently harvested wheat was placed in a one tonne bag from October 2017 to June 2018 in southern Queensland. The bag was thoroughly sampled using a grain spear and adult beetles (lesser grain borers) were counted a number of times over the nine month storage period (Figure 1).

The number of lesser grain borer beetles increased to almost 4000 per tonne by three months, then to about 30,000 per tonne by six months, with little change in numbers between six and nine months.

There are three key conditions that support rapid increases in grain pests:

- A good sheltered site with uniform conditions, such as the inside of a grain silo or grain handling equipment, including the header that sits in the shed during the off season;
- A food source, such as grain residues left sitting in a silo that may be empty, but not cleaned out well; and,
- Warm ambient conditions along with warm grain in storage encourages both grain insect flight around the farm and significantly favours rapid breeding activity.

We know for the lesser grain borer grain pest examined in

FIGURE 1: Rate of population increase of the lesser grain borer in one tonne of wheat over nine months

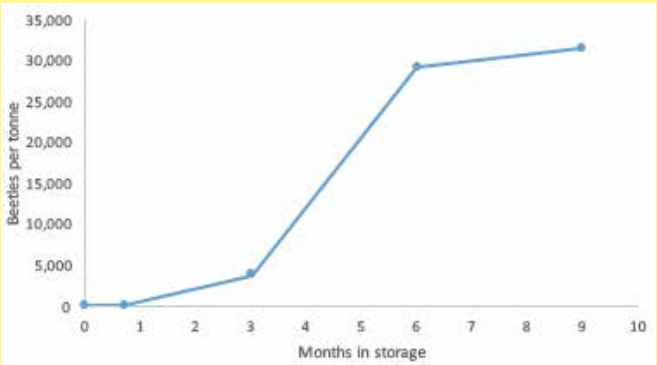
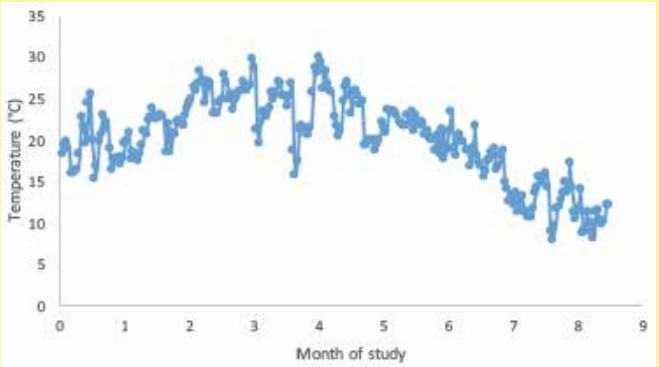


FIGURE 2: Median daily ambient temperature during our one tonne bag experiment



When a grain storage pest's natural habitat is to stay hidden, sieves and insect probe traps are needed to detect them.

our two experiments, the ideal conditions for rapid breeding are temperatures around 34°C and a relative humidity of 70 per cent.

Under these warm conditions the life cycle is quick – 25 days from egg through to the new adult beetle.

Figure 2 shows the 'median' ambient temperatures (midpoint between minimum and maximum temperatures) during the nine month period the one tonne bag of wheat was monitored for insect pests. When looking at the range of ambient temperatures during this experiment, it was common to see daily 'maximum' temperatures in the range of 27 to 37°C between mid-November and early March.

This was the period of rapid increase in lesser grain borer numbers during the experiment.

One of the most effective, non-chemical strategies we can use to slow down or stop this rapid increase in grain pests in Australia's favourable climate conditions, is to lower the grain temperatures.

Aeration cooling systems – when correctly managed – have the ability to reduce grain temperatures in storage to 18–23°C in summer and well below 15°C during winter.

Achieving these grain temperatures in storage will either significantly slow, or completely stop, any increases in the grain pest population.

For the lesser grain borer, instead of the rapid 25 day life cycle achieved at 34°C, the life cycle is slowed to 50 days when grain temperatures are lowered to 22°C.

This has a very large impact on the pest population rate of increase. At grain temperatures of 18°C and below, there will be no increase in the lesser grain borer population.

Successful grain storage results

There are clear rewards for those prepared to build a good reputation for supplying the grain quality required by the market, along with delivering grain with no pest problems.

Some key areas to focus on to provide reliable results for stored grain include:

- Hygiene – A good standard of grain storage and handling equipment hygiene is a vital starting point in keeping initial pest numbers to a minimum and reducing the risk of grain contamination;
- Aeration – With appropriately managed aeration cooling fans, grain temperatures can be reduced to assist with preserving grain quality attributes and significantly reduce storage pest numbers;
- Monitoring – Regular monthly checking of grain in storage with an insect sieve, probe traps and checking grain temperatures is vital if you are to prevent costly surprises. Pest infestations can quickly cause serious losses and damage your reputation as a reliable grain supplier;
- Storage records – Make a habit of keeping records. Identify and record pests found, any grain treatments applied, plus other helpful details of what is in each silo; and,
- Fumigation – In Australia we only have gas treatments to control insect pests in infested grain. To achieve effective control of the full insect life cycle (eggs, larvae, pupae and adults) we require a gastight – sealable silo to hold the required gas concentration for the length of time specified on the label.

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