Incidence and Spread of Insects from Bucket Elevator Leg Boots

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Problem

Research has shown that commercial grain elevator storage facilities can quickly become infested with stored-product insect pests. Data suggest that insect pest infestations are likely carried over from one year to the next in equipment or other areas that accumulate residual grain. Many locations can be identified where infested residual grain accumulates, the largest collection point within the handling equipment is often the bucket elevator leg boot.

Knowledge of insect pest densities and commingling of insects in grain causing spread of an infestation from an elevator boot and pit area is essential for commercial elevator and feed mill facility insect pest management programs.

Feed mill and elevator managers understanding of insect species diversity present and their management is critical for improved facility guidelines and establishment of good manufacturing practices.

Project Overview

The elevator boot (fig. 1) is the enclosed base of the bucket elevator leg casing where residual grain unavoidably accumulates during use. Residual grain often remains in the boot because manual clean-out of the elevator boot is not done on a regular basis in most grain elevators. Residual grain accumulation in the elevator boot likely contributes to commingling of insects with grain that moves through the elevator leg.

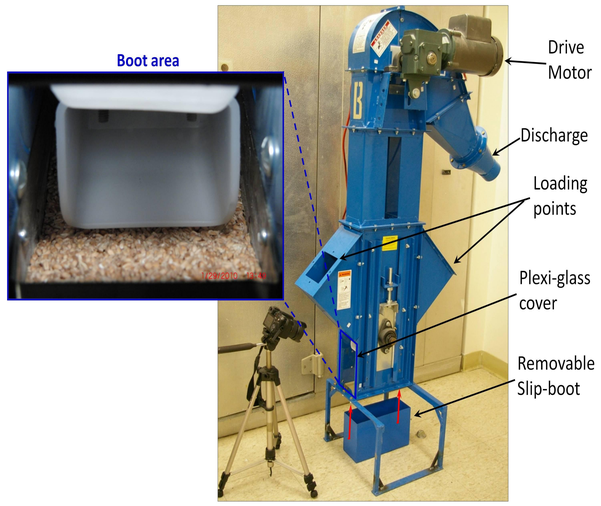

Figure 1. Pilot-scale bucket elevator leg arrangement.

Laboratory pilot-scale boots were infested with four levels of insect densities: zero, 50, 100, and 200 adult insects of each species per kg of grain Wheat samples were infested with adult lesser grain borer, rusty grain beetle, and red flour beetle (fig. 2); corn samples were infested with adult rice weevil, sawtoothed grain beetle, and red flour beetle (fig. 3).

Cryptolestes ferrugineus (Rusty Grain Beetle) | *Rhyzopertha dominica (Lesser Grain Borer)* | *Tribolium castaneum (Red Flour Beetle)*

Figure 2. Insects infesting wheat.

Oryzaephilus surinamensis (Sawtooth Grain Beetle) | *Sitophilus oryzae (Rice Weeveil)* | *Tribolium castaneum (Red Flour Beetle)*

Figure 3. Insects infesting corn.

Field Survey and Pilot-Scale Results

Survey data from monthly residual grain samples taken from feed mills and elevators were combined by facility type. Total adult insect counts for each facility type were significantly different between seasons of each year, except for feed mills summer and fall seasonal periods of 2009 (fig. 4).

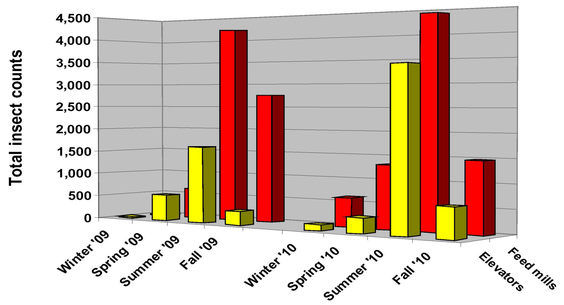

Figure 4. Total seasonal insect counts for elevator and feed mill facilities in Kansas during 2009 and 2010.

Pilot-scale bucket elevator leg boot tests had insect density levels immediately after the clean grain transfer of about 1 insect/kg (external insects), increasing to 2 insects/kg after an 8-week grow-out period (fig. 5).

Internal developing insects were allowed to mature to adult stage, emerge from the grain kernel and were counted. Higher "after grow-out" insect counts indicated larger numbers of internally infested kernels were commingled with clean grain flowing over the infested boots as compared to adult external insects being commingled.

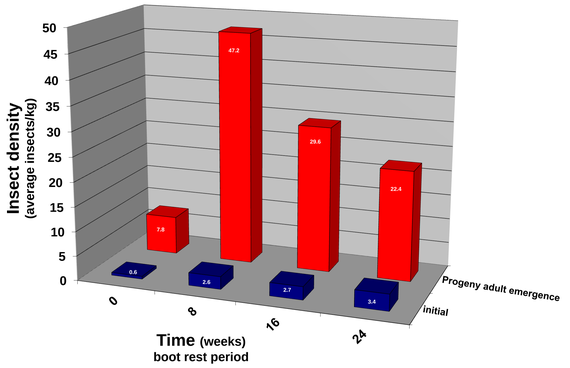

Figure 5. Insect density levels from initially clean corn transferred over infested boots. Infested boots were incubated at 0, 8, 16, or 24 weeks, simulating four different insect population generation cycles. Immediately following the clean grain transfer external insects (initial) were removed and counted. Internal insects (after grow-out) were enumerated after an 8 week period.

DEM Modeling

Four particle shapes for each grain type were evaluated to represent corn (fig. 6) and wheat (fig. 7) kernels using bulk grain property tests in discrete element method (DEM) simulations. Published and measured physical properties of corn and wheat were incorporated as inputs to model commingling of sound and infested kernels using DEM simulations (fig. 8).

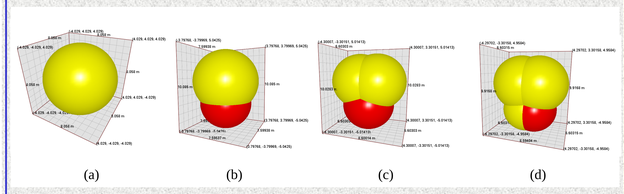

Figure 6. Particle shapes of corn in the simulation: (a) 1-sphere, (b) 2-sphere, (c) 3-sphere, and (d) 4-sphere models (drawn in EDEM 2.3 Academic software.

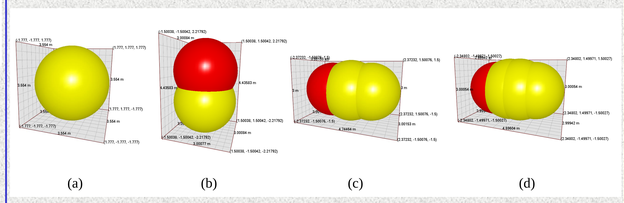

Figure 7. Particle shapes of wheat in the simulation: (a) 1-sphere, (b) 2-sphere, (c) 3-sphere, and (d) 4-sphere models.

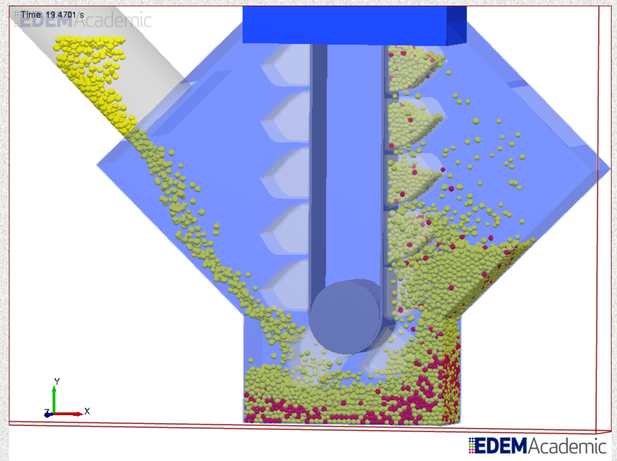

Figure 8. Commingling of sound and infested grain kernels in the bucket elevator boot using DEM simulation.

Conclusions and Impact

Conclusions from this research:

- Insect density level in the boot affected the level of insects transferred through the elevator leg to other locations.
- Clean grain transferred over infested boots picked-up one insect/kg immediately after the transfer, increasing to two insects/kg after an 8-week period.
- Larger numbers of internally-developing insects were commingled with clean grain flowing over the infested boot, compared to commingling of externally developing insects.

Important bucket elevator boot and pit sanitation guidelines:

- boot residual grain clean-out every 30 days,
- removal of residual grain, floor sweepings and grain spillage from the pit area,
- proper disposal of boot and pit residual grain.

Following new guidelines developed here will:

- reduce insect pest carry-over in feed mills and elevators,
- reduce the number of insects, both internal and external feeders, from being picked up in the boot area and transferred to other locations in the facility.

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