Investigating the Dung Beetle Population at the Beef Grazing Farm, UW Arlington Research Station

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Introduction

Dung beetles may sound like disgusting insects, but their value to the beef grazing and cattle production industry should not be overlooked. This project was conducted at the UW Arlington Agricultural Research Station (AARS) Beef Grazing farm during May-August, 2012. The objective was to identify the various dung beetle species represented in the existing dung beetle populations and observe their activity and behavior to determine potential positive impacts to pastures and cattle production.

Pasture managers are interested in dung beetles because these insects serve beneficial roles in the microenvironment of a dung pat that positively impact the larger pasture ecosystem. Dung beetles may play a significant role in controlling horn fly populations. Horn flies also use dung to reproduce and the adults feed on the blood of cattle and other grazing livestock. Their pesky feeding behavior can greatly reduce cattle weight gains, reduce vitality, and may cause animal injuries as the cattle try to stop their annoying blood-sucking. An Australian study reported that the introduction of 23 dung beetle species in a particular area resulted in a 90% reduction of bush fly populations (a species similar to horn flies). By maneuvering around the dung pat and manipulating dung into brood balls, dung beetles can physically damage the eggs of horn flies. Evidence also exists that *Sphaeridium scarabaeoides* larvae may feed on fly larvae in the dung pat.

Photo 1. A dung beetle tunnel located beneath a dung pat that was removed. Hole is at right side edge of knife blade.

Dung beetle nesting activities assist in redistributing and recycling nutrients from the dung pat as well as improving soil structure and water absorption; activities that are important to pasture soil health. ***Photo 1*** shows a hole that was found underneath a dung pat representing the beginning of a tunnel leading to a beetle larval development site. The hole in the picture had a measured depth of 6 inches and had a diameter about the size of a large pea.

Beetle Species Identified

Dung beetles belong to the Order ***Coleoptera*** and most are members of the Family ***Scarabaeidae***. The majority of species can be further grouped into the Subfamilies ***Scarabaeinae*** and ***Aphodiinae***, with a few species representing various other beetle families. For the current study, dung beetles were sampled by digging through dung pats layer by layer and picking out beetles individually for later identification. Eight species were collected at the UW AARS Beef Grazing Farm (***Table 1***).

Table 1. Identification and brief description of dung beetle species found at UW Arlington Agricultural Research Station Beef Grazing Farm.

	***Aphodius badipes*** ('big black beetle")—an all-black scarab beetle greater than 1 cm long with fossorial legs
	***Aphodius fimetarius*** ("red backs")—a mostly black, non-native scarab beetle of European origin with red elytra; less than 1 cm long, with fossorial legs
	***Aphodius granarius*** ("small black beetle")—an all-black, non-native scarab beetle of European origin; less than 5 mm long, with fossorial legs
	**Aphodius rubripinnis** ("brown backs")—a scarab beetle chararcterized by reddish-brown elytra, less than 1 cm long, with fossorial legs
	***Onthophagous hecate***—an all-black scarab beetle less than 1 cm long, with fossorial legs, exhibiting sexual polymorphism
	***Onthophagous nuchicornis***—Non-native beetle of European origin characterized by yellow and black elytra, 5 - 8 mm long, with fossorial legs, exhibiting sexual polymorphism
	***Sphaeridium scarabaeoides*** ("half brown backs")—beetle representing the family Hydrophilidae, characterized by brown, red and black elytra, and legs with spines; 5 - 7 mm long
	***Xestipyge conjunctum*** ("headless beetle")—beetle representing the family Histeridae, an all-black, flat, glossy beetle less than 1 cm long, with a strongly retracted head and fossorial legs

Life Cycle

The life cycle of dung beetles is very interesting and unique with respect to most other beetles. Most dung beetle species spend 95% of their life in dung or in the soil beneath dung pats. The only time dung beetles may be observed outside this environment is when they are searching for a new dung pat to start preparing and laying their eggs. Since each dung beetle species exhibits different adaptations to their preferred microenvironment, they have somewhat specific life cycle characteristics.

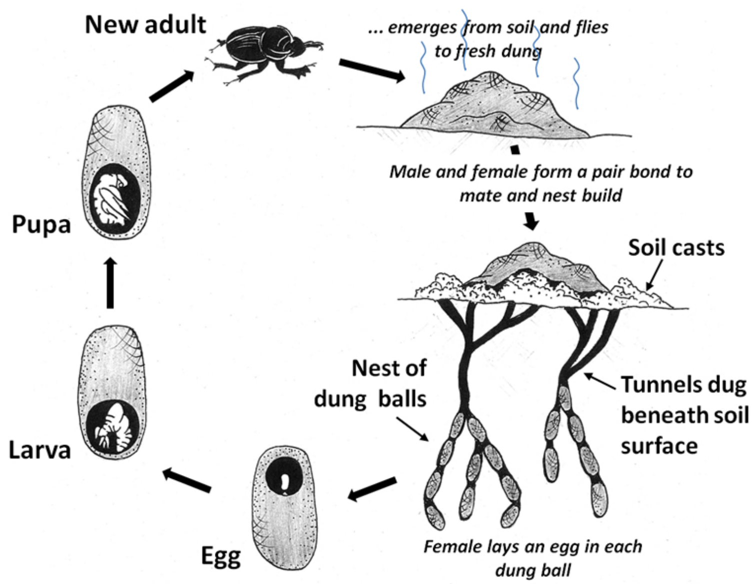

Figure 1. General life cycle of dung beetles.

Figure 1 shows the general life cycle processes of dung beetles, described as follows:

1. Male and female dung beetle pairs mate and create a *nest environment* that will provide their eggs the best probability of development and survival.
2. *Eggs are laid*. All dung beetles lay their eggs in dung, either in the dung pat itself or in a dung ball. A brood ball refers to dung ball in which an egg has been laid. Different beetle species utilize particular methods to lay their eggs. Some species lay their eggs so they remain attached to their backs. Once they partition a ball of dung from the pat, they place a single egg in that ball of dung and close it up. Other species lay their eggs and then individually wrap eggs in dung until it forms a ball shape. Usually, an egg hatches in 1 – 2 days, entering the larval stage. A typical female dung beetle can lay from 10 – 80 eggs in her lifetime.
3. *A majority of the development occurs during the larval stage.* Beetle larvae do not resemble the adult insect forms. Instead, the larva resembles a grub with six legs and a mouth and is “C” shaped. Entomologists call this form of larva “scarabaeiform”. The larva feeds on dung while it develops and grows. It normally consumes only about 40 – 55% of the dung ball, leaving the remaining particles behind. After 1 – 4 weeks, the larva pupates and moves into stage 4.
4. *The transition from larva to adult form begins during pupation.* The pupal stage may last from two weeks to several months and is the most variable stage among different dung beetle species. The pupal stage determines the population spikes seen among dung beetles. The pupa remains in the dung ball until it fully matures. At the conclusion of the pupal stage, the beetle emerges as an adult.
5. *In the final stage of the dung beetle life cycle, adults are ready to relocate to a fresh dung pat to start the life cycle process over again.* They must find a mate with which to pair bond and start preparing a new nesting environment. Even though dung beetles are modest-sized insects, they can fly up to 30 miles in search of fresh dung.

Beetle Nests

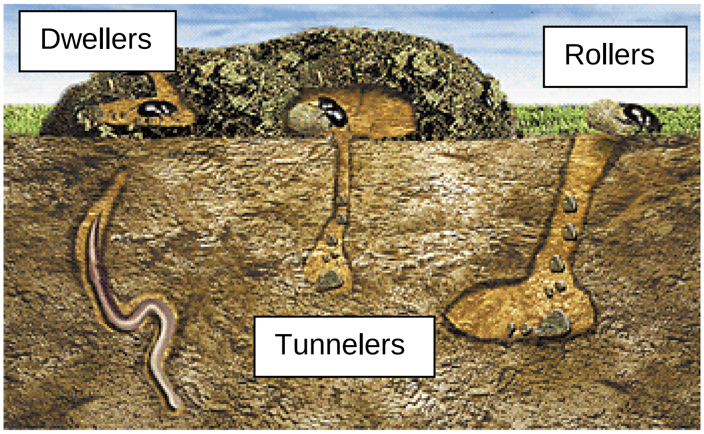

Figure 2. Three types of beetle nests.

The most valuable trait of dung beetles in pasture ecosystems is in the way they prepare the nest environment and lay their eggs during stage 1 of their life cycle. ***Figure 2*** illustrates three ways that different dung beetle species prepare the nest environment and lay their eggs to ensure successful development of the next generation of dung beetles.

- **"Dwellers"** do not penetrate the soil to dig out a chamber for their eggs. Instead, they dwell in the dung pat above the soil and lay their eggs directly in the dung pat. Eggs of dwellers are more prone to physical damage from fly larvae and other predators, but the larvae have an abundant food source for growth. In the current study at the UW Arlington Beef Grazing Farm, only *Sphaeridium scarabaeoides* is a dweller, and its larvae are primarily predators of the fly larvae that also inhabit the dung pat.

- **"Tunnelers"** get their name from their tunneling behavior underneath the dung pat. Male and female beetles work together to excavate egg chambers beneath the dung pat where they eventually place brood balls containing the eggs at the end of the tunnels. Different dung beetle species dig different types of tunnels. Some create branched tunnels while others create a single tunnel deep within the soil. Multiple brood balls may be packed into a single tunnel and once they are in place, the beetles secure them in their places with soil. This is the most common dung beetle nesting behavior observed at AARS Beef Grazing Farm because the remaining seven species of dung beetles identified are all considered tunnelers. The defining characteristic of these types of beetles compared to dwellers are their fossorial legs, which are specifically designed for digging.

- **"Rollers"** are dung beetles that roll their eggs into a dung ball and roll it some distance away from the dung pat. These beetles build underground nests away from the dung pat and roll their brood balls to this remote location. Aside from the rolling behavior, nest tunnels have the same general characteristics as those excavated by tunnelers. No rollers were identified during the AARS Beef Grazing Farm study. The most well-known roller species are native to Africa and Australia. These rollers tend to be larger in size and have longer legs than dwellers or tunnelers. These defining characteristics give them the ability to efficiently maneuver their brood balls to their nest location.

Observations on Tunneling and Nesting Behaviors

In order to gain a better understanding of each species' tunneling behavior, we wanted to conduct several observational experiments to help us understand the ideal conditions for tunnel excavation and beetle development. Six "beetle farms" were constructed to compare and contrast environmental conditions that may affect larval development and tunneling behaviors.

The first experiment attempted to address whether the beetle farms needed to be manually populated with dung beetles and what types of tunneling behaviors the different beetle species utilized. Two beetle farms were filled with soil and dung and placed, uncovered, near a corral of cattle (UNPF = unpopulated farms). The remaining four beetle farms were filled with soil and a dung layer and populated with 5 – 7 beetles of one species harvested from dung pats in a nearby pasture (POPF = Populated farms). Covers were placed on the farms and they were left outside in an area that would receive direct sunlight for only half a day. All of the soil used to fill the beetle farms was collected from a nearby ditch at one time. Due to extremely high temperatures and drought conditions, no beetle activity was recorded in this experiment. We observed that the dung in the UNPF lost all moisture within three days. Over a two-week period, we recorded soil temperatures and moisture diffusion into the soil from dung pats. Our results suggested that dung beetles may not be active in soil temperatures exceeding 90ºF and moisture from dung was found to be absorbed into dry soil as much as 2.25 inches from the dung-soil interface.

Concurrently, animals were removed from the pastures due to the extremely dry conditions. We observed that beetle populations severely declined when their source of fresh dung was removed. We conducted one additional experiment with the beetle farms using a lower temperature range and dark conditions. We compared two beetle species and two types of soil: potting soil in one farm and topsoil in the second farm for each species. All four beetle farms were filled with the same amount of dung, randomly seeded with 7 – 10 beetles and maintained in a cool dark room at 75ºF for two weeks. At the end of this experiment, larval counts were conducted on all farms. Larvae developed in only the potting soil environments, even though both soil types had relatively similar moisture content (52 – 53%). Potting soil has a much higher organic matter content than top soil, which may have been a limiting factor. Dung beetles did not seem to need sunlight to build tunnels, lay eggs, and for larvae to develop.

Summary

Dung beetles can positively contribute to grazing farm ecosystems by minimizing horn fly populations that are a nuisance to cattle, put stress on them and possibly limit cattle weight gains. From observations at the Beef Grazing Farm at AARS, the community of beetles present during the study was not sufficient to significantly alter horn fly populations. The impact of heat on the dung pat environment may have caused a decrease in dung beetle numbers but this cannot be concluded since the cattle had to be relocated to the barnyard for hay feeding at the same time. Consequently, the dung beetles' food source was severely diminished. Horn flies use the dung pats to reproduce as well, and the dung pats on the farm were not used or mobilized enough by the available dung beetles to significantly damage horn fly eggs. In some of the Australian studies, many dung beetle species were known for their ability to mobilize dung quickly and efficiently. In the present study, only 2-3 dung beetle species exhibited significant tunneling behavior. These were the *Onthophagus* beetles and *Aphodius badipes*. It is possible that a much higher number of these beetles would be needed to mobilize the dung pats fast enough to produce an impact on horn fly populations. This may be worthy of investigating in future studies.