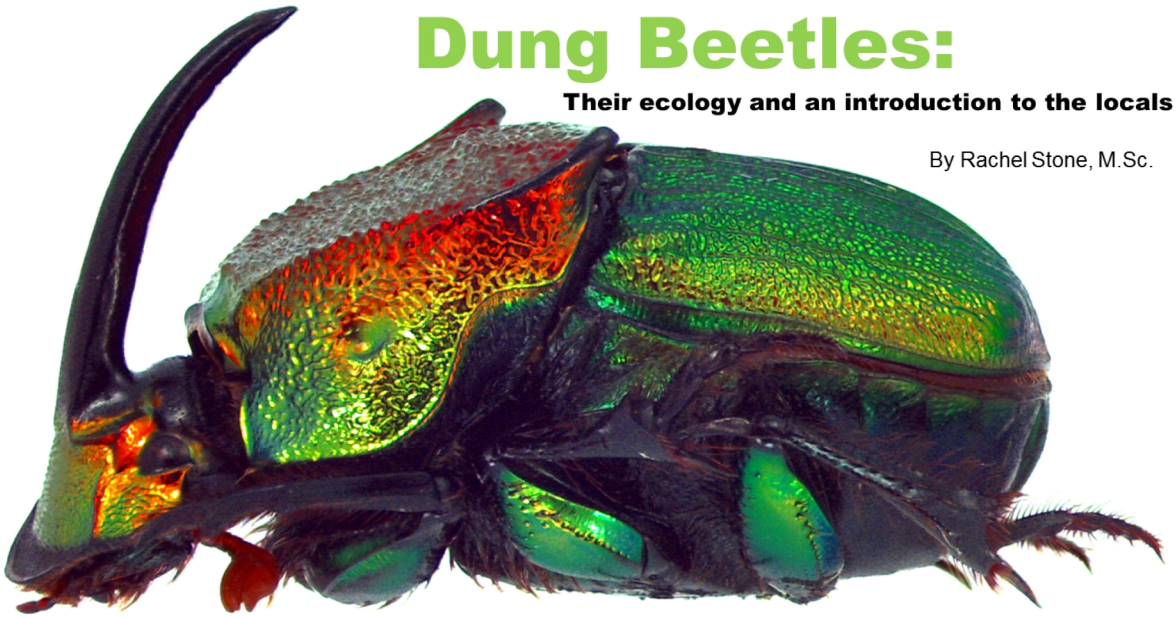
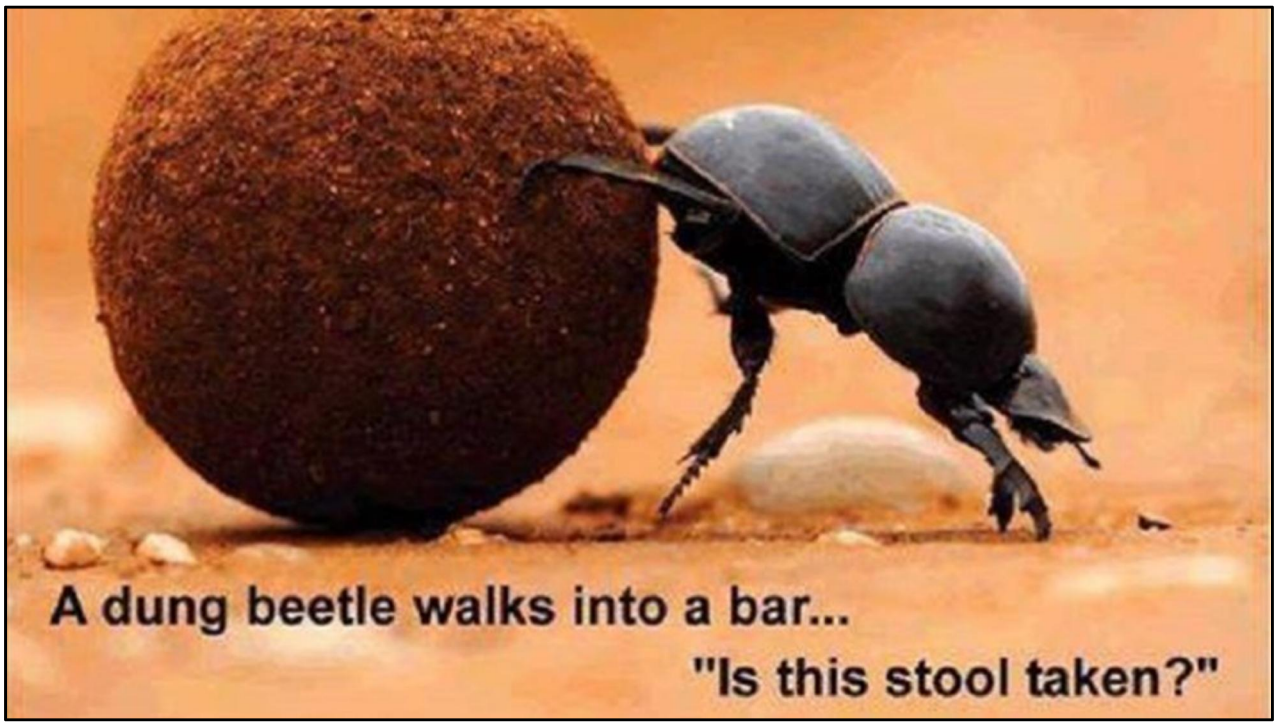
# Dung Beetles:

**Their ecology and an introduction to the locals**

By Rachel Stone, M.Sc.






I'll start with the obvious– that dung beetles eat dung. But that's not the only requirement to be categorized as a "dung beetle". For example, in this region you have lots of water beetles, called hydrophilids, that have made a neat behavioral shift from swimming in water to swimming in fresh cow poop, BUT they are not called dung beetles even though they are absolutely beetles in dung. We can safely call them dung-inhabiting beetles, but "dung beetle" strictly refers to specific taxonomic groupings of beetles found within the scarab super family that have all life stages associated with dung.

# Dung Beetle Taxonomy

***"The beginning of wisdom is calling things by their right name."***

Order: Coleoptera (Beetles)

Superfamily: Scarabaeoidea (Scarab-like beetles)

Families: **Geotrupidae (Earth-boring scarab beetles)**

Scarabaeidae (Scarab beetles)

Subfamilies: **Scarabaeinae (Dung beetles)**

**Aphodiinae (Tiny dung beetles)**

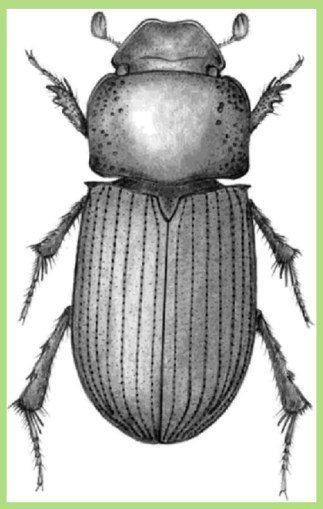


Now, I come from an insect biodiversity background, which means that I really like to order and categorize life into evolutionarily meaningful arrangements. And that is taxonomy in a nutshell. For my group, the dung beetles, we can see how they fit into the larger classification of beetles.

Those considered dung beetles include: those from family Geotrupidae, depending on who's defining the term "dung beetle" and two scarab subfamilies: Scarabaeinae and Aphodiinae– these two groups are the ones I work most closely with. And for two groups who are very closely related, there is an incredible amount of variation in things like development, behavior, and size. For example, the adult body size of these guys can span four orders of magnitude!

**Scarabaeinae**

**Aphodiinae**



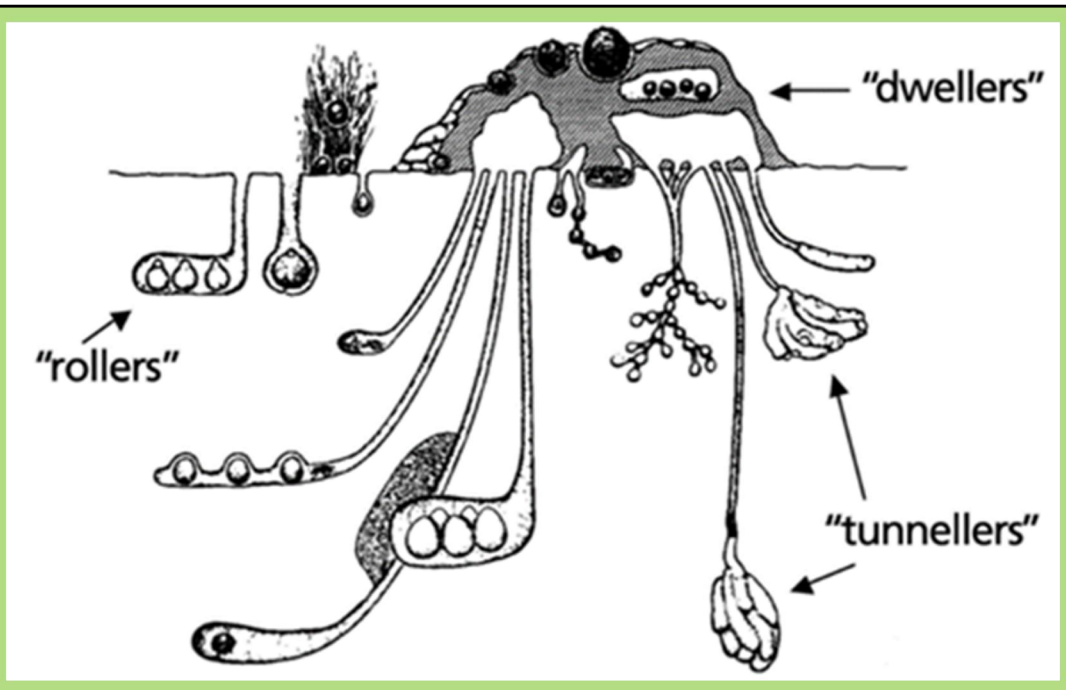
I don't want to bog you all down too much with the morphological characteristics we look at to distinguish scarabaeines from aphodiines, but in looking at a representative from each subfamily– we can see they're pretty different and they serve as a great example of how so often in biology that form follows function. Scarabaeines are tanks– they're stout and robust because they need to efficiently dig into the ground. Member of this group are classified by behavior into the tunneling guild or the rolling guild (which I'll talk about in just a little bit).

While Aphodiines, remember, are tiny-- typically a couple of millimeters long and are elongate and more delicate in form, because they need to efficiently swim and live inside dung as a medium. Members of this group are part of the dwelling guild, as in they dwell in dung.


And that diversity of behaviors we see utilized by dung beetles is thanks in large part to the fiercely competitive nature of those that must capitalize on temporary resources to survive. In ecological jargon we call temporary habitats like dung or carrion “ephemeral resources”, and they serve as really high nutrient islands that sit in a metaphorical desert of low nutrients around them.

I think it’s hard sometimes for people to imagine that a decomposing heap of poop or dead animal can be such a highly prized resource, but they are.

The placement of fresh poop on the ground sets off an intricate chain of animal interactions with flies usually arriving first, then dung beetles, then predator species such as rove beetles and ground beetles there to opportunistically feed on the dung-eating critters. You’ll find parasitoid wasps and flies, spiders, and even snails and slugs just there for the moisture. It’s like you’re stranded and starving on a desert island and suddenly someone drops a pizza on the ground– there is a mad rush to greedily get there first to get your fair share.

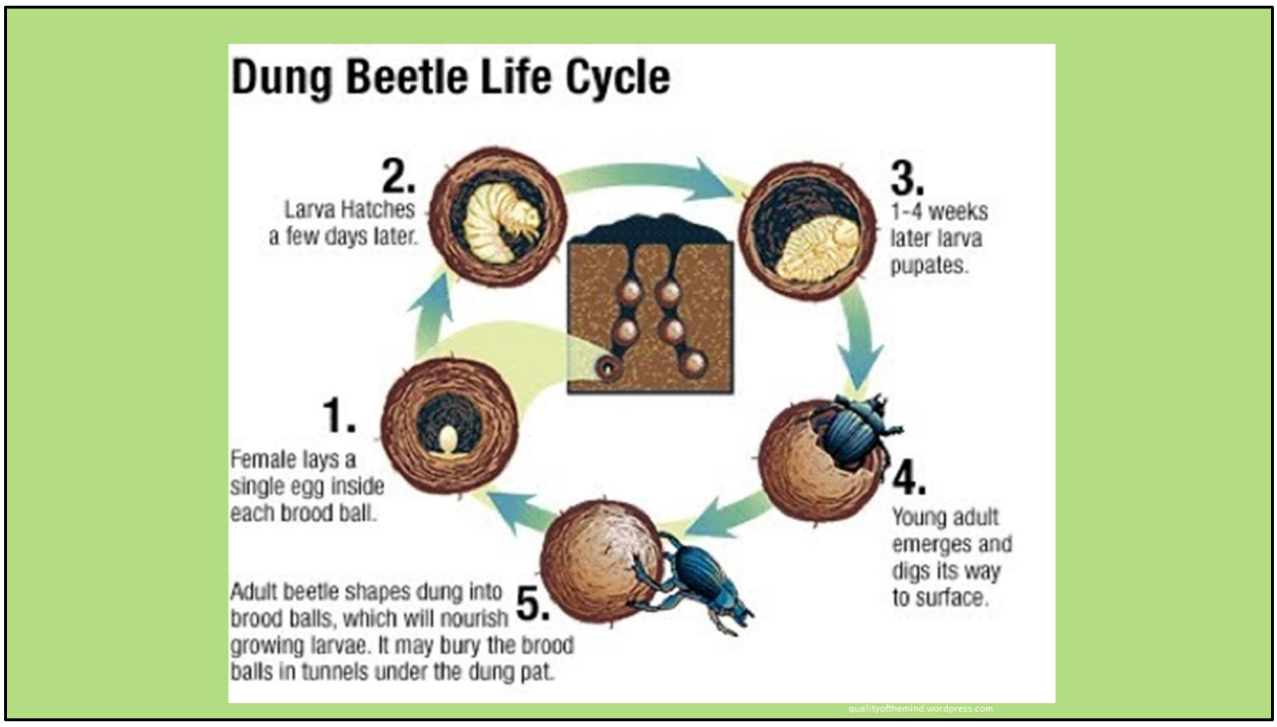



Floate, K.D. 2011. Arthropods in Cattle Dung on Canada's Grasslands (Chapter 4)

And in a effort to get their fair share, dung beetles have developed different behavioral strategies to access the dung heap. To help you visualize the behavioral guilds, here is a representation of the three predominant nesting / feeding behaviors of dung beetles. Those in the subfamily Aphodiinae are the dwellers, meaning that they live inside of the dung pat itself, they will feed from within and lay eggs within as well– some show just the tiniest bit of nest-making behavior but most do not– they simply live, develop, and eat inside of dung.

Then we have the scarabaeines that display more sophisticated behaviors. The tunnellers will drill into the soil directly under the pat and pull down hunks of dung. Then we have the rollers who have one more added level of complexity with their behavior, they also drill tunnels into the ground to bury dung, but before that they actually carve a hunk of dung out of the larger pile, form it into a ball, and roll it away from the chaos of the dung pile.

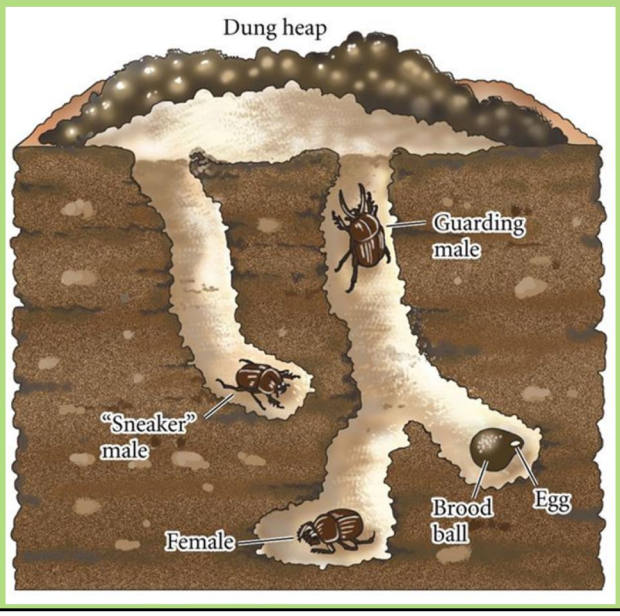
Tunneling and rolling behaviors are complex and absolutely remarkable to me because these are examples of parental care– which is so incredibly rare in insects. These behaviors result in pulling dung away from the competition and leaving it behind to feed their young. The extra investment dung beetles make for their young helps ensure they have a better chance of surviving to adulthood.




Most species of adult scarabaeine dung beetles form a temporary pair bond and make a 1-20 brood balls from feces. Once the dung is pulled down and set into a nest, an egg is laid inside the dung ball– which will serve as a source of food and shelter for the developing beetle larva, which will then pupate, and finally emerge as an adult dung beetle and repeat the process that their parents once did.

# Drama at the Dung Heap!



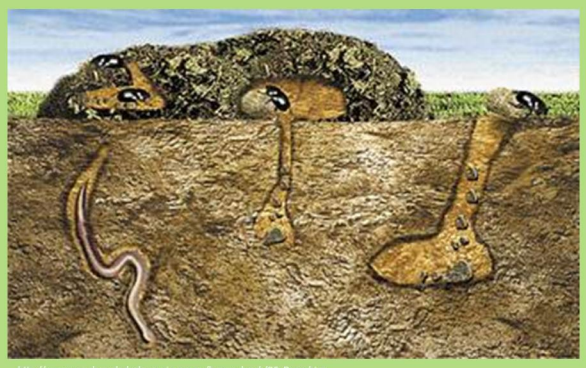



Parental care is important for dung beetles to get a head start because their lives are going to be difficult. A heap of poop is actually the stage of immense drama for the dung beetle– there's all sorts of treachery and romance and danger that abounds. Poop, for the dung beetle, is everything! It's food, it's their childhood home, it's where they will meet their mate, and it's how they will raise up the next generation. The stakes are incredibly high. But, predators know this too, and opportunistically wait at dung pats for their prey to come filing in. For the those that make it past hungry predators, they must then deal with the intense competition of other greedy dung beetles. They're greedy to eat, but they're also greedy to find a mate.

Such as in the interaction between sneaker males and guarding males. In tunneling species there can be a great amount of variation in horn size within the same species. Major males have the largest horns, while minor males might not have one at all. Large horn structures are used as obstacles to block tunnels below dung pats in an effort to guard the male's mate. But even if a minor male can't put up a fight, all hope is not lost for minor males, they can avoid the major males all together by sneakily digging a separate tunnel to meet up with another, where they can surreptitiously mate with his prized female while the major male guards them. Pretty scandalous stuff!

It’s kind of neat to think about the soap opera unfolding for these guys when all we see is this from the outside: the small bits of evidence of dung beetle activity. This first image was taken just the other day and shows tons of evidence of small dweller species, this other image shows the classic “pushed up” soil you see with big tunnellers like the beautiful rainbow scarab from the title slide.

# Dung Beetles are a Farmer's Best Friend



http://www.ccmaknowledgebase.vic.gov.au/brown_book/06_Dung.htm

http://dungbeetleexpert.com.au/dungbeetlebenefit

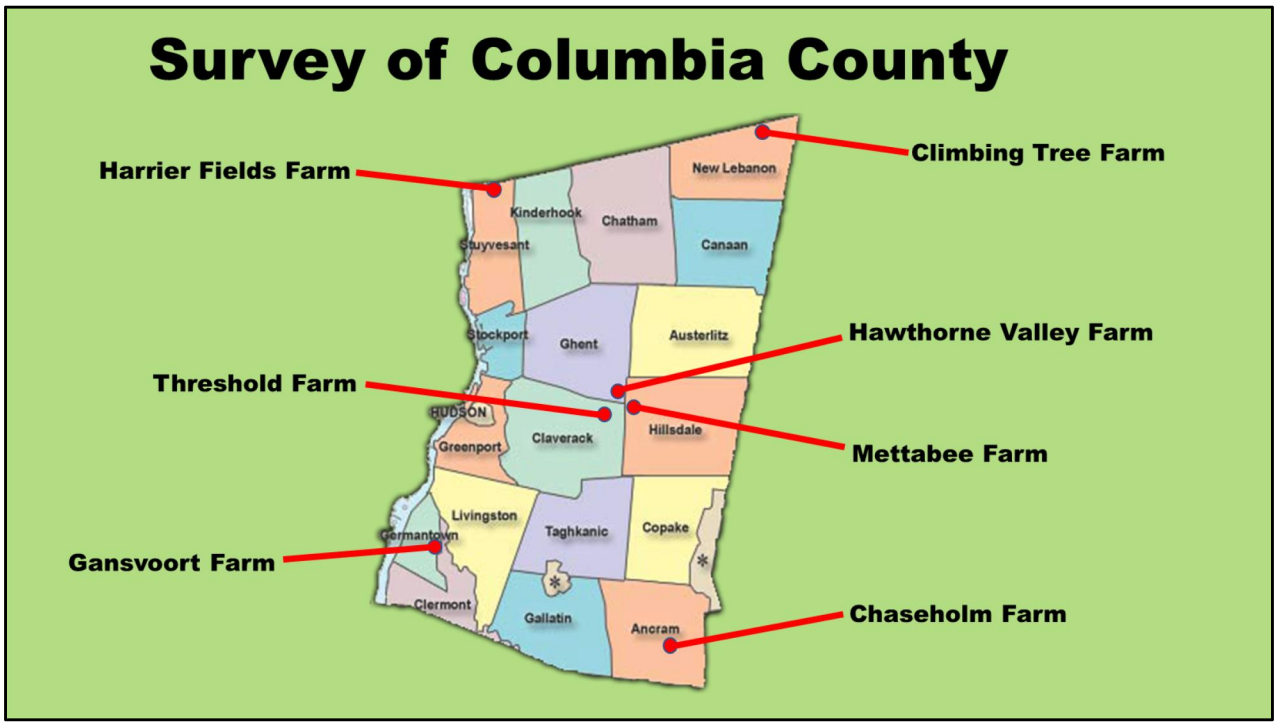
Outside of the drama the dung pat, dung beetles are actually doing a lot of good in the world, outside of the obvious benefit of breaking down poop in the environment, their work provides numerous benefits to soil health.

By Taking organic matter underground, they fertilize the soil with carbon and nitrogen--research has revealed that 80% of the nitrogen in dung when left on pastures goes off into the atmosphere. When dung is well buried by dung beetles the loss is 20% with 80% being placed in the grass root zone.

They also aerate soil with their tunneling, and their buried dung produces a healthy environment for microbial activity, which in turn stores massive amounts of carbon in the soil.
Dung beetles are also capable of burrowing through very compacted soils. Which encourages earthworm activity to follow and enables grass and other plant root systems to penetrate more deeply into zones which could not otherwise be accessed.

By quickly breaking down dung at the surface, dung beetles also interrupt the life cycle of stable flies that are a nuisance to livestock as well as vectors of disease. Dung beetles introduced in Australia, for example, have been tremendously successful in the dramatic reduction of bush flies which even a few decades ago were considered a huge nuisance.

So as you can tell, dung beetles are highly beneficial insects to have around, particularly in the context of agriculture. Which is why it seemed logical to want to know about the dung beetle community here in Columbia County.




Now that you have learned a bit about what dung beetles do and why we'd like to have them around, I want to pivot to the short survey I was able to conduct over June. There are so many great questions we can ask about dung beetle communities here– but the absolute first step is always finding out what species are present, then future studies can build off a solid foundation. So to go about figuring out what species can be found in the county, we selected farms in each corner and a few centrally-located to cast a wide net.


Primarily I focused on baited traps at each farm, what you see is dung enclosed in cheesecloth and carefully suspended over a pitfall trap– which is just a cup buried in the ground filled with some water and dish soap to collect beetles. This technique is the standard for dung beetle collecting and resulted in the most species caught. Using a similar technique, but with a different bait, I set up pitfall traps next to squirrel carrion. I was actually very surprised that I caught no dung beetles at all over the course of three weeks of decay– my thesis was on dung beetles attracted to carrion, and I caught tens of thousands of dung beetles in the course of a year baiting with small mammal carrion in Kansas.

One technique that works very well, but skews towards the dweller species is the floatation technique– you scoop up dung with evidence dung beetle activity and you submerge the whole thing in water and see who floats out. This is a great approach for people who are curious about the presence of dung beetles on their land but don't want to kill them– you can simply interrupt them momentarily and dump the bucket out.

And, the most hygienic of dung beetle survey methods– blacklighting. Many species of aphodiines, the dwellers, are attracted to lights– this again skews towards the dwellers but can help you find some species that don't generally come to dung traps.

One method that wasn't feasible for me, but can produce some of the rarest species is the excavation of mammal burrows. This usually requires a back ho and tedious sifting of soil. Rodent burrows and tree squirrel nest harbor dung beetle specialists that account for about 40% of the species of aphodiines in the mid-western and western US, so it'd be interesting to see what this technique would yield in the north-east.


So while I didn't rent a back ho to sample for beetles, I still did manage to catch a good amount. Overall, I got 384 individuals from 17 different species. Making up a whopping 67% of the almost 400 beetles collected were these three species, which are all aphodiines, or dwellers, and all generalist feeders: Blackburneus stercorosus- a native dung beetle,

Calamosternus granarius- an introduced species from Europe that is now considered the most widespread aphodiine in the world, adult beetles of this species have even been found in ancient Viking waste burial sites!

And over to the right is Oscarinus rusicola, the most widespread native species of aphodiine in the US. This guy is interesting because his species name is still not agreed upon– it's either rusicola or ruricola depending on who you ask– it's argued that ruricola is a misspelling from an entomologist in 1848 that gained traction.

Here is a sampling of the dung beetles I found in moderate numbers.

These include Colobopterus erraticus- a widespread,  introduced European species.

Onthophagus pennysylvanicus- at the size of a big sesame seed, they are the smallest tunnellers found

Geotrupes splendidus- a geotrupid tunneller species that is commonly found in wooded habitat, most of this species were caught at Climbing Tree Farm.

Onthophagus hecate- the most abundant tunneller species and a native

Otophorus haemorrhoidalis, named thusly because he has a little red butt- an introduced European species that I found only in cow dung, and

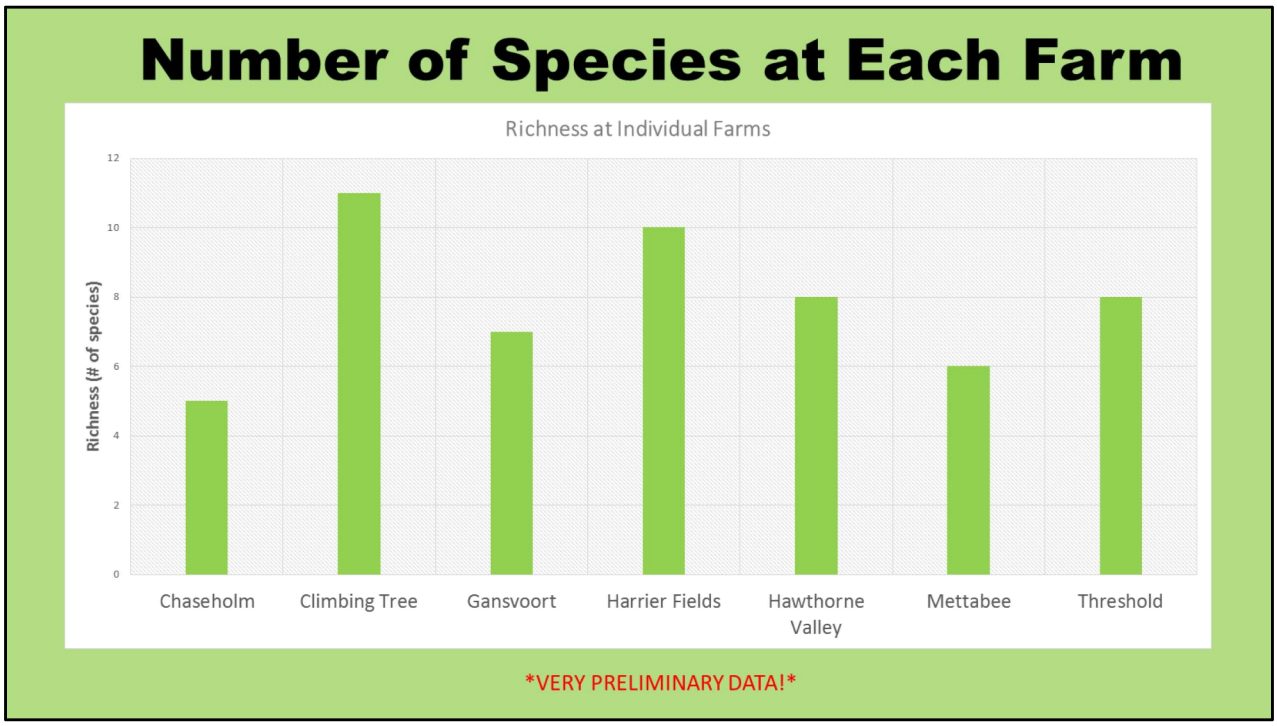
Onthophagus Orpheus canadensis- a cute little shiny tunneller that tends to prefer wooded habitat.

These are a few fun beetles that I found in low numbers but still think are of note, all of these are tunneller species:

Phanaeus vindex- a native and wonderfully charismatic beetle known as the rainbow scarab. 3 individuals of this species were collected, all from Harrier Fields Farm.

Onthophagus Taurus– a non-native species intentionally released in California that has made it up to New York- this species has not been found in the mid-west, but we're expecting its arrival in the next decade.

And finally, Copris fricator, a wonderful native tunneller who goes an extra step in parental care– the mother stays in the nest with her brood balls and carefully cleans and smooths the surface of the ball keeping it free of fungi and mold, only 2 of these were caught– one at Mettabee and one at Climbing Tree.

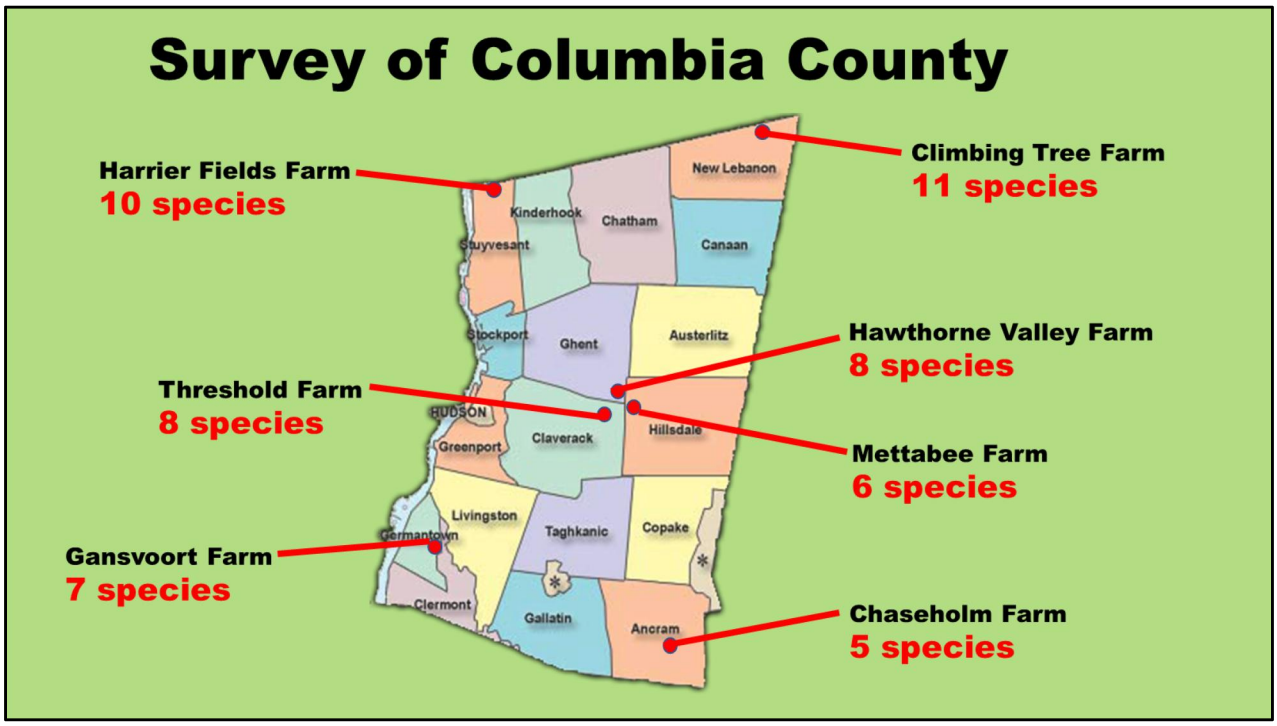



So now that you've met the local beetles, I thought I'd share some little data tidbits. Remember: all data is very preliminary not does not necessarily indicate actual trends!

Overall, I got 384 individuals from 17 different species. Most of those species were the tiny dung beetles, called aphodiines. Overall, 10 species of aphodiines, 6 species of scarabaeines, the true dung beetles, and 1 species of geotrupid, which are technically tunnellers too. Looking at just richness, which just means the number of species, Climbing Tree Farm in New Lebanon was highest with 11 species, while Chaseholm in Pine Plains had the lowest with 5 species caught. Observationally, I noticed a much higher abundance of the water beetles I talked about earlier that swim in cow poop at Chaseholm– there might be an interesting interaction going on there were the water beetle activity is excluding dung beetle activity. Something that would be neat to look at in the future! All other farms had somewhere between 10 and 6 species of dung beetles.

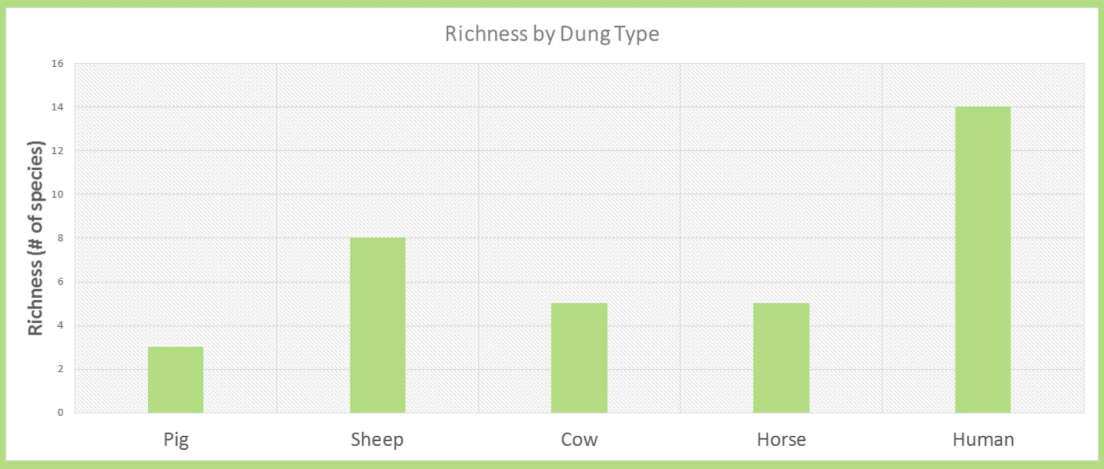

We were just looking at richness, that is number of species, in the last slide, we still have that on top, but below we can compare it to abundance, which is the number of individuals caught. You might notice some discrepancies like with Hawthorne Valley farm where we I found 8 species but only count 2 individuals in the abundance graph– what I did was only look at data from my baited pitfall traps at each farm. This component of the survey was designed and carried out in a uniform way– I had two traps at each farm that were baited once a week and left for 48 hours before pitfall traps were collected for all of June, so four weeks. So I'm comfortable making comparisons of abundance with this data versus the dung beetles I might have caught from a cow pat I picked up at Hawthorne Valley but didn't standardize for size of the dung pat collected or time of day or even the age of the pat.

We can still see though that Climbing Tree Farm wins out with 84 dung beetles caught, while the next runner up is Harrier Fields Farm with 51 individuals. The lowest numbers were at Chaseholm with only 6 collected, and Hawthorne Valley with only two dung beetles caught over the course of four weeks!




For now I wouldn't put too much stock into abundance data as, only a month's worth of sampling is not enough to know any of the trends in dung beetle communities, so while it's interesting, I want to look at richness again. Once again we can see our farms plotted on a map of the county but this time with their associated dung beetle species richness number. I think it's neat that there seems to be some sort of gradient from north to south– although livestock type present on the farm could be a confounding factor making me think that there's a trend when there's really not one-- another interesting component to look at sometime!

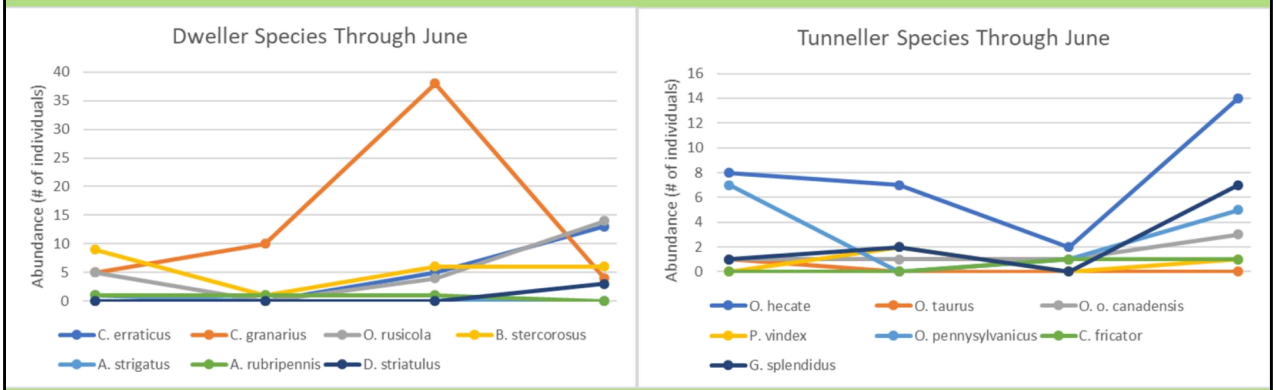
## Whose Poos Do Dung Beetles Choose?




*VERY PRELIMINARY DATA!*

It well known that some dung beetles tend to show food preference with certain kinds of dung, so whenever I'm using multiple kinds of poop it's fun to find out which one brought in the most species– human poop always seems to be the winner. I'd chalk that up to our extremely varied diets. I've never worked with pig poop before and had always read that it was the next most enticing next to human, but did not find that to be the case– in this survey pig poop brought in the lowest richness with only 3 species. Again, though I wouldn't put too much stock into comparisons here as human poop was used for the baited pitfall traps which was highly standardized, while all other animal poops were just happened upon and selected based on no more factors than whether it looked promising and whether or not I had room in my bucket. More work should be done to really figure out any dung beetle preferences for the area.

# Snapshot of Abundances in June




*VERY PRELIMINARY DATA!*

Finally I thought I'd throw in a little snapshot of how abundances of individual species varied throughout my four weeks of collecting. On the left is a graph of dweller species and to the right is a graph of tunneller species– I did not catch any rollers at all while out here! Although Conrad did receive photo evidence of one rolling a dung ball by the Catskills!

I thought it was interesting that when overall tunneller species were collected in their lowest numbers on the 3rd week, that the aphodiine, Blackburneus stercorosus skyrocketed– it is widely reported in dung beetle literature that the scarabaeine species, that is tunnellers and rollers, outcompete the smaller aphodiines, or dwellers, and it's only in the absence of tunnellers and rollers that dwellers can get to really high abundances. Which is maybe what we're seeing play out here. Again, not nearly enough data to actually know.

# THANK YOU!

A month's worth of surveying doesn't give us much, but it gives us a place to start!