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Ecology, Environment, & the Anthropocene

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Term Project Proposal

My subject of focus will be on dung beetles. Or to be more specific, how their presence contributes to the overall health and prosperity of their inhabited ecosystems. I'll also be covering how our presence and subsequent anthropogenic change on these environments has affected their lives. Addressing the cascading effect that has, and can continue to be, exacerbated by humans due to direct and indirect interactions with dung beetles. These interactions have been primarily categorized as negative but are just as easily susceptible to positive change with the proper consideration on how to minimize or even remove intrusive anthropogenic operations or practices in dung beetle territory. This is particularly important for the dung beetle's efficiency and population as any detriment to these measurements has been shown to put unnecessary strain on their ability to cycle nutrients and "dispose" of waste. These are two services that not only ensure the steady and appropriate flow of energy in an ecosystem but also allow humans to benefit from these ecosystems in the first place.

My research consisted of secondary sources that held information on four things:

1. The beneficial properties of dung beetles on their immediate environment;

2. How dung beetles and their environment can be seen supporting one another, creating a positive feedback loop;
3. How this interaction can very easily lead to detrimental effects on either party when one or the other are harmed through anthropogenic changes;
4. And how the reversal or minimization of these negative anthropogenic changes can pose to be beneficial not only to the environment but to humans as well.

From this research I began to recognize just how important these tiny beetles are to so many organisms. These, for lack of an even greater term for my affection, “lil guys” do more than just roll dung around. These beetles are actively living their lives and acting as walking waste recyclers. They are a jack of all trades in the world of dung. They act as pest control, pollution reducers, nutrient dispersers, and seed dispersers.[4] And with all the good they can do, outside of my time researching these beetles due to personal curiosity and for this project, not much is discussed on their benefits. This left me considering what is the most likely culprit for this blatant disregard. The most likely thing would be the fact that these beetles, in the most literal sense, get their hands dirty. These are 6 legged armored bugs for all the public cares and the fact that they are related with waste is in no way supportive of their public image. But it's these beetles' interactions with waste that allow them to be so great. To remove that portion of their function in favor or public approval would be disrespectful and untruthful. Thus I will be more descriptive in what I have learned from this research.

I’ll first discuss the dung beetle's ability to disperse nutrients. Dung beetles feed off of, roll, and place their larvae into dung. These processes introduce bacterial and fungal organisms through the channels left by the aftermath of these activities, creating ample conditions for rapid decomposition.[4] The dung beetle’s dependency on dung allows for consistency in the

decomposition of the dung pats (fecal piles) present on pastures and other grazing areas for cattle or other animals.[3] These dung pats contain vital nutrients for soil such as ammonium, methane, nitrogen, phosphorus, and carbon.[4,5] And when dispersed by dung beetles and other decomposers they can enrich the surrounding soil. These increases can also be seen to vary amongst dung beetle species, with dweller, tunneler, and roller dung beetles — in their different interactions with dung — affecting different depths of soil.

In terms of the tunneler dung beetle, they are found to live underground where they interact with dung pats in small quantities, transporting dung from above the soil to down below within their created tunnels for the sake of reproduction. This process creates an observable increase in total nitrogen (N), phosphorus (P), and organic matter within soil profiles found to contain tunneler beetles by 50%.[4] Rollers, unlike tunnelers, are found to primarily reside above the soil surface. Taking portions of dung pats and moving them above the soil and away from the original mass in the form of a ball, later burying these balls for both consumption and reproduction. This process was found to increase ammonium (NH_4^+) in deep soils by 60%.[4] Lastly, dwelling beetles are observed to live within the dung pats themselves, reproducing and consuming the dung during this time. This approach would be found to increase soil surface phosphorus (P) and organic matter concentrations by 50%.[4] And with the movement of both the tunneler and roller dung beetles, the presence of seeds in dung allows for the beetles to contribute to the secondary dispersal of seeds. The decomposition of animal manure through dung beetles provides an extremely favorable situation for seedlings, both due to the distance and means through which they were moved, vertically (rolling) and horizontally (burial)[4], and the removal of dung that could actually have acted as a barrier to their germination.[5]

Moreover, to discuss the removal of air pollution, dung beetles have their legs and palps in that too. With the aforementioned life styles of different beetles, there is a reduction in carbon dioxide, methane, and nitrous oxide emissions from dung pats. This is done through the aeration of dung pats through the dispersal, burial, and consumption of dung by the beetles. This has been shown to result in a decrease of 7% carbon dioxide emissions, 2% from nitrous oxide emissions, and 14.5% from methane emissions from dung pats during grazing periods.[4]

And to step towards a more closely human involved service, dung beetles provide pest reduction. Dung beetles, as they move and consume dung, often encounter and compete with pests such as flies and gastrointestinal parasites. These interactions often include the burial of larvae alongside dung without proper means of escape or the consumption of these pest eggs as they are contained within dung. Dung beetles act as a natural barrier to pest overabundance as they curtail the reproductive cycle of common flies and parasites at the larval stage. This in turn prevents cattle and other mammals from contracting health threatening infections and illness. The dung beetle represents a natural method to avoid cattle health issues.[2]

But, it would be wise to recognize that, with the current framework to cattle rearing, farmers are taking matters into their own hands. Cattle are often treated with antiparasitic medicines. One of which is classified as anthelmintics, otherwise known as dewormer, which target and cause the expulsion of parasitic worms from within the gastrointestinal tract. The use of anthelmintics comes from the prevalence of two things: the parasites themselves, which pose health risks to cattle they make contact with, and the easily transmittable conditions many cattle find themselves in within farms. These conditions often consist of the practice of using grazing land to store dung, permitting the accumulation of both waste and pests within the general feeding areas of cattle. This facilitates cattle exposure to infection and reinfection by parasites.[2]

And with the natural expulsion of parasitic worms through manure, the eggs present in the manure when provided enough time will hatch and present larvae in the area in which they were laid, which in the case of most cattle, will be near where they will graze. This is how cattle find themselves infected, through the accidental consumption of said larvae. And most cattle farms consist of large quantities of cattle to turn a profit on meat, dairy, or for cattle reproduction, exacerbating this problem due to a large quantity of waste that comes from the grazing and herding of said animals.[2] This can be seen as an issue of quantity and space on farms. With the amount of cattle on grazing land directly contributing to the amount of waste on said land at any given time. While the space given to cattle for grazing (which is also affected by the amount of cattle) determines the amount of un-affected grazing land (by parasite larvae) at any given time. Both of which, while still capable of contributing to the likelihood of parasitic infection, can have their effects lessened with the presence of dung beetles to speed up decomposition and reduce pest populations. [2,4]

This is all to say that anthelmintics are being used as a man-made method to combat cattle illness through the prevention of parasitic infection. However, the presence of anthelmintics not only overshadows the natural antiparasitic properties of the dung beetle, but has been shown to harm dung beetles when present in significant quantities.[2] This comes from anthelmintics doubling as insecticides, which when coming into contact with dung beetles (via significant enough quantities in dung), has been shown to act as a toxin.[2] This is especially important to note as the reduction in dung beetle populations harms their ability to cycle nutrients and reduce waste, allowing for the growth of parasite populations while doubly harming soil richness.[4]

This brings me to the broader topic of anthropogenic based environmental and climate change. On top of the use of resources for human interests there is also the “renovation” of areas for those same purposes. Dung beetles make use of shrubbery as supporting flora. The shade provided by shrubbery acts as a very delicate supporter of appropriate temperature for dung beetles. The removal of shrubbery detrimentally impacts the dung beetle’s diversity in affected areas.[3] And I must highlight that the removal of this natural shrubbery has been done through human means, with clearing for both timber and grazing grounds being the main culprits. These ecosystems are being shifted from being a diverse and heterogeneous mix to a monoculture of tall grasses made to satisfy the basic needs of cattle.

And for the more indirect interaction between humans and dung beetles, that being climate change, we can observe that increases seen in both temperature and greenhouse gases are producing just as harmful effects on beetle abundance, diversity, and health.[4] The increase in temperature in dung beetle habitats was found to slow beetle reproduction, showing an inverse relation with brood numbers as temperatures rose. With an example showing a 30-36% decrease in brood numbers as temperatures began to rise by 2^{o}C and 4^{o}C within a 22-30^{o}C range.[4] And in terms of greenhouse gases, an increase of carbon dioxide from external sources has been seen to increase dung beetle mortality. An increase of over 600 ppm of atmospheric carbon dioxide inside a dung beetle ecosystem has displayed a decrease in beetle size while also impeding larval development, causing this negative change.[4] On top of this direct effect on dung beetle mortality, the increase of carbon dioxide has also affected the plants present in those ecosystems. Lowering nitrogen and phosphorus levels within plants which are eaten and act as nutrient providers within cattle waste, removing nutrient availability for dung beetles and other organisms who rely on waste.[4]

From all this research I have learned that dung beetles are strong environmental helpers that havent been treated as such. It has been made clear that we have taken their environmental services of burying and digesting pests, cycling vital nutrients (like nitrogen, carbon, and organic matter), waste reduction, and air pollution reduction for granted.[3,4,5] And have allowed temperature changes (via climate change) to reduce their ability to properly reproduce and efficiently work for the betterment of the environment.[4] We are looking at the world solely through a human centered lens when there are so many animals who live in the same world as us. These environments are not closed circuits, we are ultimately being harmed as well when we neglect environmental superpowers like dung beetles, with soil richness being reduced and the nutrients present in plants going down just the same with dung beetle reductions.[4] We've even gone as far to have radically altered their regions for livestock efficiency, removing diverse forests in favor of a uniform grassland for grazing. And to go even further we've introduced anti-parasitics into their food-chain without regard for their toxicity,[2] finding it more efficient and trusted to focus on our cattle than the natural anti-parasitic nature of dung beetles.

I want to highlight the clear importance of these beetles in my creative work. They are capable of taking out so much from what we as humans perceive as waste. I want to highlight how they benefit their ecosystems with nutrient cycling, seed dispersal, and waste removal.[1,2,5] I would like to portray how we as humans must take action against climate change and not only acknowledge our own practices but also change them to reduce fatalities not only in dung beetle populations but in organisms across the world. I want to convey just how severe these issues are and how even though they can seem as minor as "small" percentages now, they can easily ramp up into larger problems that we might not be able to walk away from. And what better way to do so than humanize these critters?

In my creative work I want to create a clear dynamic between dung beetles and their environment. To make something that seems approachable by the public, removing the negative stigma behind dung beetles and their *unique* lifestyle. I want to add character to these beetles, allowing viewers to see how dung beetles give back to the environment they inhabit and that their means of doing so shouldn't make them any lesser than more "human" animals. That said, I am likely to add a level of imagination to my creative work to achieve this purpose. And to that end I would like to approach this project with a younger audience in mind as I will be using a more cartoony approach in my work as bugs can be seen as off putting to a greater majority than those who enjoy their weird and at times almost extraterrestrial appearances.

I would like to create a cartoon for this very reason. Where I will approach one of two ideas. One where I will produce an intro, much like in an animated tv show in a storyboard format. I would show the life of a dung beetle and the hijinks they get up to, showing clips from the supposed show they'd be a part of where it would contain highs and lows of the dung beetle, their potential companions, and the main challenges dung beetles face today. The second being a poster for said show, portraying the dung beetle character interacting with the environment in this fantastical way as the main threats and companions loom over their head much like a star wars film poster or even an animated show's debut poster.

In this imaginary world where dung beetles can talk and their soil benefits are near instant, I would like to create a small protagonist that explores this upsized world full of thick shrubbery, tunnels, and dung. Although, my portrayal of the dung is likely to be more mystical in this universe to highlight how fundamental it is to an ecosystem, with its powers being showcased in the near instance growth of plants. I'd have stark differences between underground

sections, cleared thickets, and shaded shrubberies, adding a level of suspense and awe with each one, bringing fantastical sizes and portrayals of dung beetles and their environment.

Annotated Bibliography

1. ***Milotić, Tanja, and Maurice Hoffmann. "Cost or benefit for growth and flowering of seedlings and juvenile grassland plants in a dung environment." Plant Ecology 217.8 (2016): 1025-1042.***
    - Dung acts as seed carriers allowing for the dispersal of plants over an area through a process known as endozoochory. This is done through the presence of undigested seeds in manure being transported by the tunneling and rolling of dung by dung beetles.
2. ***Beynon, Sarah A., Warwick A. Wainwright, and Michael Christie. "The application of an ecosystem services framework to estimate the economic value of dung beetles to the UK cattle industry." Ecological Entomology 40 (2015): 124-135.***
    - Human use of anti-parasitic medicine (anthelmintics) on cattle has been shown to detrimentally impact dung beetle populations due to their toxicity (to dung beetles).
    - Ecosystem services of pest fly control, prevention of pasture fouling (could be related to previous source's discussion of plant damage via fresh dung, could illustrate dung beetle's ability to maintain a balance in nutrient cycling alongside other insects and decomposers.), gastrointestinal parasite control (potentially discuss the human involvement in parasite prevention (anthelmintics) and the

natural approach which cannot be done with the currently prominent excessive cattle presence), and increased nutrient cycling.

3. ***Sarmiento-Garces, Rodrigo, and Malva Isabel Medina Hernández. "A decrease in taxonomic and functional diversity of dung beetles impacts the ecosystem function of manure removal in altered subtropical habitats." PLoS One 16.1 (2021): e0244783.***
    - Habitat destruction disrupts vital systems put in place to cycle nutrients, causing potentially irreversible damage to an already delicate and fine tuned ecosystem.
    - The explosive growth in livestock can be seen to harm the diversity present in dung beetles and the like by creating an unsustainable monoculture from landscape altering for grazing, removing crucial shade and fauna for the dung beetle.
4. ***Torabian, Shiva, A. Joshua Leffler, and Lora Perkins. "Importance of restoration of dung beetles in the maintenance of ecosystem services." Ecological Solutions and Evidence 5.1 (2024): e12297.***
    - Greater info on nutrient cycling. How their interaction with dung is carried out and how that process is capable of cycling the necessary nutrients for an ecosystem.
        - Dung beetles digest, bury, and roll pests and their larvae present in dung, reducing their overall presence in wildlife and livestock. These actions by dung beetles act as a barrier between pests and cattle by preventing the re-infection of cattle or the spreading of pests to previously unaffected cattle through dung contact.

    - Dung beetles reduce Carbon Dioxide emissions by 7%, Methane emissions by 14.5%, and Nitrous Oxide by 2% from dung pats made by cattle during grazing. This is done through the burial of dung, leading to their decomposition by microbes in the soil (instead of open-air decomposition) and the increased decomposition of dung pats through the movement done by dung beetles.
    - The presence of dung beetles such as dwellers has been seen to “increase organic matter and phosphorus concentrations by 50% at the soil surface”
    - Rollers were found to “ increase ammonium in deep soils by 60%”
    - And tunnelers, much like dwellers, were found to “increase organic matter, total nitrogen, and phosphorus throughout the soil profile by 50%”
- Climate change has caused higher mortality rates amongst dung beetles through higher carbon dioxide amounts, temperatures rising out of their tolerance range, and shrub reduction in areas going below 10%.

5. ***Menéndez, Rosa, Paul Webb, and Kate H. Orwin. "Complementarity of dung beetle species with different functional behaviours influence dung–soil carbon cycling." Soil Biology and Biochemistry 92 (2016): 142-148.***
    - Not only acknowledge the diversity in the dung beetle species but discuss their different approaches and benefits of their presence in ecosystems.
    - Discusses the Dweller species of dung beetles and Tunneler species.
        - Both are capable of being sufficient nutrient cyclers on their own.
        - When in the presence of one another additional benefits can be observed. (high soil microbial respiration)

- Use this discussion as a reason to burrow *(see what I did there)* into how biodiversity has allowed so many species, just like the dung beetle, to provide **different** avenues of environmental assistance while staying within their niche. (Possibly taking a step back to connect the protection of dung beetles to other, equally as important, species.)