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Art + Science + Dung Beetles: Collaborating to Sustain People, Land and Water

Dung beetles connect history, myth, science, and economy. They symbolise regeneration and restoration of life. They keep vital ecological cycles churning, build soil, disperse nutrients, and even play a role in protecting our streams. They improve soils to help feed people. That makes dung beetles joiners and menders – what better agents for connecting the minds and hearts of an artist (Jessica Ritchie), an entomologist (Emma Curtin) and an ecologist (Henrik Moller) in an Art+Water project?

DOWN TO EARTH ON THE FARMS

We begin at a rather surprising place. New Zealand has a big, not to say, smelly problem – a need to disperse a whole heap of animal dung! Farming covers 17 million hectares[1], or 54.8% of New Zealand[2], and supports around 52 million grazing animals[3]. New Zealand has the second highest number of cows per capita in the world. One cow alone defecates on average 16 times a day[4].

Healthy soil is like a sponge that can help solve some of the problems caused by dung. It's full of air pockets, called soil pores, that store oxygen for plant roots and provide homes to many beneficial soil invertebrates[5]. Soil pores soak up and store water when it rains, which reduces erosion, keeps the soil moist and healthy, and staves off drought. That, in turn, keeps the grass and stock growing faster and for longer. The soil's organic matter, partly provided by dung, is the glue that builds the soil structure and creates those crucial soil pores. Cattle are heavy and can compact the soil by destroying the soil pores when they trample paddocks. Rain falling on compacted soil is more likely to wash off instead of soaking in, thereby flushing dung into waterways.

This runoff is a serious threat to the health of streams and water quality[6]. It is also a waste of precious nutrients that could otherwise have been retained in the paddocks to build soil and grow grass and animals to feed us. Loss of soil pores leads to decreased plant growth[7], which in turn leads farmers to apply more fertiliser to their soils. Excessive fertilisation is environmentally damaging[8] and expensive in both financial and greenhouse gas pollution terms. Stock, understandably, avoid grazing too close to dung[9], which harbours intestinal parasites and biting flies.[10] Cattle dung is also a significant source of greenhouse gases.[11] The quicker we can integrate dung into the soil profile, the better for people, profit and planet.

DUNG BEETLES: BEAUTIFUL ECOSYSTEM ENGINEERS

Soil is not just dirt! It's a living ecosystem that holds nutrients and water, stores carbon and grows plants, upon which all animals depend. Soils are also the world's composting system – a thriving community of bacteria, fungi, and invertebrates that drives a vast recycling system to break down dead plants and animals into nutrients, which can be reused by the next generation of plants and animals. Life on earth depends on keeping this recycling system going.

An army of soil decomposers have some special allies that ecologists call "ecosystem engineers" – creatures like earthworms and dung beetles. These engineers build and maintain the soil itself and thereby enable all the other soil decomposers to do their work. Earthworms and dung beetles gently till the soil, spreading the nutrients and mixing in the organic matter that glues soil particles together. They also create tunnels, which let air and water in, allowing plants to thrive, and the soil to absorb water and nutrients.

Figure 1. *Bubus bison*, one of the species of dung beetles that has been cleared for release in New Zealand. The "teeth" on their front legs are used for scraping soil to form burrows up to 30 cm below dung pats in compact silt and clays.
Photograph: Can Stock Photo, image 5135991, purchased by Dung Beetle Innovations.

Figure 2. Emma Curtin, the entomologist in the project team, holds a *Copris hispanus* on her hand. It comes from south-west Europe and makes tunnels up to 40 cm deep below dung pats.
Photograph: Guy Frederick.

Dung beetles feed partly or exclusively on dung from animals. Different beetles eat different dung, be it from cow, sheep, goat, deer, pig, or even dog. There are three different types of dung beetles: rollers, dwellers and tunnellers. Rollers compact dung into balls and roll it away across the surface of the soil to bury it in chambers they have prepared elsewhere. Dwellers do not move the dung anywhere, they simply live in the dung pat. It's the tunnellers that do the most work to build our soils. They dig burrows below the pat, which they pack with dung that is formed into brood balls, where they lay their eggs. These hatch into larvae, which feed on the stored dung before becoming adults and crawling to the surface to fly off to find a fresh dung pat, and start the cycle all over again.

For us in this Art+Science team, the dung beetles are more than just useful links in ecology's golden chain – they are spectacularly beautiful animals in their own right. They have amazing textures on their armour-plated exoskeleton (Figure. 1). Some are coloured – for example, *Geotrupes spiniger* is commonly called the pāua beetle because of its shimmering blue iridescence. The beetles may be small (Figure. 2), but they are incredibly strong – they can force their way out of a mere human's clenched fist, which indicates the power they muster to burrow into compacted earth!
All dung beetles are "scarabs", i.e. they belong to the superfamily Scarabaeoidea, and most of them are in the subfamily Scarabaeinae. There are over 5,000 species of dung beetle worldwide, with many countries (such as England, Russia, Madagascar, and Australia) having several hundred species each. South Africa alone has nearly 2,000 species. New Zealand missed out on this diversity because it lacked browsing mammals (and their supply of dung) in its evolutionary history, but it does have 16 native species[12]. These native dung beetles are small, flightless, and live in forests – and unfortunately, they are unable to cope with mammalian dung, which now abounds in the landscapes we modified for pastoral farming[13].

CONNECTING PEOPLE AND THE LAND ... BY INTRODUCING DUNG BEETLES

Establishing large numbers of the "missing" dung beetles to New Zealand farmland will be a big step to enhance the environmental health of our land and water, to reduce waste, and to demonstrate land stewardship to both New Zealanders and overseas customers who buy our meat, wool and milk. The unintended environmental and social consequences of intensive livestock farming have begun to erode farmers' social license to operate even though they are mainstays of New Zealand's export economy. Bringing a variety of dung beetles to New Zealand, rearing them, and spreading them throughout our farmland is now an urgent and collaborative mission of many ecologists and entomologists, as well as an increasing number of farmers and townies alike.

In 2011, the Environmental Risk Management Authority (now the Environmental Protection Agency) approved the importation and release of eleven species of dung beetles into New Zealand, after prolonged safety testing and public consultation. A team at Dung Beetle Innovations have spent 5 years mass-rearing the beetles in an Auckland facility, ready for dispersal across New Zealand. Farmers, regional councils, land care groups, and catchment groups are now releasing these facility-reared beetles. It may take a decade for them to build up numbers to reach their ecological carrying capacity, but benefits for soil and water health, parasite control, climate change mitigation, and soil facility are expected from about five years onwards.

Beef+Lamb New Zealand is one of several groups working with farmers and rural communities to release the beetles, monitor their progress, and learn about their ecological benefits. Their "Hill Country Futures" research project is promoting dung beetles as a citizen science engagement with farmers and school children at the Whangawehi Catchment Management Group's community at Mahia. The monitoring and teaching modules will next be rolled out around Otago.

Dung beetles are superb ambassadors for biological farming approaches and land stewardship in general. There is a Māori saying that is particularly relevant here: "Ka ora te whenua, ka ora te tangata" (If the land is healthy, the people are healthy). Whenua is the Māori word for both placenta and for land; the land forms and nurtures us and our society in spiritual and material ways. We have a daunting ethical challenge ahead to feed a growing world population, which is expected to reach 11 billion people by 2050. This will require us to be smart and efficient and not degrade the healthy soil on which food and fibre production depends. Releasing dung beetles gives locals a chance to join together to improve our system of food production and learn that we all can play a part to secure our common future.

AN ARTIST'S VISION: *"NAVIGATING THE WORLD BY THE SUN"*

Jessica Ritchie, the artist in our coalition, blew the team's dung beetle obsession into a more spiritual sphere. She points out that Egyptian scarab beetles are connected to Khepri, the scarab-headed god of the morning sun. According to Egyptian mythology, this god renews the sun daily, by rolling the rising sun across the sky, over the horizon, and then carries it through the underworld, so that it is renewed for the next day. The scarab is worshipped as the embodiment of rebirth and regeneration[14]. What better inspiration for painting the work of dung beetles regenerating and connecting land, communities, and water?

When Jessica first thought of dung beetles, she had a dual reaction: they are creepy crawlies, yet beautiful at the same time. Looking at images of a variety of dung beetles, it was their iridescent colours that inspired Jessica's choice of reflective materials, with colours that shift with variation of the angle of light and viewing. Her finished artwork consists of five round panels. From bottom to top, each round represents land, community, moon, sun, and water (Figure. 3). The small glass domes in each work (Figures. 4, 5 and 6) represent the beetle moving through, over, and under. They are reminiscent of the beetles' hard shiny shells and the reflective nature of water. Jessica did not want a literal depiction of the dung beetle; instead, she aimed for an image of an object moving through water and in and across land. The fluid-like nature of her paint recalls glistening water, as the dung beetle's work improves water retention and creates cleaner catchments.

The final works (Figure. 3) are arranged in the pattern of a wave or cycle to represent the flow of water. The reflective and metallic materials contrast with the black wall the paintings are hung on, giving the final works a celestial look. The title of the work, *Crawling out of the Darkness and Navigating the World by the Sun*, comes from the fact that dung beetles use celestial cues from sun, moon, or stars to navigate their path in a straight line[15]. It is also suggestive of a brighter, more positive path. The dung beetle's process is that of a complex interaction of recycling and reusing; in this series of five round paintings, each round makes part of a whole. Just as streams and waterways are all interconnected, so are the ties between land and communities. Dung beetles offer a long-term sustainable solution to preventing pastoral-based pollution entering our waterways.

Figure 3. Jessica Ritchie, *Crawling out of the Darkness and Navigating the World by the Sun*, 2019, acrylic, glass, glitter, gold and copper leaf, and shellac on wood panels, 20 cm, 30 cm, and 40 cm. Photograph: Jessica Ritchie.

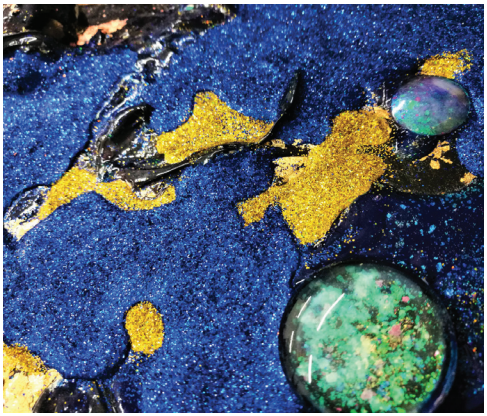

Figure 4. Jessica Ritchie, *Crawling out of the Darkness and Navigating the World by the Sun*, 2019, acrylic, glass, glitter, gold and copper leaf (detail). Photograph: Jessica Ritchie.

SCIENTISTS AND ARTISTS AT A JUNCTURE:

Jessica found that creating a project with scientists provided perspectives outside her own usual practice, and an entry point into a scientific idea. It was an opportunity to gain insights into a different realm without fear of the unknown. This provided a glimpse into a world that she previously did not know existed. Making the artwork bridged a space between Jessica's art practice and our shared beliefs in the importance of ecology and looking after the land and each other. Neither Emma nor Henrik had been invited to take part in a collaboration with an artist before. They found the experience really invigorating; Jessica's studio was refreshingly different from their own clinical workspaces.

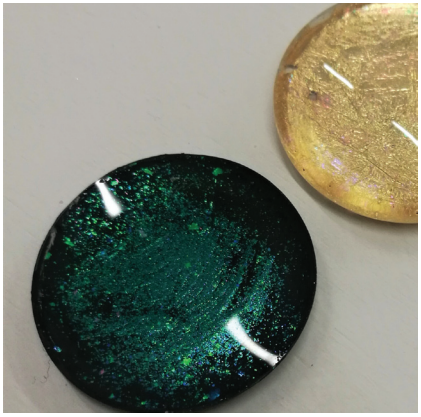

Figure 5 and 6. Jessica Ritchie, work in progress: experimentation with reflective materials (detail), 2019. Photograph: Jessica Ritchie.

Collaboration need not be complicated or have some cerebral and intellectual agenda. We were coming from seemingly very different places (art and science) but we had the same simple goal in mind: to showcase the fascinating world of dung beetles and the benefits they bring to people and society. However, the process still surprised and delighted us in unexpected ways. Scientists use hard facts, numbers, and reasoning to find some "truth" – they are trained to not let feelings and emotions blind them to evidence. But in reality, all scientists have feelings and emotions about their work. What they choose to study is an emotional and ethical choice. Forming models and hypotheses to test requires both imagination and logical thought by the scientist. The objective disciplines come later in their practice when it's time to assess evidence. This is not that different from an artist imagining and conceiving a work and then critically evaluating their assemblage, use of colour, textures, and materials at the end.

Emma and Henrik are besotted with beetles and committed to supporting farmers and farming practices that will be valued by all New Zealanders. They were refreshed by seeing their work reflected back to them – not in figures, numbers, and words – but in shapes, textures, and colours. Jessica's reference to the Egyptian's ethereal explanation for nature's rhythms at first greatly surprised Henrik, but in the end, brought him to realise humanity's different ways of knowing and expressing metaphors about ecological connection and renewal. The artist saw a bigger shimmering celestial picture of sky and earth; the scientists expected a focus on beetles and dung. Although artists and scientists, alike, need to mobilise different knowledge, experimentation, and communication skills, both start with imagination and paint preliminary pictures in their heads.

Artist and scientists, when they work together, can communicate better, reach different levels of understanding, and move different people. Artwork joined to scientific commentary allows the public to engage with ideas and issues in a more complete way. Science can be complicated, but artwork provides an accessible way to enter the conversation, encouraging non-scientists to seek a deeper understanding or see something in a way that may change their own perspectives. We think artists and scientists can also learn a lot through such collaborations. The scientific process too often closes down perspectives to try to understand the world's parts, and artists can help them open out again. Art and science aren't so different after all: both are looking for the beauty in things – they just express that beauty differently. And by sensing that beauty in different ways together, we each return to our work, enhanced with heightened passion and new perspectives.

Emma Curtin, a PhD student based in the Zoology Department at the University of Otago, is investigating three main research questions: Do dung beetles provide benefits to soil structure and composition, and does this lead to a decrease in nutrient leaching? Do dung beetles affect the biomass and abundance of earthworms? Can dung beetles effectively break the life cycle of intestinal worms?

Jessica Ritchie, a Dunedin based artist, has a Master of Fine Arts (distinction) from the Dunedin School of Art. Her practise is concerned with process, the exploration of the formal qualities of painting, and the expressive forces of colour, light, and materiality. She is a qualified art and music secondary school teacher, and early childhood teacher.

Henrik Moller is a Professor Emeritus at the University of Otago's Centre for Sustainability – Agriculture, Food, Energy & Environment. He co-leads the "Hill Country Futures" project for Beef+Lamb New Zealand, which features release and monitoring of dung beetles for regenerative agriculture and other potentially valuable biological farming approaches to future-proof hill country farming, the hill lands, and their communities.

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