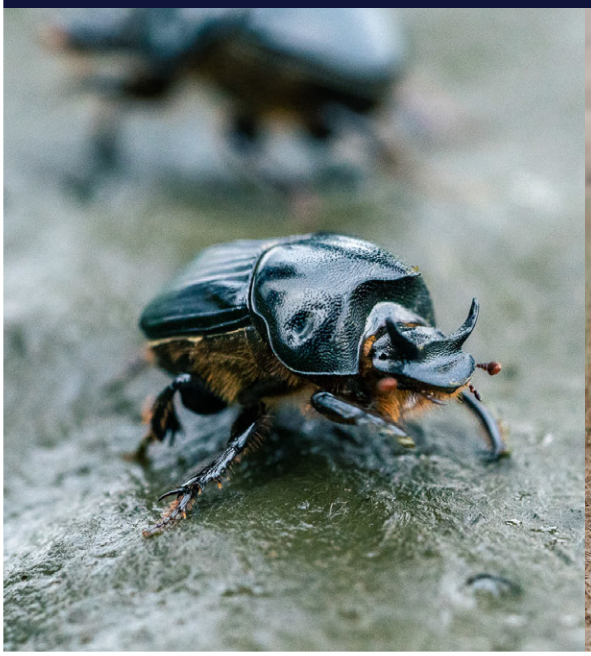
Managing dung beetles on your farm

A guide to making dung beetles work effectively on your property.

DUNG BEETLE
Ecosystem Engineers



Introduction

Dung beetles are an important group of insects that mostly feed on animal dung. They can play a critical role in processing significant quantities of dung in a variety of ecosystems and are found on all continents except Antarctica.

KEY BENEFITS

- **Improve soil**
- **Increase pasture growth**
- **Reduce livestock parasites**
- **Reduce water runoff**
- **Reduce bushfly and buffalo fly populations**

In Australia there are more than 25 introduced species established and over 500 species of native dung beetles. Dung beetles vary in size, colour, and body mass depending on species *(Figure 1)*, but they also differ in the way they process dung, and in their preference for different dung types. Australian native beetles generally prefer dry pelleted dung from marsupials, while introduced species have been selected for their ability to process dung associated with introduced livestock. Certain dung beetles are very active in processing dung and are capable of burying up to 250 times their body mass in a single day.

Globally there are over 5000 species of dung beetles belonging to the families *Scarabaeidae* and *Geotrupidae* which utilise dung in different ways. Dung processing is performed by rollers (telecoprids) which shape fresh dung into balls to be used as a food source for beetles. Tunnellers (paracoprids) typically bury dung by forming dung masses in tunnels, while dwellers (endocoprids) spend their entire lifecycle in dung, and do not roll or tunnel.

Figure 1: Brood balls showing the relationship of brood ball size or mass to dung beetle.
L-R: *Onitis alexis, Onthophagus vacca* and *Geotrupes spiniger* (Photo: Russ Barrow)

Dung beetles find their food using their sense of smell, through sensitive olfactory receptors on their antennae. They generally reproduce by laying eggs inside a ball of dung. Such brood balls vary in size, shape and burial depth, and serve as a food source for the developing beetle larvae.

Once the larva undergoes metamorphosis, the adult beetle, which can vary greatly in size and colour, emerges from the ground and repeats the cycle. Most beetles are flight active and can readily expand their range by flying up to several kilometres to locate fresh dung.

In Australia, the first Australian Dung Beetle Project was conducted by CSIRO from 1965-1985 and successfully introduced a diverse group of beetle species from Asia, Europe and Africa.

Most recently, the Dung Beetle Ecosystem Engineers Project (DBEE 2019-2023) introduced several additional spring active species from northern Africa.

DID YOU KNOW?

Dung beetles can increase pasture growth while also reducing pest burdens.

Why are dung beetles important ecosystem service providers?

Dung beetles have been shown to play an important role both in agricultural and forest ecosystems. Researchers have shown that through the rapid consumption and burial of dung, dung beetles can provide some very important ecosystem services in diverse settings. The DBEE project estimates that

dung beetles in Australia create up to $620 M per year in economic value to the agricultural economy.

The presence of dung beetles, along with a reliable source of fresh livestock dung, can improve both the quality and fertility of Australian pastures, resulting in better soil aeration and reduced run-off. Rapid dung processing by beetle populations has resulted in both a reduction of pasture fouling and also reduced numbers of pest flies and parasites responsible for disease in grazing livestock.

Recent research using lysimeters containing various soil types has shown that dung beetles can also significantly improve soil water penetration by dung burial and tunnelling, thereby increasing pasture growth while reducing pest burdens.

However, there are challenges associated with the establishment of dung beetles for pest management. Surveys have shown dung beetle activity in processing dung varies by species. The DBEE project has supported data collection from two years of monthly monitoring across Australia to evaluate beetle numbers and species prevalence. Results have shown that while many regions support multiple species of dung beetles, others lack activity. The lack of dung beetles can generally be attributed to geographic barriers to beetle distribution or local environmental conditions.

www.dungbeetles.com.au

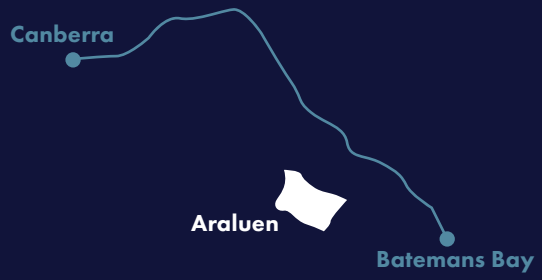
CASE STUDY / ARALUEN

A property near Araluen on the Southern Tablelands of NSW has shown remarkable dung beetle diversity over a two year period, with up to 12 introduced and 3 native beetle species actively processing cattle dung. Beetle diversity and abundance have remained high, despite challenges over recent years including flooding, drought and fire.

Most recently the cool winters, warm summers and ample rainfall have generated lush pastures for the cattle, which have produced abundant quantities of dung. When high rainfall has not resulted in flooding or waterlogged soils, dung beetles have typically thrived and repopulated over time.

The valley environment at Araluen provides a diverse topographic profile ensuring some areas are well drained even with above average rainfall, contributing to successful beetle breeding and establishment.

In contrast, in grazing regions lacking topographic relief, such as the region around Parkes and Forbes in the Central West of NSW which have recently experienced extensive flooding, dung beetle populations have been significantly impacted, suggesting that repopulation with beetles may be required.



A key objective of the DBEE project was to improve beetle diversity across southern Australia by increasing the number of imported beetle species, particularly those active in late winter to spring.

Project staff have recently introduced imported Moroccan strains of *Onthophagus vacca* to numerous farms across WA, SA, NSW and the ACT. Following field release, these spring active beetles have only been detected near Araluen, in the Southern Tablelands of NSW.

By introducing newly imported species or redistributing existing species, the DBEE project also aimed to significantly increase the abundance and diversity of beetles on farm, to support year-round beetle activity. Those populations which were well adapted to the local region were more likely to establish.

Monitoring of these populations over the next several years will determine how successful these introductions have been.

ON-FARM CHALLENGES

Challenges to on-farm management – time, information, labour, cost

KEY POINTS

– Choose suitable dung beetle species for the local environment
– Ensure sufficient quantity of dung is available for beetles
– Ensure sufficient number of beetles are introduced

Challenge 1: Chemical use

Management of introduced or existing dung beetles requires an investment in time and labour and caution when applying pesticides or veterinary chemicals on-farm.

Challenge 2: Species selection

Producers will need to select, introduce and manage those species best adapted to local and regional conditions.

Challenge 3: Dung management

When planning livestock rotation or movement, it is important to maintain a sufficient source of dung for beetle consumption and reproduction.

Challenge 4: Beetle quantity

Successful establishment of a new beetle species also requires sufficient beetle numbers for introduction to a single site (estimated > 1000), and frequent monitoring of beetle activity over time. Monitoring can be performed by beetle trapping or frequent surveillance of existing dung pads on farm (see DBEE website for more information).

FURTHER INFO:

Local **Landcare and farming systems groups** have provided workshops and guidance on how to successfully introduce and manage beetles in regional areas across Australia, and also assisted producers with redistribution.

Find a group

www.landcareaustralia.org.au/landcare-get-involved/findagroup/

SELECT A SPECIES

Which dung beetles to select for new introduction to the farm?

The choice of dung beetles selected for introduction on-farm is usually based on prior knowledge as to which species might be obtained and successfully established in a particular site using beetles well-adapted to the local climatic conditions.

In order to make a reasonable decision on which beetle to select, it is neccessary to consider the ability to obtain reasonable beetle numbers by redistribution or purchase. Monitoring of existing beetle populations across regional Australia is important in order to determine where beetles have successfully established. The Atlas of Living Australia presents results of survey reports and is a critical resource used to evaluate potential range of establishment across Australia. The DBEE project has presented the results from two years of beetle monitoring, from more than 120 survey sites, across southern Australia, from Tasmania to Western Australia.

Visit the DBEE website for project monitoring results.

While dung beetles show preferences for certain dung types, most introduced species are generalist feeders that will operate on cattle, sheep, horse, goat or pig dung. While camelid dung can also be utilised, camelids create communal dung piles where they urinate and defecate providing less than optimal conditions for dung processing by dung beetles.

Selection of the correct species

to complement existing dung beetle fauna is important as dung beetle activity is seasonal and species dependent. Ideally, processing of dung from your livestock 365 days a year would provide optimal ecosystem services. While an Australian dung beetle service gap is an ongoing challenge, producers should be aiming to make this gap as small as possible for as short a time as possible ***(Figure 2)***. This is generally achieved by maintaining multiple species of beetles on your property.

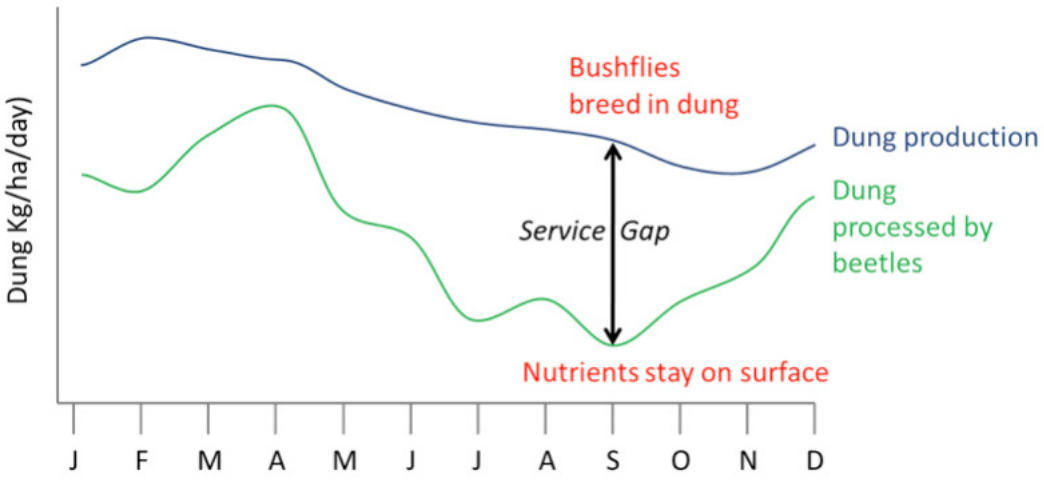


Figure 2: Graph depicting a typical grazing property situation showing seasonal service gaps caused by the lack of optimal dung beetle fauna.

Selection of the next species to introduce is reliant on knowing what beetle diversity you already have. The simplest way to determine this is to get a dung beetle consultant to come and assess your property. Questions relating to stocking rates, grazing practices, pasture varieties and drenching regimes also need to be considered. A commercial supplier will determine what beetles are suitable for your location, climate and soil types and design a beetle management strategy that encourages beetle diversity and abundance.

If you want to determine which beetles to introduce on your property yourself, a beetle monitoring program can be conducted on-farm to identify the existing beetles. Resources to help you identify beetles can be found on the DBEE program's website. Data from the DBEE monitoring program is available on the website and should be considered along with the data from the Atlas of Living Australia.

DID YOU KNOW?

In 1965, more than 50 dung beetle species were introduced to Australia by CSIRO.

Most regions in southern Australia lack winter and early spring active species.

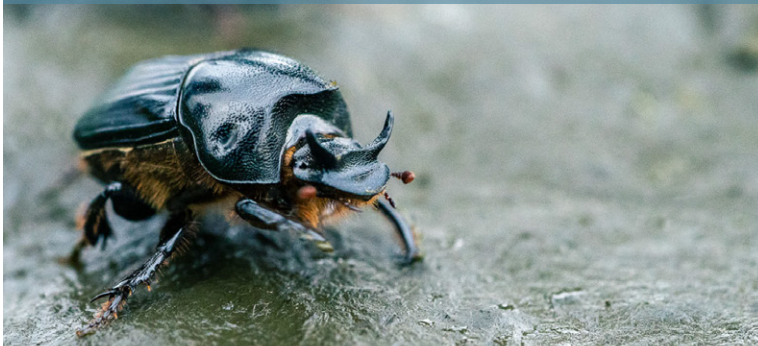
Determine if either *Bubas bison* or *Onitis caffer* are suitable for your region as these are the dominant winter active species available to close this gap.

To expand seasonal activity, the DBEE project has introduced over 60,000 *Bubus bison* to new locations across southern Australia. This species has potential to rapidly incorporate large quantities of dung below ground.

Commercial suppliers:
www.dungbeetles.com.au/livestock-producers/buying-dung-beetles

DBEE project:
www.dungbeetles.com.au

Atlas of Living Australia:
www.ala.org.au



CREATE A NURSERY

How to propagate beetles on-farm by setting up of a beetle nursery.

Beetle nurseries can be simply described as a container in which beetles are placed and nurtured ***(Figure 3)***, allowing you to breed up numbers suitable for a field release. Nurseries are used by commercial suppliers to breed adequate numbers of beetles to distribute. Field releases should be conducted with 1000 or more dung beetles to allow a good chance of establishing a self-sustaining population.

Certain beetles are not readily available in numbers that facilitate field release. In some cases, producers may choose to buy a starter colony and invest time in producing beetles to stock their property.

What is the perfect nursery design? - Experience suggests that there is no perfect nursery design, but features that make a nursery successful include:

1. Location. A good site is one that has a lot of sunshine. Partial shading may be desirable along with proximity to water.

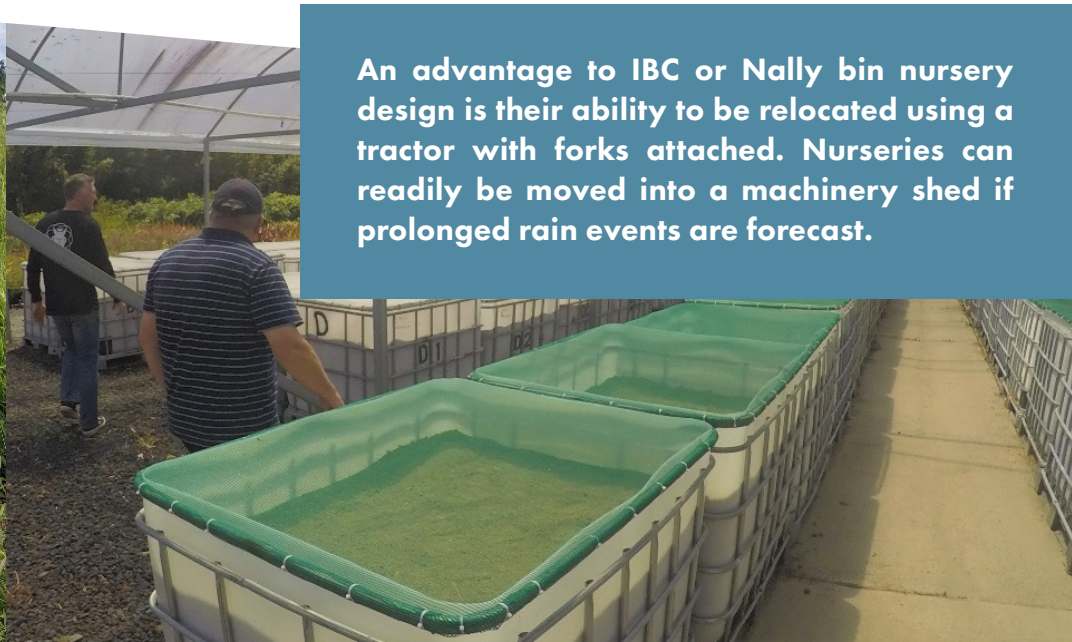
2. Security. A mesh lid is required to prevent beetles escaping and predators entering.

3. Drainage. Good drainage is required so the soil doesn't become waterlogged. A pole placed in the middle of the nursery to give the mesh top a pitched effect to drain water is recommended.

4. Maintenance. A nursery is at least a year-long commitment and requires regular feeding (2-3 times per week) for 6-8 months of the year, and regular removal of old dung, weeding, and watering in hot dry conditions. Nurseries are not a set and forget exercise.

The use of above ground nurseries constructed from materials that are readily recycled is recommended. Intermediate bulk containers (IBC), fruit bins (Nally bins), raised garden beds and old water tanks have all been repurposed to make excellent nurseries. It is very important to provide good soil drainage, so provision of drainage

Figure 3: Examples of embedded and above-ground nurseries. Note the lack of plant material allowed to accumulate in both designs.



An advantage to IBC or Nally bin nursery design is their ability to be relocated using a tractor with forks attached. Nurseries can readily be moved into a machinery shed if prolonged rain events are forecast.

holes near the base of the nursery to allow water to escape, but not beetles, is important *(Figure 4)*. Start by placing down a layer of geotextile (shade cloth will suffice), then place soil or media on top of the cloth. If the beetles of interest are currently unsuccessful in breeding in existing soils in the nursery, they are also less likely to establish in a field release on-farm.

What type of beetles? - The answer will depend on your seasonal gaps and determination of the best available species to introduce to minimise these gaps. Common nursery species that are frequently available in southern Australia include *Bubas bubalus, Copris hispanus, Onitis caffer, Onitis pecuarius* and *Onthophagus vacca*.

How many beetles? - The answer depends on the size of your nursery and the species of beetle. Using an IBC based design (1000 mm L x 1000 mm W x 500 mm H) approximately 100-200 beetles are recommended to generate over 1000 beetles the following season.

Soil? – The type of soil in the nursery can be very important. A sandy loam is a good medium that is suitable for most beetle species. Ideally the soil will be sourced locally, particularly if you already know that your soil type is suitable for the beetles you are releasing. To increase moisture retention, you can also mix in some vermiculite (Grade 1 or 2) with the soil. We would recommend 50 L of vermiculite in a 400 L IBC based nursery.

Release? – When the beetles start to emerge, trap them using a plastic container baited with fresh dung and later transfer them to the paddock chosen for their release. It is critical to:

- Select a paddock with fresh, clean dung (with limited pesticides or veterinary chemicals)
- Continue to release beetles into the same paddock to enhance the chance of future breeding due to beetle proximity. This may require that fresh dung is manually brought into the release site.
- Immediate redistribution of beetles is not generally recommended.
- Keep some beetles aside to repopulate another local nursery on-farm if you want to repeat the process.

Can I reuse the nursery? Nurseries can be reused but the bulk density of the soil and the amount of organic matter in the soil may eventually alter the physical characteristics of the nursery soil. It is recommended not to use the same soil for longer than 2 years. Consider using the spent nursery as an above ground vegetable garden or re-distribute the enriched soil onto garden beds or paddocks.

CASE STUDY / CSIRO

Staff at CSIRO Black Mountain facility in Canberra have been successfully breeding *Onthophagus vacca* and *Bubas bubalus* in outdoor nurseries ***(Figure 4)*** for over 5 years. Over this time the actual design has varied ranging from above ground garden beds to the Nally bins shown in the images.

Figure 4: Above ground nurseries used at CSIRO in Canberra. The design on the left uses an internal pole to give a pitched roof, while the middle image shows a fitted lid. Good drainage is common to all designs.

GETTING BEETLES

Challenges associated with dung beetle acquisition

Producers are always keen to know where to obtain healthy dung beetles.

Generally, the easiest and most cost-effective way to acquire beetles is to enlist a commercial supplier. Dung beetles breed only at specific times of the year, so it is important they are on your property for as much of their breeding season as possible. If you are going to use a commercial supplier, it is recommended that put your orders in early as suppliers will only collect as many beetles as they have orders for.

If you want to collect beetles yourself and relocate them to your property, then you need to know where and when to collect them. The Atlas of Living Australia provides access to detailed records that you can use to construct a calendar of observations that should assist you when locating beetles. The time to collect beetles is when the weather is right, NOT when you have some free time. The best conditions to collect are on warm sunny days with a light wind, and if it's raining or overcast stay home.

Be aware that some beetles are active during daylight hours while others are night active. To target a species for collection, it is critical to know when it is active. Indiscriminately catching beetles and relocating all of them runs the risk of introducing pest species such as the African black beetle (*Heteronychus arator*). Make sure beetles are sorted and washed before transporting them.

Beetles can be sent across state borders provided they are correctly packaged and labelled. Labelling must include the beetle species contained in a package and the approximate number of beetles. If the package is inspected by biosecurity officers and found to be non-compliant, it may be destroyed. Best packing materials are moistened vermiculite or coir peat. After wetting the medium, you will need to squeeze out as much water from the packing material as possible.

How do I collect beetles?

If collecting dung beetles from field locations, there are a couple of methods to employ. Once you've identified a location where the species you are seeking is established, permission to access the property will be required from the site manager. Beetles can then be collected through setting pitfall traps or flotation methods ***(Figure 5)***.

Pitfall Traps.

An above ground pitfall trap can be constructed using a plastic container, with 3-4 cm of water in it and a dung bait sitting across the top. When constructing the trap the potential harm to other species should be considered.

The cleanest method involves placing dung in a fine mesh bag, such as the ones used to store fruit in. Beetles will be attracted to the dung and fall into the water below. A trap should be set at the time of day that corresponds with optimal beetle activity for the required species. In summer months traps should only be left out for 2-4 hours during the day. In winter traps can be left for up to 12 hour cycles. When ready to collect, sieve out the beetles, sort them to remove any pests or other undesired species and place into a well-aired container containing moist vermiculite or coir peat.

Flotation

Not all beetles can be easily caught in pitfall traps and may require collection directly from dung pats. This method is easy but requires access to large volumes of water.

To do a flotation scoop up some dung along with a little soil from beneath and place it into a bucket, covering with at least two volumes of water. It is not necessary to agitate the dung and doing so makes it more difficult to collect beetles.

Repeat the process in separate buckets as you walk the paddock. After at least 5 minutes return to the first bucket and sort through the beetles that floated to the surface, use a small kitchen strainer to remove the beetles. Replicating this process with 6-10 buckets allows a production line process.

Figure 5: Collecting beetles using the flotation method.Flotation.

How many beetles should I take?

The dung beetle density on a healthy property will be many thousands per hectare and you may get hundreds in each trap ***(Figure 6)***. When you are collecting beetles on a property over a couple of days you will not make a noticeable impact on the population. Collecting a few thousand beetles may seem like a lot but consider how many pitfall traps were put out, or the amount of dung in a bucket you used to source those beetles.

The average cow deposits around 25 kg of dung per day. If you set 25 traps each baited with 1 kg of dung you would only be collecting beetles associated with a single animal.

Cattle dung is preferable even when collecting on sheep properties because of the ease of preparation of the bait. When collecting over 20,000 beetles from a 10 ha paddock for three consecutive years, we have not noticed any change in the catch rate.

Figure 6: A variety of species in a single pitfall trap near Gundagai (March 2021)

https://www.animalethics.org.au/policies-and-guidelines/wildlife-research/pitfall-traps

DRENCHING & GRAZING

Drenching and Grazing Management

The question producers ask most frequently is "Can drenching harm dung beetles?"

In Australia the most relevant document concerning the impact of drenches on dung beetles remains the 'Bardon Report', published over 20 years ago. The 'Bardon Report' is recommended reading for comprehensive coverage of the topic of drenches and their impact on dung beetles. The need for a more contemporary treatment of the area has also been recognised and raised with government and industry bodies.

It is important to note that discussion of drenching is not restricted to that as defined by the APVMA as the oral treatment of an animal with a liquid product such as an anthelmintic. The use of veterinary chemicals to treat animals, regardless of the method of administration or the intended target, should be considered as potentially detrimental or impactful to dung beetles.

A dung beetle cannot differentiate poisoning with a synthetic pyrethroid used in an ear tag designed to combat buffalo fly from a macrocyclic lactone given orally, designed to treat gastrointestinal nematodes.

Not all veterinary chemicals harm dung beetles. (See tables 1 & 2)

The study of the impact of veterinary chemicals in dung and their impact on beetles under a variety of Australian conditions is limited and research therefore needs to be conducted to thoroughly assess their impact. As a land manager it is critical to be aware of the chemicals that are likely to impact any stage of the beetle lifecycle and adjust farm management practices to account for this.

This guide presents only a summary of information available and recommended practices focussed on optimal performance of dung beetles and is not meant to substitute for professional veterinary advice.

CASE STUDY / MONARO

A producer on the Monaro in southern NSW reported to us a huge reduction in dung beetles following the use of a macrocyclic lactone based drench. Dung beetles had been abundant on the property prior to its use but were rare for several years afterwards. In this case the chemical used was ivermectin which is known to be toxic to dung beetles, especially at the larval stage.

When the property was examined in November 2022 a few native ***Onthophagus australis*** were found but no introduced dung beetles were encountered backing up the owners claim that beetles were absent and the ecosystem services they provided had been lost. The property was surrounded by forest on all boundaries so this presented a case where introduced dung beetles would not readily be able to re-establish, as they will not travel through wooded areas.

What veterinary chemicals are commonly used?

The pesticides used to treat your livestock will be listed on the container or package in which they originated. In many cases there will be a mixture of veterinary chemicals present and each must be considered. The impact on dung beetles ***(Table 2)*** is associated with the excretion pathway and the likelihood of beetles coming into contact with the veterinary chemical. A low impact rating does not indicate the chemical is not toxic, it suggests rather that a dung beetle is unlikely to come into contact with significant quantities of the product.

It is also important to note that adult beetles are filter feeders, ingesting mainly water-soluble chemicals, while larvae ingest solid dung and any chemicals it contains. As a result, pesticides which are not water-soluble may not harm the adult but could be toxic to the larvae. All stages of the beetle lifecycle need to be considered.

How can I use veterinary chemicals and not harm dung beetles?

While dung beetle populations can be adversely impacted by veterinary chemicals, good management practices can reduce the likelihood.

Do I need to treat all my animals at the same time?

If treatment can be staggered, then you can ensure that clean dung is always available for dung beetles. Only a proportion of the available beetles will be exposed to toxic dung.

Can I quarantine treated animals?

If possible, quarantine animals that have been treated with toxic veterinary chemicals ***(Table1 & 2)***. The amount of chemical in dung diminishes with time and quarantining them into a paddock for 1-2 weeks post treatment will limit the number of beetles coming into contact with toxic dung.

http://www.dungbeetle.com.au/bardonreport.pdf
https://apvma.gov.au/definition-of-terms

Is there a good time to treat animals?

Animals need to be treated as required but producers should be aware that dung beetles are seasonal. The drench selected may have major impacts on beetle mortality and successive generations. For example, ***Figure 7*** shows the seasonal variation of *Digitonthophagus gazella*.

Treating animals with an ivermectin based drench in October or November could have an adverse impact on successive generations, whereas using a moxidectin based drench would be safe. To rotate drenches to reduce pesticide resistance, a drench from a different family or those with greater toxicity can be employed when beetles are less active.

Currently in Australia there is a paucity of winter and early spring active beetles and in many cases this is the time to use more toxic drenches.

Does grazing management impact beetle numbers?

Having a quarantine paddock for animals to graze after being treated with veterinary chemicals can reduce exposure of beetles to toxic dung.

A study based in the USA has shown that rotational grazing gives rise to higher densities and species richness of dung beetles when compared to set stocking regimes and that high density rotational grazing was better than low density rotational grazing*.

Data from comparable studies in Australia have not yet been published, however the DBEE project findings support the concept that high density rotational grazing benefits dung beetle numbers and diversity.

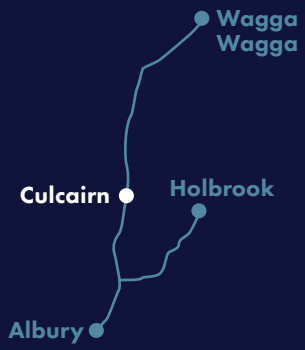
Figure 7: Examples of the seasonality of dung beetles

Figure 8: 24 hours of *Bubas bison* activity on a dung pat near Culcairn, NSW (May 2021)

CASE STUDY / CULCAIRN

A beef cattle producer in the Murray region near Culcairn employed high density strip grazing practices and had higher dung beetle densities than an adjacent property that employed a continuous grazing regime. Using rotational strips for grazing ensures a high dung density, and as the pasture is not overgrazed, it results in a protective covering for beetles.

If cattle are moved on every couple of days, beetles are left undisturbed to progress their breeding, tunneling and dung burying activities ***(Figure 8)***. Beetles will follow the animals so dung is continuously processed.



*Environmental Entomology, 50, 2021, 222–231. doi: 10.1093/ee/nvaa130

SUMMARY

Key takeaway points for livestock producers

- Select dung beetle species carefully for adaptation to your property and environment when introducing a new species.
- Consider where to purchase beetles and gain support from consultants
- If you choose to establish beetles yourself on your property, you will need to monitor your populations on-farm first.
- The choice of dung beetle nursery for increasing beetle numbers on-farm depends on your property and materials that are available.
- Establishing dung beetles on your property will require time, effort, access to high quality dung and favourable environmental conditions.
- Manage your livestock carefully to provide beetles with access to ample fresh dung and protect the pasture from over-grazing.
- Evaluate the choice of drench and timing of drenching to best preserve and protect your dung beetle fauna on-farm.

www.dungbeetles.com.au

Table 1: Targets, veterinary chemicals and potential to harm dung beetles

What pest am I targeting?

There are a multitude of veterinary chemicals designed to protect animals from various pests and parasites.

Target	Chemical active	Chemical group	Harmful to dung beetles
flies, ticks, lice	deltamethrin cypermethrin flumethrin permethrin	synthetic pyrethroids (SPs)	yes
nematodes (roundworms), ticks, lice, flies	moxidectin ivermectin abamectin doramectin eprinomectin	macrocyclic lactones (MLs)	most MLs display toxic effects (see Table 2). Moxidectin belongs to a separate subclass of MLs and is less harmful.
flies, ticks, lice	dichlorvos chlorfenvinphos diazinon naphthalophos fenthion chlorpyrifos	organophosphates (OPs)	Toxicity has been reported for dichlorvos. Excretion of OPs which is predominantly in the urine limits exposure.
ticks, lice	cyromazine dicyclanil diflubenzuron fluazuron	insect growth regulators (IGRs)	no data indicating harm
nematodes, trematodes (fluke)	levamisole albendazole fenbendazole oxfendazole triclabendazole	imidazothiazole (LVs), benzimidazoles (BZs),	no data indicating harm
flies, lice, mites, ticks	propoxur bendiocarb acetamiprid imidocloprid	carbamates (CMs), neonicotinoids (NNs),	no data indicating harm
flies	spinosad	spinosyns	Highly toxic to invertebrates and excreted in dung therefore highly likely to be harmful to dung beetles.
cestodes (flatworms), nematodes, trematodes	closantel praziquantel monepantel nitroxynil amitraz clorsulon	Amino-acetonitrile derivative (AADs), formamidines (FAs), isoquinolines (IQs), salicylanilides (SAs) sulfonamides (SFs)	no data indicating harm

Adapted from Flyboss – https://flyboss.com.au/dung-beetles

Table 2: Veterinary chemicals in common use and their potential impact on dung beetles.

Pesticide group	Group	Chemical example	Significant excretion pathway	Impact on dung beetles
1A	CM	propoxur	urine	low
1A	CM	bendiocarb	urine	low
1B	OP	dichlorvos	urine	probable [#]
1B	OP	chlorfenvinphos	urine	probable [#]
1B	OP	diazinon	urine	probable [#]
1B	OP	naphthalophos	urine	probable [#]
1B	OP	fenthion	urine	probable [#]
1B	OP	chlorpyrifos	urine	probable [#]
3A	SP	deltamethrin	dung and urine	high
3A	SP	permethrin	dung and urine	high
3A	SP	bifenthrin	dung	high
3A	SP	cypermethrin	dung and urine	high
3A	SP	flumethrin	dung and urine	high
4A	NN	acetamiprid	urine	low
4A	NN	imidocloprid	urine	low
5		spinosyns	dung	high
6	ML	doramectin	dung	high
6	ML	ivermectin	dung	high
6	ML	eprinomectin	dung	high
6	ML	abamectin	dung	high
6	ML	moxidectin	dung	low
7	IGR	cyromazine	dung and urine	low
7	IGR	dicyclanil	dung and urine	low
7	IGR	diflubenzuron	dung and urine	low
7	IGR	fluazuron	dung	low
	BZ	albendazole	urine	low
	BZ	fenbendazole	dung	low
	BZ	oxfendazole	dung	low
	LV	levamisole	urine	low
	SA	closantel	dung	low
	IQ	praziquantel	urine	low
	AAD	monepantel	dung	low
	AAD	nitroxynil	urine	low
	SF	clorsulon	dung and urine	low
19	FA	amitraz	urine	low

AAD – amino-acetonitrile group; BZ – benzimidazole group (white drenches); CM – carbamate group; FA – formamidine group; IGR – insect growth regulator; IQ – isoquinoline group; LV – levamisole group (imidazothiazoles); ML – macrocyclic lactone group (mectins); NN – neonicotinoid; OP – organophosphate group; SA – salicylanilides/phenols group; SF – sulfonamide group; SP – synthetic pyrethroid.

[#] even though excretion is primarily in the urine, dung from animals treated with dichlorvos has been associated with high dung beetle mortality.

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