

**Dung Beetle
Solutions**
Australia

**Adding value to a DairySA dung beetle
project:
Evaluation of pasture growth due to the late
summer/autumn-active dung beetle
Geotrupes spiniger at Flaxley SA**

**Final report prepared for
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1 Project proposal

The project was designed to evaluate alteration in pasture growth, soil permeability and the quality of run-off water in response to dung burial by the dung beetle *Geotrupes spiniger* at Flaxley SA. This phase, phase 2, extended the evaluation of pasture growth and soil permeability for another season, to March 2006.

2 Summary

This document is the final report for the Flaxley dung beetle trial (established in March 2004). It presents the progress of the project from October 2005 to March 2006 (phase 2) and a summary of earlier data that has been previously reported in detail (phase 1).

Dung beetle activity substantially increased the permeability of soil to water and this effect persisted for at least 2 years after the dung beetles had buried the dung. In the first phase of the project (2004–05), dung burial activity of the dung beetle *Geotrupes spiniger* increased the permeability of soil to water substantially (up to 40-fold) in dry conditions but to a lesser extent during winter when the soil was saturated with water. Dung (without beetles) applied to the soil surface caused a minor increase in the permeability of soil to water. In the second phase of project (2005–06) dung that had been applied during 2004 increased the permeability of the soil to water (5-fold over the controls) and dung beetles provided an additional increase (7-fold over the controls), indicating that a separate effect of dung beetles persisted for at least 2 years.

Pasture growth was assessed on five occasions over the two-year test period (October 2004 (test period 1, reported in the final phase 1 report), October 2005 (test period 2), and three times between November 2005 and March 2006 (test period 3)). The addition of dung to the plots in March 2004 had no significant effect on total pasture production in any of the three test periods, indicating that pasture growth was not limited by soil nutrients. There was no additional significant response to the presence of dung beetles. The absence of a pasture response to dung beetles indicates that soil-based changes induced by beetle activity did not enhance pasture production in the test circumstances. A different result may have been obtained if the pasture had been harvested before the pasture plants matured, thereby allowing continued growth that could make use of the additional soil nutrients.

Cape weed biomass in the first test period (to 9 months after the trial began) was substantially lower in the dung+beetles plots than in the other plots and this effect was still evident 12 months later. Cape weed was removed after the second test period and was not assessed in the third test period.

The most important finding of the study (reported in phase 1) was the profound effect of dung burial by *G. spiniger* on water quality. Dung beetle activity altered the chemical composition of the water that ran off the plots during winter (as a result of artificial rainfall applied 12 weeks after the trial was established), with substantially reduced levels of soluble organic compounds, DOC (dissolved organic carbon) and soluble N, compared with

the dung-only plots. Phase 2 of the project did not allow for these effects to be assessed again.

3 Background to the current project

DairySA funded a project to demonstrate the impact of the late summer / autumn-active dung beetle *Geotrupes spiniger* on soil and water quality. The field plots were established at Flaxley SA in March 2004. Pasture production and beetle biology were also studied (at no additional cost to DairySA). The final phase 1 report was submitted in February 2005.¹

In summary for phase 1, dung burial by beetle activity was rapid and complete. Beetles burrowed 20–30 cm into the soil and their tunnels were lined with dung, which was eaten by earthworms. Subsequently the tunnels were lined with loosely packed earthworm casts. The roots of pasture plants grew down the beetle tunnels and around the dung beetles' brood.

During phase 1, dung beetle activity caused:

- a 90% decrease in dissolved N and C in run-off water. These enter the soil and promote plant growth and soil health.
- a substantial increase in the permeability of soil to water
- a substantial reduction in Cape weed in pastures

Pasture production was measured once (9 months after establishment, representing growth from March to October 2004), and there was a pronounced positive effect of dung but no additional effect of dung beetles. Parallel trials in central Victoria have shown that the activity of the dung beetle *Bubas bison* caused a 2-fold over-winter increase in pasture growth and the activity of *Geotrupes spiniger* caused a 1-fold over-winter increase in pasture growth.

A one-year extension was granted to the project (phase 2) to evaluate whether there was a continued impact of dung burial on pasture production and the permeability of soil to water.

4 Methods

4.1 Experimental protocol

The experiment was established at Flaxley SA on 31 March 2004. There were nine plots, each measuring 0.92 m² (adjacent plots separated by 1 m) in a row inside a cattle-proof enclosure on a deep alluvial loam soil at Flaxley, South Australia (Dave Kuchel's property). There were three replicates of each of three treatments (dung+beetles, dung only, controls [no dung, no beetles]) (Photo 1).

¹ Doube, BM, in collaboration with Mr Nigel Fleming, February 2005, The impact of the activity of the late summer/autumn-active dung beetle *Geotrupes spiniger* on soil and water properties in the field: final report, prepared for DairySA.



Photo 1 Experimental plots at Flaxley, SA

In the six +dung plots, 16 1-litre dung pads were added to each plot on day 0. Following this, 15 adult dung beetles were added to each of the dung+beetles pads (240 beetles per plot). All nine plots were then covered with beetle-proof wire mesh cages. An additional 1 litre of dung was added to each pad on day 7 and day 14 (a total of 48 litres of dung was added to each plot). The beetle-proof cages were removed after 4 weeks to release the beetles. On each occasion before the addition of further dung and before removing the cages, the level of dung burial in each plot and the presence and numbers of soil casts around the pad were assessed.

During phase 1 the following parameters were assessed:

- three evaluations of soil permeability
- one assessments of pasture growth and composition
- one assessment of the impact of dung beetle activity on the quality of run-off water

During phase 2 the following were assessed:

- one evaluation of soil permeability
- four assessments of pasture growth and composition

4.2 Permeability of soil to water

Phase 1 of the DairySA project reported three evaluations of the permeability of the soil to water, in autumn and winter 2004 and summer 2005.

On 22 March 2006, the permeability of the soil to water in the plots was assessed using five test sites (cores) per plot and one litre of water per core. The time taken for the water to soak into the soil was recorded and the rate of infiltration was expressed as mm water per minute.

4.3 Plant growth

In October 2004, about the time that the pasture grasses were haying off, the plant material present on each plot at Flaxley was harvested (using portable

electric shears) and the wet weight of plant material from each plot was assessed. Cape weed was separated from the other plant material (mostly grasses) and the wet weights of the Cape weed and the remainder of the plant matter in each plot were assessed separately. Samples of about 400 g wet weight of grass and of Cape weed were air dried for 4 weeks and reweighed to determine the original moisture content. These data were used to calculate the dry weight of the plant matter produced on each plot.

In October 2005, the plots were again sampled, and evaluated in the same way. Spring and early summer of 2005 were unusually moist and pastures continued to grow into summer. The plots were therefore also sampled in November and December 2005 and March 2006. Cape weed in these samples was not treated separately.

5 Results

5.1 Permeability of soil to water

In both phases of the trial dung burial activity of the dung beetle *Geotrupes spiniger* caused an increase in the permeability of soil to water.

In the first phase of the project (2004–05), beetle-induced increase in soil permeability was substantial (up to 40-fold) in dry conditions but was lower during winter when the soil was saturated with water. Dung (without beetles) applied to the soil surface caused a minor increase in the permeability of soil to water. These results have been reported previously.

In the second phase of project (2005–06) the permeability of soil to water was assessed in dry conditions, in March 2006, 2 years after the trial was established. The beetle-induced increase in soil permeability was significant for both the dung+beetles plots (7-fold over the controls) ($P < 0.001$) and the dung-only plots (5-fold over the controls) ($P < 0.001$) and the infiltration rate for the dung+beetles plots was significantly greater than that for the dung-only plots ($P < 0.01$) (Table 1).

Table 1 The effect of dung and the activity of the dung beetle *G. spiniger* on the rate of ponded water infiltration into soil 2 years after setting up the experiment

Treatment	Mean Infiltration time (minutes)	Infiltration rates
		(mm water per minute) Mean±SD
Dung + dung beetles	2.5	119.6 ± 11.7
Dung only	3.5	83.6 ± 38.7
Control (no dung, no beetles)	17.2	17.1 ± 5.4

5.2 Impact of beetle activity on plant growth

In October 2004, the plant matter on each plot at Flaxley was harvested and weighed. Direct observations of the plant composition on the plots suggested that Cape weed was virtually absent from the plots with dung and beetles but present in substantial amounts on the plots with dung only and in the controls. A sample of each type of plant matter was air dried for 4 weeks and weighed again to determine the moisture content of the Cape weed (13.2% dry matter by weight) and the grasses (32.2% dry matter by weight). These data were

used to calculate the dry weight of the plant matter produced by each plot, which has been reported previously. In the October 2005 samples, the Cape weed and pasture grasses from each plot were again separated before weighing and then air dried for 4 weeks and weighed again to determine the moisture content of the Cape weed (15% dry matter by weight) and the grasses (30% dry matter by weight).

Cape weed was largely absent from the dung+beetles plots in 2004 and 2005 but common on the dung-only plots and the control plots (Figure 1). This suggests that dung beetle activity caused substantial suppression of Cape weed. The mechanism for this is not clear.

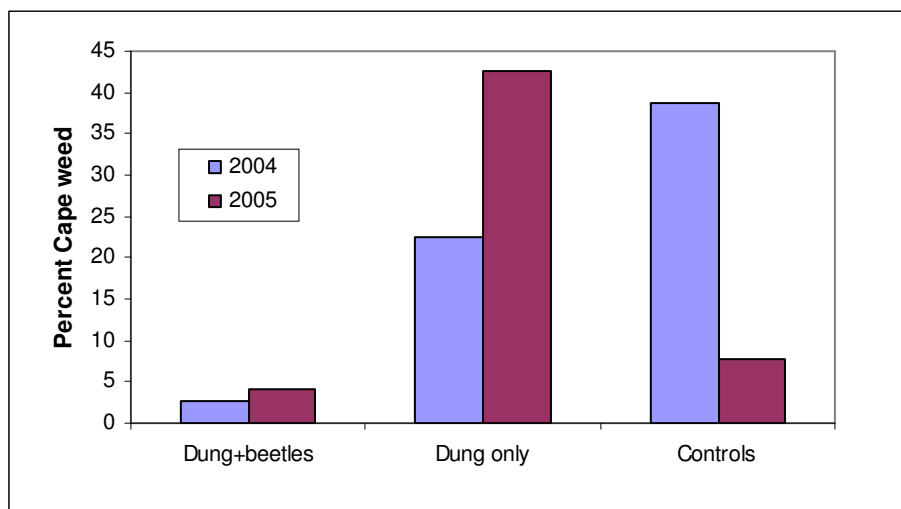


Figure 1 The effect of dung and dung beetle activity on the presence of Cape weed (by dry weight) as a percentage of all plant matter on the test plots in mid-spring in 2004 and 2005

There was no significant treatment effect (dung+beetles vs dung-only vs control plots) in total dry weight of plant matter produced during winter and spring 2005 (sampled October 2005). There was no separate effect of dung beetle activity.

In test period 3 (November 2005 – March 2006) pasture production (dry weight) was 18% higher in the dung+beetles plots than in the control plots and this effect was due largely to the differences in the December to March pasture production (Table 2) and was not statistically significant at 5%. There was also no significant increased growth in the dung-only plots over the controls during test period 3 (Table 2, Figure 2).

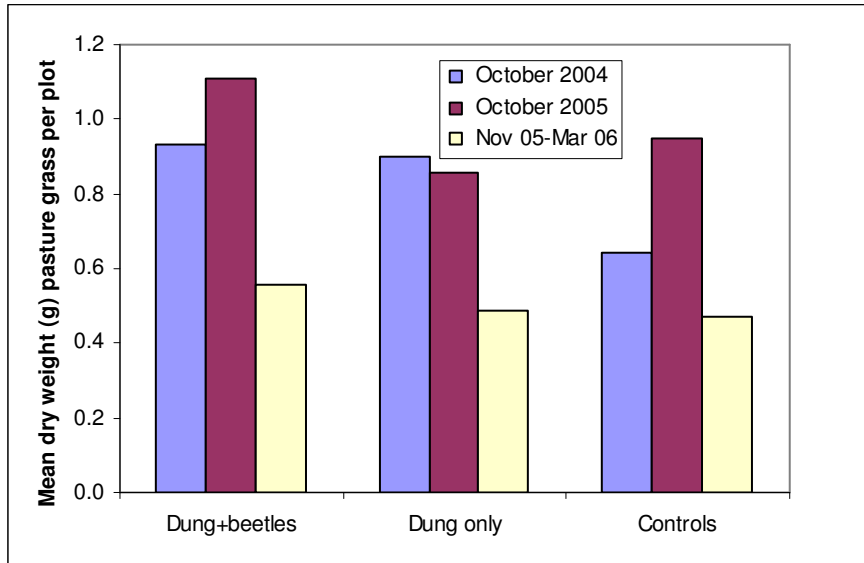


Figure 2 The effect of dung and dung beetle activity on the production of pasture grass (dry weight) during three test periods. The trial was established in March 2004.

Table 2 The effect of dung and dung beetles (*G. spiniger*) on pasture production from the field plots at Flaxley. The trial was established in March 2004.

Sampling date	Mean dry weight of pasture grasses (kg per plot)		
	Dung+beetles	Dung only	Controls
20 October 2004	0.93	0.90	0.65
10 October 2005	1.11	0.86	0.95
28 November 2005	0.27	0.24	0.26
16 December 2005	0.16	0.18	0.17
22 March 2006	0.13	0.07	0.04
Subtotal (Nov–Mar)	0.56	0.49	0.47
Total (pasture grasses)	2.60	2.25	2.07
	Mean dry weight of Cape weed (kg per plot)		
	Dung+beetles	Dung only	Controls
20 October 2004	0.03	0.36	0.45
10 October 2005	0.05	0.64	0.08
Total (Cape weed)	0.08	0.99	0.53
Overall dry weight (kg/plot)	2.68	3.24	2.60

Overall the dung+beetles plots and the dung-only plots produced 26% and 8% more pasture grass respectively than did the control plots (Table 2). However, when the Cape weed production is factored in, there was no significant effect of dung or dung beetles on the total dry weight of pasture produced during the 2-year study period.

6 Extension and education

A successful field day/site inspection was held in April 2004. A second field day to demonstrate the benefits of dung beetles will be held on Saturday 23 September 2006. Members of the recessed Myponga and Meadows Dairy Discussion Groups will be invited to attend.

7 Discussion

The trial was established in 2004 to demonstrate the pasture production, soil health and water quality benefits of the dung beetle *G. spiniger*.

The dung burial activity of *G. spiniger* had a pronounced effect on the permeability of soil to water and this effect persisted for at least 2 years (March 2004 to March 2006). This accords with findings for both *G. spiniger* and *B. bison* activity in field studies in the Central Highlands of Victoria (funded by Central Highlands Water). The depth of friable surface soil was also increased by dung beetle activity at Flaxley and in the Central Highlands.

The most important finding in the Flaxley study was the effect of dung burial by *G. spiniger* on the quality of run-off water. Three months after the experiment was established, the plots were exposed to artificial rainfall and the composition of the run-off water was examined. There was little or no dung on the surface of the dung+beetles plots and the dung on the dung-only plots was obvious but appeared to be largely decomposed. Despite this, a substantial amount of nitrate, dissolved organic carbon (DOC) and other organic compounds leached out of the dung on the dung-only plots while the amounts leaching from the dung+beetles plots were reduced by 95+%.

These data indicate that dung placed on the ground in the field in March has a substantial capacity to contribute organic pollutants to run-off water if rained upon in early winter and that dung beetle activity (eg of *G. spiniger*) that buries dung in the autumn–early winter period can substantially reduce that pollution. The off-site consequences of farming activity (eg dung pollution of waterways) are now recognised as a serious component of managing our agricultural industries and it is clear from the data reported for this project that autumn and winter-active dung beetles have the potential to substantially reduce levels of dung-derived nutrients in our waterways.

The pasture production data failed to demonstrate a significant effect of dung or dung beetle activity on pasture production over the 2-year period of the study. These data contrast with those of other studies on *G. spiniger* in the Victorian Central Highlands, and on *B. bison* in the Victorian Central Highlands and on the Fleurieu Peninsula SA, where the effects of dung in the dung-only plots were initially strong but largely disappeared within 12 months, while the effects of dung beetle activity have persisted, and possibly increased, over at least 3 years.

The reasons why similar effects were not evident in the current trial are not clear but the absence of a growth response to dung suggests that pasture growth was not limited by the nutritional status of the soil, at least that which could be influenced by the addition of cattle dung. In the first two sampling intervals in this trial, the pastures were allowed to grow to maturity and then hay off before being harvested. If the nutritional status of the un-amended Flaxley soil was sufficient to allow optimal growth of pastures to maturity in spring–early summer, then the presence of additional dung-derived nutrients would not have the capacity to influence plant growth. In other words, the amount of pasture produced may have been determined by the seasonal growth patterns of the pasture plants, and not by the supply of additional (dung-derived) nutrients in the soil.

A different result may have been achieved if the pasture growth had been harvested on a series of occasions before the plants reached maturity, thus extending the duration of the growth phase and allowing the use of additional nutrients (and possibly water) in the soil as a result of dung beetle activity. These possibilities need to be further investigated before we can make general claims about the capacity of *G. spiniger* to increase pasture production.

8 Conclusions and recommendations

From this study we conclude that:

- Dung burial by *G. spiniger* increased the permeability of soil to water and this effect persisted for at least 2 years.
- Dung removal by *G. spiniger* and other beetle species has a substantial capacity to reduce levels of nitrate and organic pollution in run-off water.
- Pasture production in this trial environment was not limited by soil nutrients and so neither dung nor dung beetle activity increased pasture production.

We recommend that:

- The dung beetle *G. spiniger* be considered for introduction to the Fleurieu Peninsula as one way to improve regional water quality
- The production benefits of *G. spiniger* be further examined in environments where soil nutrients limit pasture production.