final report

Project code: B.ERM.0212

Prepared by: Tom Davison and Malcom Caskill

Date published: July 2007

PUBLISHED BY
Meat & Livestock Australia Limited
Locked Bag 991
NORTH SYDNEY NSW 2059

.

Review of MLA Project. The pasture growth and environmental benefits of dung beetles to the southern Australian cattle industry

Meat & Livestock Australia acknowledges the matching funds provided by the Australian Government to support the research and development detailed in this publication.

Review of MLA Project. The pasture growth and environmental benefits of dung beetles to the southern Australian cattle industry

Project Number. ER 211
Project Leader. Bernard Doube

Review Team: Malcolm McCaskill, Soil and Water Scientist DPI (Victoria), Hamilton and Tom Davison, Environment Program Coordinator Southern Beef, MLA.

Review conducted on site in South Australia on May 21st , 2007.

Purpose of Review:

1. Review what has been achieved to date in the research program including the methods used in the research program
2. Review the implications of the research findings for the southern beef industry and suggest what options if any, for future work.

Summary of review.

1. The project team exhibit great enthusiasm for their work and have put in a lot of work above and beyond that expected from the project proposal.
2. This study is the first in Australia to investigate the relationship between the role of dung beetles and their effect on pasture growth and soil fertility changes over time.
3. In response to demand for dung beetles from beef producers and catchment management authorities, the project team have developed a small dung beetle collection and distribution business.
4. The project has provided strong evidence that dung beetles support increased pasture growth, improved soil structure and improved soil fertility.
5. However, due to the small-scale nature of the study with large quantities of dung spread onto small areas, the evidence that dung beetles cause paddock-level benefits is still weak, and relies on modelling.
6. This case needs to be proven at a paddock scale to take into account the spatial variability of dung beetles and their potential impact on pasture growth.
7. There is a case for some work to be supported to determine if dung beetles have a role in carbon sequestration in soil.
8. A hypothesis was presented that deep burial of dung released unavailable P from deeper in the soil.
9. A modelling approach to determine likely benefits from dung beetles is recommended prior to a paddock scale study being implemented.
10. Limited plot work continue to determine data for future modelling work if funding permits.

Recommendations

Next 2 months

1. That additional funding be provided to analyse topsoil samples collected at the release sites, so soil fertility can be described in a way that beef producers can relate to.
2. An article be prepared for the MLA Prograzier magazine on dung beetles, with contact details for how producers can obtain dung beetles. The review team suggests that Bruce Munday be approached for this task, because he is located in Adelaide.

Next 6 months

1. A cost-benefit analysis should be conducted as a consultancy in November or December 2007 after the final pasture growth results have been collated. Skills required include modelling, economics, biometrics, soil nutrient cycling, pasture measurement and GIS (for the area of applicability). Some individuals may have several of these skill areas. A modelling template that could be used as part of the cost-benefit analysis is described in Appendix 5. The cost/benefit analysis should also review detailed plans for a field experiment, to ensure that the experimental design can capture statistically significant differences in pasture growth due to dung beetles.

2. That MLA facilitate discussions with the Australian Greenhouse Office to fund a study of the carbon sequestration benefits of dung beetles.

Next 1-2 years

1. A grazing experiment be funded to examine the paddock-level benefits of dung beetles. A potential site on Kangaroo Island was suggested to the review team, where there is already a good population of dung beetles including *Bubas bison*. The “control” (no dung beetle) treatment would need to be implemented by using substances toxic to dung beetles. A field study of this scale may require the involvement of additional funding and research delivery partners, and this would take time to negotiate.

2. To minimise any potential loss of staff and expertise, it would be worthwhile minimising the time gap between when the current MLA-funded project B-ERM.0212 finishes in June 2008, and the next project.

3. A booklet on dung beetles developed for South Australia, should be adapted to a wider southern Australian audience in a follow-up project. This publication should be made available more widely, such as through the MLA website.

4. Within MLA there is a need to co-ordinate investments in dung beetles with respect to other proposals.

5. MLA should look to include dung beetles as part of a postgraduate study of phosphorus in soils. The case for introducing dung beetles does not rely on proving the hypothesis that deep-burying dung beetles cause release of otherwise unavailable P from deeper in the soil, so for dung beetle research it

is a low priority. However, if MLA is involved postgraduate study in phosphorus forms in soil, or in suggesting topics to university supervisors for ARC or CRC-supported scholarships, this topic should be included.

Background

Between 1965 and 1992, the CSIRO conducted a program to introduce dung beetles to Australia. The main motivation was to reduce the population of the Australian bush fly, which at the time caused considerable irritation to the human population in both rural and urban areas. The program has been one of CSIRO's most successful introduction programs. The "Australian wave" to get rid of flies was common in the 1960's, but is now rarely seen in urban areas.

The program was conducted by entomologists with no interest in other agricultural benefits of dung beetles. The highest priority for introductions was Australia's north, where bush flies would over-winter. Recent evidence shows that the tropical and sub-tropical dung beetles introduced under the program have reached the limits of their adaptation. The highest priority for southern Australia was for summer-active dung beetles to control dung at times when the Australian bush fly was active. These are also now also well distributed.

Introductions of winter-active dung beetles to Australia were made late in the CSIRO program, and subsequent spread has been limited. The most useful winter-active dung beetle, *Bubas bison*, is still limited to small areas north of Perth, Kangaroo Island, and a few areas where it has recently been introduced. The second most useful beetle for this period is *Geotrupes spiniger*, which has activity periods during autumn and spring, also has a very limited distribution.

Reasons for the slow natural spread of the southern dung beetles include

1. The limited number of release sites during the CSIRO dung beetle program
2. Slower reproductive development in the cooler environment of southern Australia, with some individuals taking 2 or 3 years between egg and adult stages
3. Gaps in suitable habitat, such as the Nullarbor Plain
4. The use of drenches toxic to dung beetles

The slow natural spread of winter-active dung beetles provides a case for R&D to demonstrate private benefits from dung beetles that would stimulate further landholder-assisted spread of the beetles. To date, there has been a high level of interest by a small number of beef producers in dung beetle introductions, but it is still not regarded as standard practice.

Bernard Doube worked in the CSIRO dung beetle project for 10 years as officer-in-charge of the South African component, with responsibility for studying dung beetles in their natural habitat. Another former CSIRO staff member, John Feehan, was responsible for mass rearing of dung beetles in Canberra. He is currently the main commercial supplier of dung beetles in Australia. The dung beetle program was instigated by Dr George Bornemisza, who has since retired to Hobart, and maintains an active interest in dung beetles through enthusiasts based in Tasmania.

There is a small dung beetle supply industry in Australia, dominated by staff formerly in the CSIRO program. These people are listed in Appendix 1.

Project objectives

By December 2006 and 2007, the project will have assessed and analysed the data on the responses of pasture and soil to dung and dung beetle activity, in particular on:

- pasture dry matter production and quality
- pasture composition
- depth of friable topsoil
- water infiltration
- earthworm activity
- soil structure
- soil nutrient levels and organic matter status down the soil profile
- beetle emergence and the corresponding release of soil nutrients

By 30 May 2008:

- conducted at least 2 field days at the experimental sites each with 30–50 producer participants
- produced a pamphlet describing the impacts of dung beetles on soil and pasture characteristics
- developed a scientific paper ready for peer review
- submitted the final report describing the impact of dung beetles on key pasture and soil characteristics

Milestones ***(excerpt from Milestone 6 report)***

The experimental program has been established for 17 months. During this time the following factors have been systematically monitored: dung beetle populations (B. bison and other species), dung burial by natural (feral) populations of B. bison, growth (dry weight) and moisture levels of pasture in experimental plots, earthworm responses to dung and dung burial, chemical and physical responses of the subsoil to dung burial, and the seasonal biology of adult and immature B. bison.

Key findings for the study period to date ***(taken from milestone 6 report)***

- *Baseline (unamended) pasture productivity for October–January in the 2x2 m plots was substantially greater at Ashbourne (0.32 t DM ha^{-1}) than at Kuitpo (0.18 t DM ha^{-1}), indicating that conditions for pasture growth were substantially better at Ashbourne than at Kuitpo.*
- *The pasture growth response to added dung was relatively minor at Ashbourne and substantial at Kuitpo.*
- *In contrast, pasture production for October–January in the 2x2 m dung+beetles plots (90% dung burial) was similar at Ashbourne and Kuitpo (0.38 and 0.28 t*

DM ha^{-1} respectively, P>0.05), indicating that soil fertility (pasture growth) in the dung+beetles plots was similar at both locations.

- *The effects of dung and dung beetle activity on the chemical composition of the subsoil were dramatic. The second analysis (using cores extracted in November) produced results similar to those of the first analysis (cores extracted in August) reported in milestone 5. Soil nutrient levels in the subsoil 20–45 cm below dung pads were substantially elevated by dung burial, particularly in the vicinity of the beetle tunnels, where, in November, nitrate levels were 2–4-fold higher than in the surrounding soil. The corresponding ratios for ammonia, phosphate, sulphur and carbon were 6-fold, 6-fold, 2-fold and 3–4-fold respectively. The tunnels comprised about 10% of the mass of the subsoil and about 20+% of its volume. Future sampling will establish the extent to which these changes persist.*
- *Carbon sequestration in the subsoil beneath the dung in the dung+beetles soil cores was equivalent to the amount of carbon in the buried dung. It is estimated that, if widely established across southern Australia, B. bison could possibly sequester annually dung-carbon levels equivalent to those sequestered by 400,000 hectares of eucalypt plantation.*
- *B. bison activity resulted in burial of about 80% and 40% of all dung pads placed in the field from May to July at Ashbourne and Kuitpo respectively: The corresponding data for August and September were 18% and 14%. B. bison was more abundant (as indicated by baited pitfall traps) at Ashbourne than at Kuitpo. Few of the dung pads placed in the field during September and none in October were buried and few B. bison were caught in the pitfall traps during that time.*
- *B. bison exhibits a third instar larval diapause that causes the immature beetle to remain as a larva for 1, 2 or 3 years before emerging as an adult in autumn. In cooler regions, eg the Ashbourne study site (a valley floor protected by shade trees), the beetle has a predominantly 2-year life cycle, whereas at the Kuitpo study site (a warmer location on a North-facing slope) the beetle has a predominantly 1-year life cycle.*
- *B. bison may also have exhibited an adult reproductive diapause (arrested adult development) at Kuitpo in which beetles emerged in autumn but did not breed for 6–8 weeks. This did not occur at Ashbourne. Both diapauses have the capacity to seriously influence mass release strategies.*

Review findings

How well is the project travelling?

Milestones have been met.

The topic generates a high level of interest from beef producers, because introducing dung beetles can be undertaken with a relatively small investment, and without continued ongoing costs. The table below sets out the distribution of dung beetles directly as a result of this project.

Releases of field cropped dung beetles by Dung Beetle Solutions Australia since the inception of the MLA project.

Species	**No of beetles**	**Release**	**Location**	**Funding support**
Bubas bison				
1	10,000	June 2007	Trigg farm, Ballarat	100% Central Highlands Water
2	Up to 20,000	July 2007	20 properties, Ballarat	50% CHW, 50% producer
3	10,000	June 2008	Trigg farm, Ballarat	100% Central Highlands Water
4	Up to 20,000	July 2008	20 properties, Ballarat	50% CHW, 50% producer
5	9.000	June 2007	9 Fleurieu properties SA	50% NRM Board, 50% producer
6	6,000	June 2007	6 Fleurieu properties SA	100% producer
7	Up to 15,000	June 2007	15 properties, KI, SA	50% FBG, 50% producer
8	5000	June 2007	C-sequestration expts	100% DBSA
Geotrupes spiniger				
1	10,000	April 2006	2 KI properties	100% KI NRM Board
2	10,000	April 2007	2 KI properties	100% KI NRM Board
3	6,000	April 2007	1 Fleurieu property	100% DBSA
4	10,000	April 2007	2 Fleurieu properties	50% CHW, 50% producer
5	5000	June 2007	C-sequestration expts	100% DBSA

The review team were impressed at the work of the dung beetles. In one enclosure, dung beetles had covered the topsoil with about 2cm of subsoil. This bioturbation (biological mixing of the soil) would eventually turn a duplex soil into a gradational soil, with the mixing powered by dung. Dung beetle burrows would reduce the soil bulk density. By placing dung at a depth of 20-30 cm, plants have access to material high in phosphorus long after the topsoil has dried off.

The MLA project has enabled several other projects to be conducted, and is part of a mix of projects that include dung beetle release, research on dung-beetle-friendly irrigation, and impacts on pasture production, water quality, earthworms. These are listed in Table 1 and Appendix 3.

The review team were impressed with the enthusiasm of the Principal Investigator, and the passion he has for his subject. A list of related projects and funding since the inception of this project is set out below. It is rare to find someone still active in research in a private capacity so long after leaving a research organisation. This is not without its difficulties, because there is not the support by way of colleagues specialising in closely-related fields, who can be consulted in the experimental design and data interpretation phases. Since leaving CSIRO, Bernard Doube has broadened his field from entomology to include pasture growth, rainfall simulation, water quality, soil phosphorus and soil carbon. The result has been that some of these measurements have not been done as well as if specialists in these other areas had been more involved. By contracting to a private researcher rather than an agency, MLA gets the benefit of lower overheads. To make up for the lack of access to specialists, MLA needs to make sure specialists in these fields are made available through project reviews or strategic partnerships with other specialists or research agencies. This is particularly important to guide the design of any new work.

Leverage of MLA funds and new projects started as a result of the MLA investment

Our gross income from scientific research has risen considerably since we started.

2002-03 ,	**$9,000:**
2003-04	**$52,000:**
2004-05	**$61,000:**
2005-06	**$164,000**
2006-2007	**estim $190,000.**

Joint projects with Fleurieu Beef Group	**$150K**
MLA	**$130K**
Central Highlands Water	**$120K**
Willunga Catchment Water Board	**$ 25K**
WA Water Corporation	**$ 95K**
Dairy SA	**$ 10K**
KI NRM Board	**$ 20K**
My Lofty & Murray Darling NRMBs	**$ 42K**

Specific areas of concern were

1. No topsoil fertility data were available (Colwell or Olsen P). These would enable producers and their advisors to relate fertility of the trial sites to their own properties. A valid question is whether the main benefit of dung beetles is at low or high levels of P fertility. Analysis of topsoil samples was not in the original budget, because hypotheses related to fertility of the subsoil. Topsoil samples have been collected and air-dried.

2. The Ashbourne trial site the review team visited had a high capeweed content. Better choice of site may have been able to increase the proportion of desirable species.
3. There was no attempt by the project team to "upscale" results to the paddock scale. An initial attempt was made by the review team, using data and assumptions listed in Appendix 4.

The project is operating well as it currently stands. However, we recommend 3 areas of additional expenditure.

1. Additional funds should be allocated to analyse topsoil samples (0-10 cm) for Olsen and Colwell P, at a minimum so there is a description of soil fertility that beef producers can relate to.
2. The project has not yet received coverage in the MLA Prograzier magazine. We suggest that Bruce Munday be approached for this task, because he is located in Adelaide, is familiar with rural research, and has done an excellent job in communications from the CRC for Plant-based Management of Dryland Salinity. This job would require a site visit for discussions and to take photos. It is important that the article not only be entertaining and informative, but also lead onto what a beef producer can do. While it is not normally MLA's policy to advertise commercial suppliers in Prograzier, it is necessary as a "next step" for readers. Instead, all commercial suppliers we know of should be listed with contact details. Suggested wording for this section is shown in Appendix 2.
3. A cost-benefit analysis should be conducted in November or December 2007. Timing should allow the final pasture growth results to be collated. Skills required include modelling, economics, biometrics, soil nutrient cycling, pasture measurement and GIS (for the area of applicability). Some individuals may have several of these skills. A modelling template that could be used as part of the cost-benefit analysis is described in Appendix 5. The cost/benefit analysis should also review detailed plans for a field experiment, to ensure that the experimental design can capture statistically significant differences in pasture growth due to dung beetles.

Where to next ?

Interpretation of the pasture growth response to dung beetles should consider the magnitude of response under the following situations

1. Duplex vs gradational soils
2. Fertile vs infertile soils (mainly P fertility)

With only 3 sites at which the pasture response is being measured (Kuitpo, Ashbourne, Ballarat), it will be impossible to complete the above 2 x 2 matrix. However, some attempt should be drawn from the data available and other knowledge of the role of dung beetles in nutrient cycling. A graphical representation of the fertility aspect is shown in Figure 1.

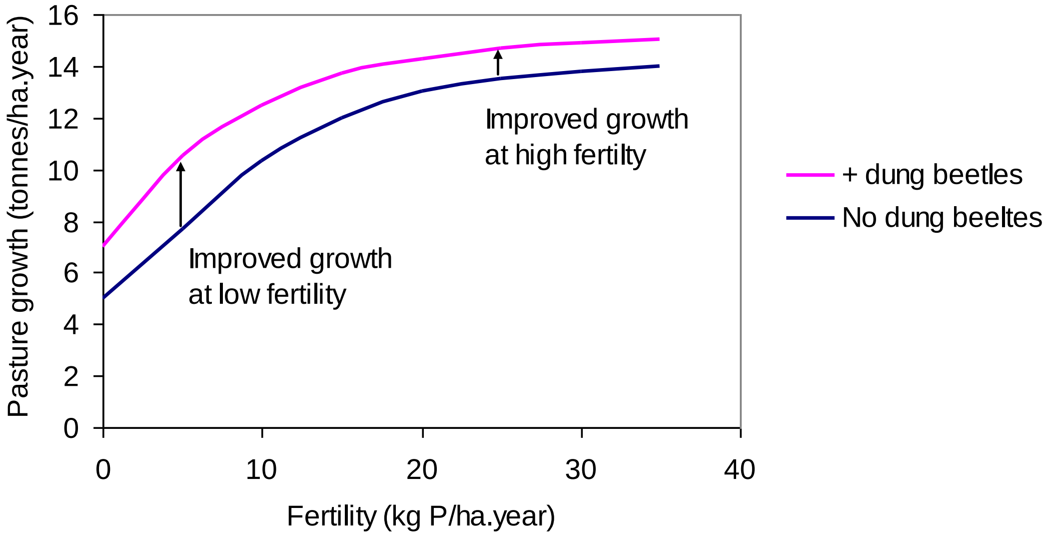

Figure 1. Hypothetical response curve to P fertiliser, with and without dung beetles

One of the review team developed a spreadsheet model to upscale from the plot to the paddock scale. This is only a framework, using small plot data from the project, and assumptions for dung distribution. As part of the cost-benefit analysis, more robust values should be used to increase the reliability of model predictions. Initial results show that even where dung beetles increase pasture growth by 40% in the first, second and third year after dung is dropped, the paddock-level pasture production was only increased by a maximum of 16% (Figure 2). This difference was achieved 6 years after there are adequate dung beetle numbers. A difference of 16% would be difficult to detect by random pasture sampling. Dungpads would instead need to be marked and separate sampling undertaken for dung dropped in the current year, previous year, etc.

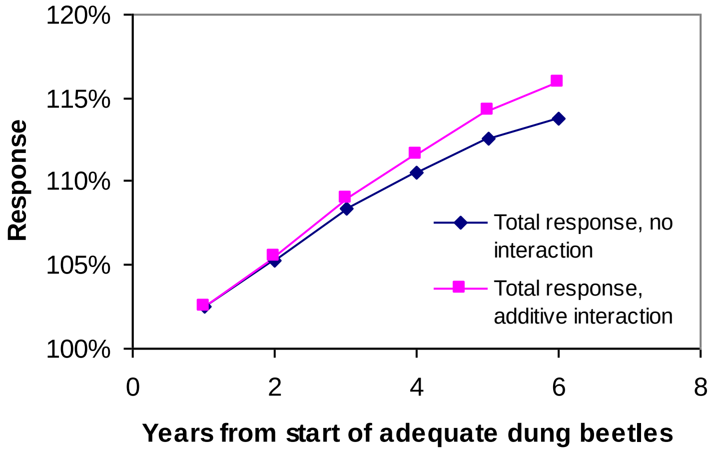

Figure 2. Modelled paddock-scale pasture growth in response to the introduction of adequate numbers of dung beetles. Response is as a percentage of pasture growth without dung beetles. For details of the 2 types of interaction modelled, see Appendix 4.

Potential directions for further work include are listed below, with review team comments:

No.	Research options	Review team comment
1	Extend monitoring at the Kuitpo and Ashbourne sites for a further 2 years. Since increases in pasture production through dung beetles can be detected for at least 3 years, the full benefit cannot be determined within a 3-year project.	Concern that pastures are uneven and dominated by capeweed. Could the pasture be evened up by herbicide treatment of capeweed, and direct drilling a new pasture ? Operating costs could be reduced slightly if no new dung is applied, and only the residual value of previously applied dung is measured. MLA's primary interest in the current sites is to determine the magnitude of pasture growth enhancement after 3 years. Only a minimal level of monitoring is required, and this should cease when differences are no longer statistically significant. Stop the work here if a paddock scale study on Kangaroo Island is initiated.

2	Conduct a detailed carbon and nutrient budget for cores to which dung beetles have been added (and controls without dung beetles).	The nutrient budget is effectively for the small area beneath a dungpad. Investment by MLA on this topic can only be justified if it is required for topic 3 below. The carbon sequestration aspect would be attractive to the Australian Greenhouse Office.
3	Quantify the paddock-scale benefits of dung beetles on pasture growth	The review team discussed paddock-scale measurement for a farm on Kangaroo Island, where there is already a high dung beetle population. Prior to grazing, cattle on the control would need to be treated with a product toxic to dung beetles. After grazing, dungpads would need to be measured and marked with buried stakes, so their location can be recorded for sampling in subsequent years. The design of this experiment will need further development, to ensure that significant differences can be measured. If this cannot be achieved at a reasonable cost, up-scaling would be more reliably undertaken by small-scale field trials at more locations. Conduct pasture growth studies with and without dung beetles at Demo Dairy in W.Victoria in collaboration with Prof David Chapman and the Dairy Australia funded 30/30 project.
4	Quantify the subsoil biodiversity of cores with and without dung beetles	Of little direct interest to MLA
5	Determine the upper limits of carbon sequestration through dung transferred into the subsoil. This would require at least a 10 year experiment.	Of interest to the Australian Greenhouse Office and potentially MLA with respect to future carbon credits for famers. MLA could facilitate discussions with AGO
6	Undertake a benefit-cost analysis	This is one of the review recommendations as part of the modelling approach.
7	Determine the geographic limits of *Bubas bison.* Caged cores could be placed on co-operator farms and the	This would work in well with a release program on the same properties. It could be suitable for

	presence or absence of dung beetles on an annual basis. The CSIRO program undertook release but did not assess survival	the regional dairy programs of Dairy Australia.
8	Update the booklet “Dung Beetles”,produced with the Fleurieu Beef Group to cover southern Australia, and make this available to a wider audience through web and paper delivery methods. Different versions could be produced for each State.	This is a review recommendation with a 1-2 year time horizon. There are relatively few people working on dung beetles in Australia, and they rarely have face-to-face contact. MLA are good at bringing groups of scientists and practitioners together to work on a common task. This would be a good task to bring the various groups together for. Names in Appendix 1.

In the current dung beetle project (ER 211), dung beetles are supplied with artificially collected dung, and are confined to 2x2m areas by mesh cages. This is necessary because dung beetle populations are still inadequate to achieve sufficient dung burial. The proposed study location on Kangaroo Island one of the few places in southern Australia that already has a high population of winter-active dung beetles. Measurements would need to include the size, shape and estimated mass of dungpads after each grazing.

Another option is to also use the current Dairy Australia funded study at Demo Dairy at Terang in W.Victoria. Here detailed studies into pasture growth are occurring on a weekly basis with dairy cattle and plus and minus beetle paddocks could be utilised. Prof David Chapman is agreeable to exploring this idea.

The study at Kangaroo Island should include both low and high P fertility, each with and without dung beetles, to determine the relative benefit of dung beetles at each fertility level.

Should the Kangaroo Island site appear to be a strong possibility, site preparation should start well in advance of a research contract. Site preparation could be a separate contract (probably under $10,000) that involves sowing the proposed area to a phalaris/subterranean clover pasture. An even pasture consisting of mature phalaris plants is more likely to show statistically significant responses than an uneven pasture dominated by volunteer annual species. Early spring is the preferred sowing time for phalaris, to minimise weed competition. Before a site preparation contract could be signed, there would need to be agreement from the landholder, and confirmation of the availability of phalaris seed of a suitable variety.

Prior to commencement of a field experiment, it would be worthwhile the technician spend time with another major field experiment with cattle, such as the Demo Dairy experiment at Terang (Dairy Australia funding), or the EverGraze experiment at Hamilton (MLA funding). This would be to broaden their range of skills in experimental set-up and measurement.

It should be emphasised that these are initial thoughts of the review team, and that much more rigour, including some pre-experimental modelling, would be required to develop a final design.

Such a study would be conducted for 2 audiences – producers, and scientists. The producer audience believes the work if they see benefits from a location or pastures similar to their own. The scientific audience is trained to be sceptical of studies that are not well conducted, or inadequately reported. To win both these audiences it would be worthwhile to work with someone with a good reputation in soil and plant nutrition.

As winter-active dung beetles become established in more locations, these studies will become redundant, and everyone will have the benefits of dung beetles.

Appendix 1 Other dung beetle activity in Australia

John Feehan, Canberra, 02 6248 0376
He is the main commercial supplier of dung beetles in Australia
Previously worked in mass rearing in the CSIRO dung beetle project
Since leaving CSIRO, he has sent out 3400 colonies of 18 species to landholders, and delivered 240 presentations to various audiences
Landline are doing a documentary, and also a French film crew
He specialises in the commercial supply of dung beetles, has full insurance, and is critical of Benard Doube trying to do the same thing
If a landholder contacts him, John asks for a sample of existing dung beetles, identifies them free of charge, then sends dung beetles that are not currently present ($400-$550 per colony of 1000)
He has an information pack on dung beetles that he sends out to those who contact him

Pam Wilson, Northern Tablelands Dung Beetle Express 02 67321200
She is willing to supply landholders in the Northern Tablelands area, and currently has a large order for a CMA
She is a project officer within the Northern New England Rural Lands Protection Board at Glenn Innes
She maintains a good website, www.dungbeetles.com.au
Some MLA funding has been received for a Harvest and Release Manual, which is available on the website
The website has good information on the safety of various drenches with dung beetles
There is also some MLA-funded research work on the impact of dung beetles on barbers pole worms, which appears to be only in the planning stages

Graeme Stevenson, Tasmania 03 6435 1319
Supplies only the winter-active dung beetle *Geotrupes spiniger*
Supplied 30,000 last year
Works with Dr George Bornemisza, who initiated the CSIRO dung beetle project, and has retired to Hobart

Doug Kershaw, Bridport Tasmania, 03 6356 1652
Supplies only summer-active dung beetles

John Allen, "Avi Ark", WA, 08 9524 1424
Has been a supplier of *Bubas bison*, but according to Bernard Doube he's no longer in a position to supply

Appendix 2. Suggested wording within an MLA-Prograzier article on dung beetles

Commercial suppliers of dung beetles in Australia:

John Feehan, Canberra, 02 6248 0376
He is the main commercial supplier of dung beetles in Australia

Pam Wilson, Northern Tablelands Dung Beetle Express 02 67321200
She is willing to supply landholders in the Northern Tablelands area

Graeme Stevenson, Tasmania 03 6435 1319
Supplies only the winter-active dung beetle *Geotrupes spiniger*

Bernard Doube [contact details to be provided]

All suppliers work from orders, because dung beetles won't keep "on the shelf"
Prices range from $300 to $550 per colony of 1000 beetles

Further information

Bernard Doube [include contact details]

www.dungbeetles.com.au This site is maintained by Dung Beetle Express at Glenn Innes. It has good information on the safety of various veterinary chemicals with dung beetles, and guidelines on how to collect and release dung beetles that were developed under an MLA-funded project.

Appendix 4 Model of paddock-scale pasture growth benefits of dung beetles

Model assumptions:

1. Pasture growth on dungpad sites with dung beetles is enhanced by 40% over that for dung only in the year dung is dropped (Yr 1). In subsequent years, the response is 40% in Yr2, and Yr 3, 30% in Yr 4 and Yr5, 20% in Yr6 and nil in Yr 7.

2. The area affected by dung is 0.25 m^2 in the first year, 0.3 m^2 in the second year, and 0.35 m^2 in subsequent years.

3. Dungpad density is 2500 dungpads/ha/yr

4. Each dungpad is 2 litres

5. Two forms of interaction are covered, for when dung lands on an area already experiencing growth enhancement from a dungpad deposited in a previous year. Firstly, the no-interaction option is that if dung falls on an area with a previous dungpad, growth enhancement follows the new dungpad, ie no interaction with the old dungpad response. This assumption would tend to underestimate growth enhancement when a high proportion of the area is covered by dungpads. Secondly, the additive interaction assumes that if dung lands on an area already experiencing growth enhancement from dung, growth response from the new dung is added to that of the old dung. In practice, the true response would lie somewhere between these 2 forms of interaction.

The model is implemented in an Excel spreadsheet on an annual basis.