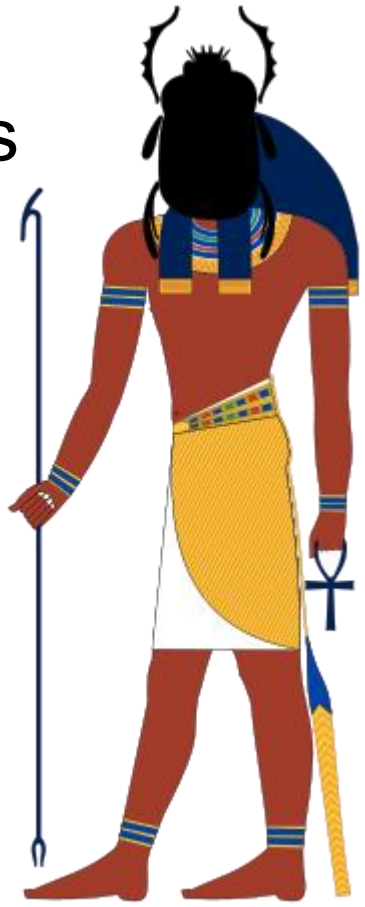
Landcare Research
Manaaki Whenua

DUNG BEETLES
The low-down, the slow-down and everything you ever wanted to know…

Simon Fowler and Shaun Forgie

Some Dung Beetle Basics

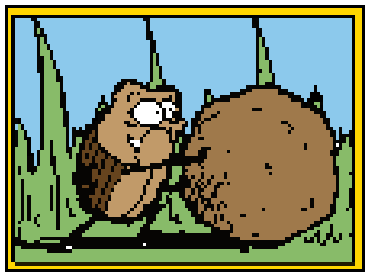
- Evolved to feed and breed in dung
- About 7000 species worldwide
- Family Scarabaeidae …. the scarabs
- Long interest from humans: the Egyptian solar deity *Khepri*
- Perhaps the best studied group of beetles



What do dung beetles do?

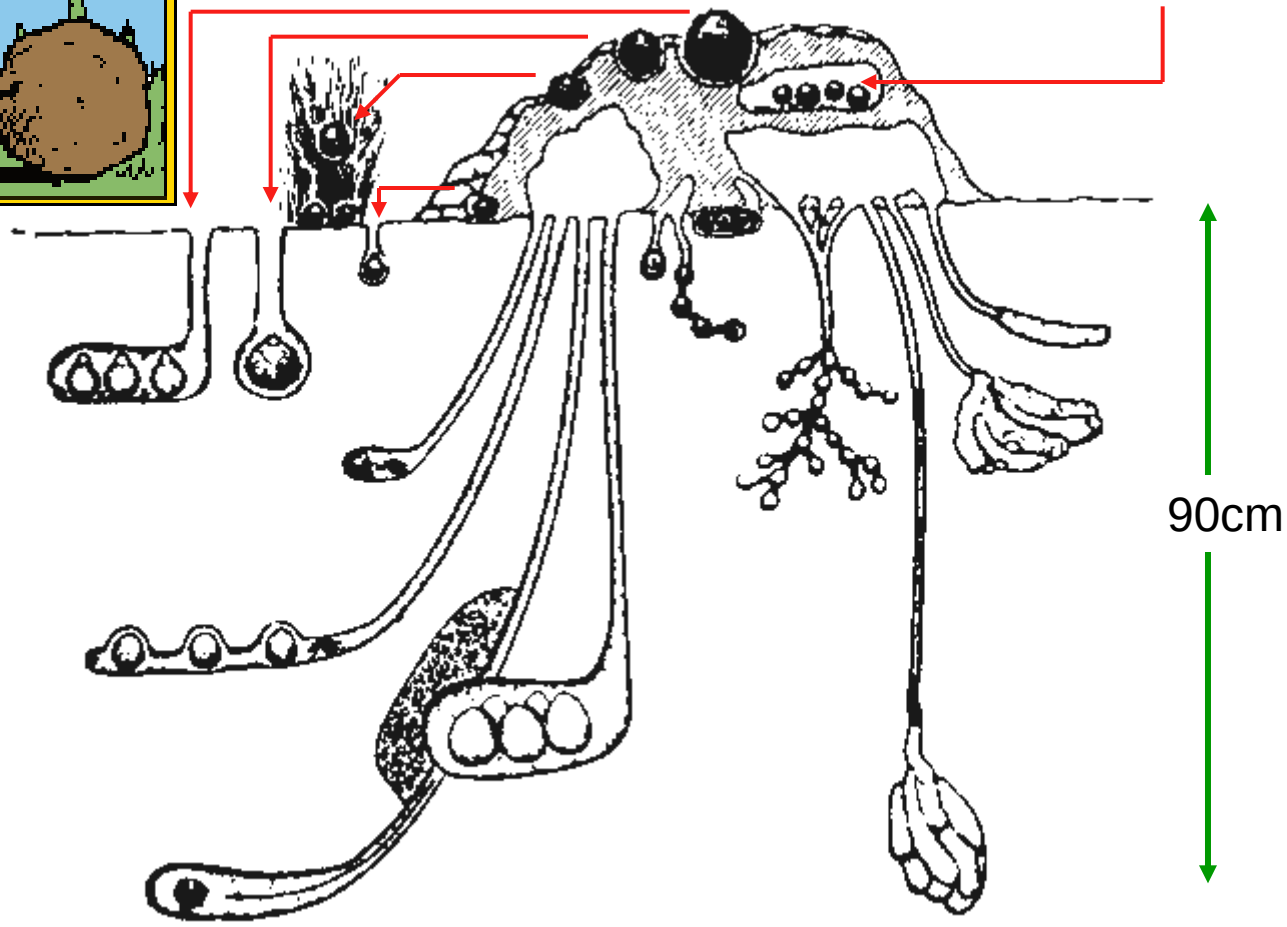
Shovel-shaped head for bull-dozing, sucking mouthparts

Front legs with teeth for digging.



Rollers
(10min - 24hrs)

Dwellers
(several weeks)



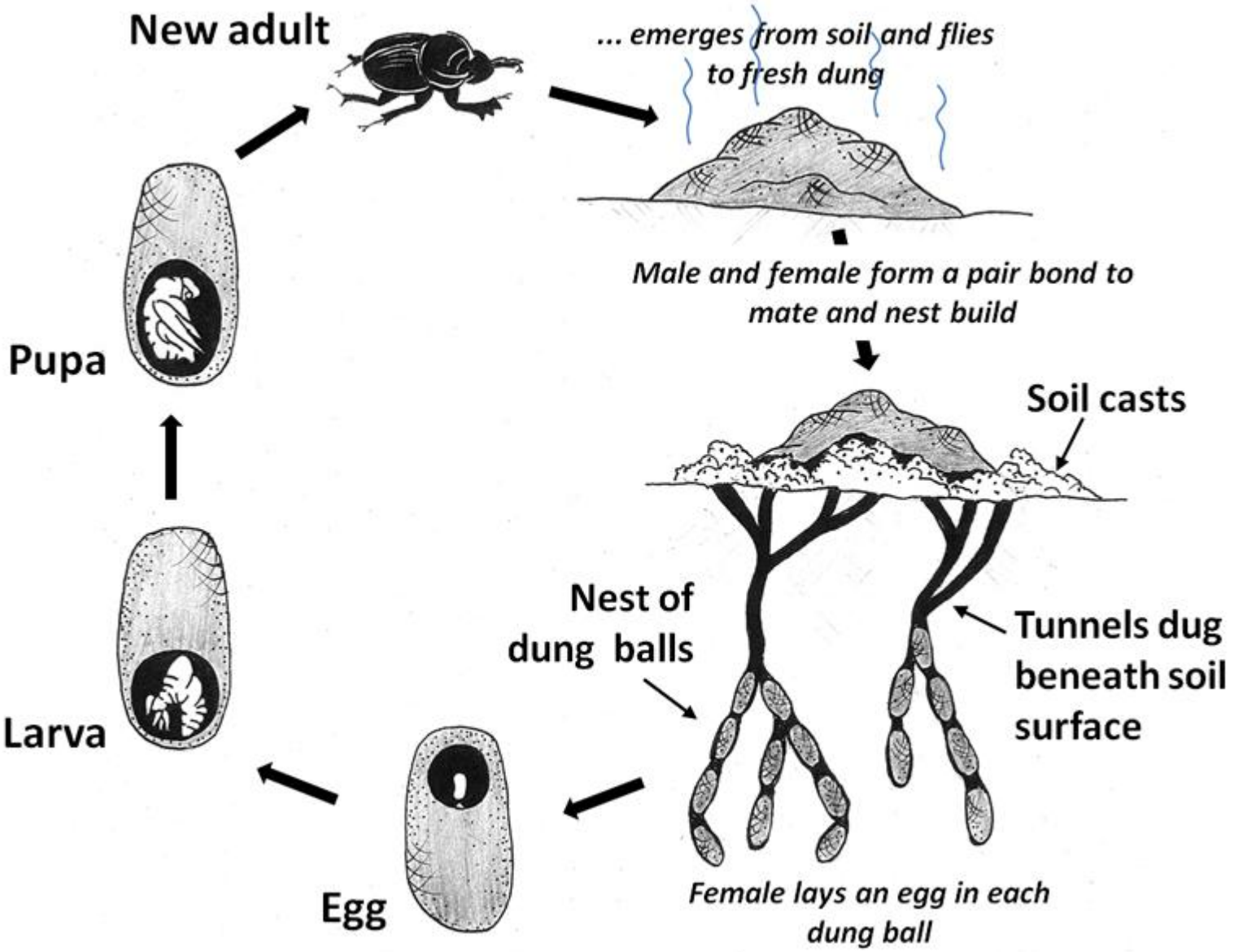
Fast-burying tunnelers
(6 -24hrs)

Slow-burying tunnelers
(up to 6 weeks)

Tunnelers are:

- **by far the most abundant.**

Life cycle of a tunneler



Dung Beetles in NZ: the Endemic Species

- 15 species, mostly small, flightless

- Often abundant in native forest – important native decomposers (dung, carcasses etc)
- Rarely in pasture – no useful role in breaking down dung in pasture systems

Exotic pasture dwelling dung beetles frequent in dung in NZ

- Several self-introduced dung dwellers

- Two self-introduced Australian tunnelers – widespread but too small and not common enough to benefit pastures

- Mexican dung beetle, larger - 17 mm introduced 1956. Present in Northland and Kaipara. Seldom common enough to produce much pasture benefit.

Overseas evidence of benefits of dung beetles

- Tunneling/dung burial: improves soils (especially if shallow/compacted); deeper grass roots; better pasture productivity (also helped by less fouling).
- Reduced run-off: better dung/urine/fertiliser retention in soil, reduced microbial/leachate pollution – better water quality + benefits for human/animal health.
- Reduced re-infection rates of gastro-intestinal nematodes in stock
- Less flies in/on dung: human/animal health benefits
- Possibly reduced greenhouse gas emissions
- Economic benefits: USA - $380 million annually

History of the Dung Beetle Project

- Dung Beetle Release Strategy Group (DBRSG) set up (Nov. 2008).
- Sustainable Farming Fund grant - $360k over 3 years (Sept. 2009)
- Science input Landcare Research (+ $200k co-funding)
- Other cash contributions: DairyNZ $24k, Environment Southland $9k, Individual farmers $9k, Auckland Council $8k.
- Application to release 11 species, June 2010

Risk assessment: 5 stages

- Workshop – including mixed views
- Pre-application consultation:
  - Regional Councils (15); government departments; NGOs + societies; interested members of the public (21)
  - ERMA National Māori Network + other Māori stakeholders (152 organisations/individuals).
  - Information on specific issues sought from national + international experts
- Public submissions and applicant responses
- ERMA Evaluation and Review – more experts
- Public hearing

Response to Pre-hearing Submissions

- Species selection: *based on daily flight activity, seasonal activity, soil preference and predicted distribution*
- Habitat/resource specificity: *prefer open pasture with plentiful dung; prefer dung of large herbivores*
- Gastro-intestinal livestock nematodes: *generally reduced in overseas studies*
- Soils, water and nutrient cycling: *soil scientist "dung beetle activity should be beneficial to most NZ soils"*
- Earthworms: *co-exist and can benefit in overseas studies*

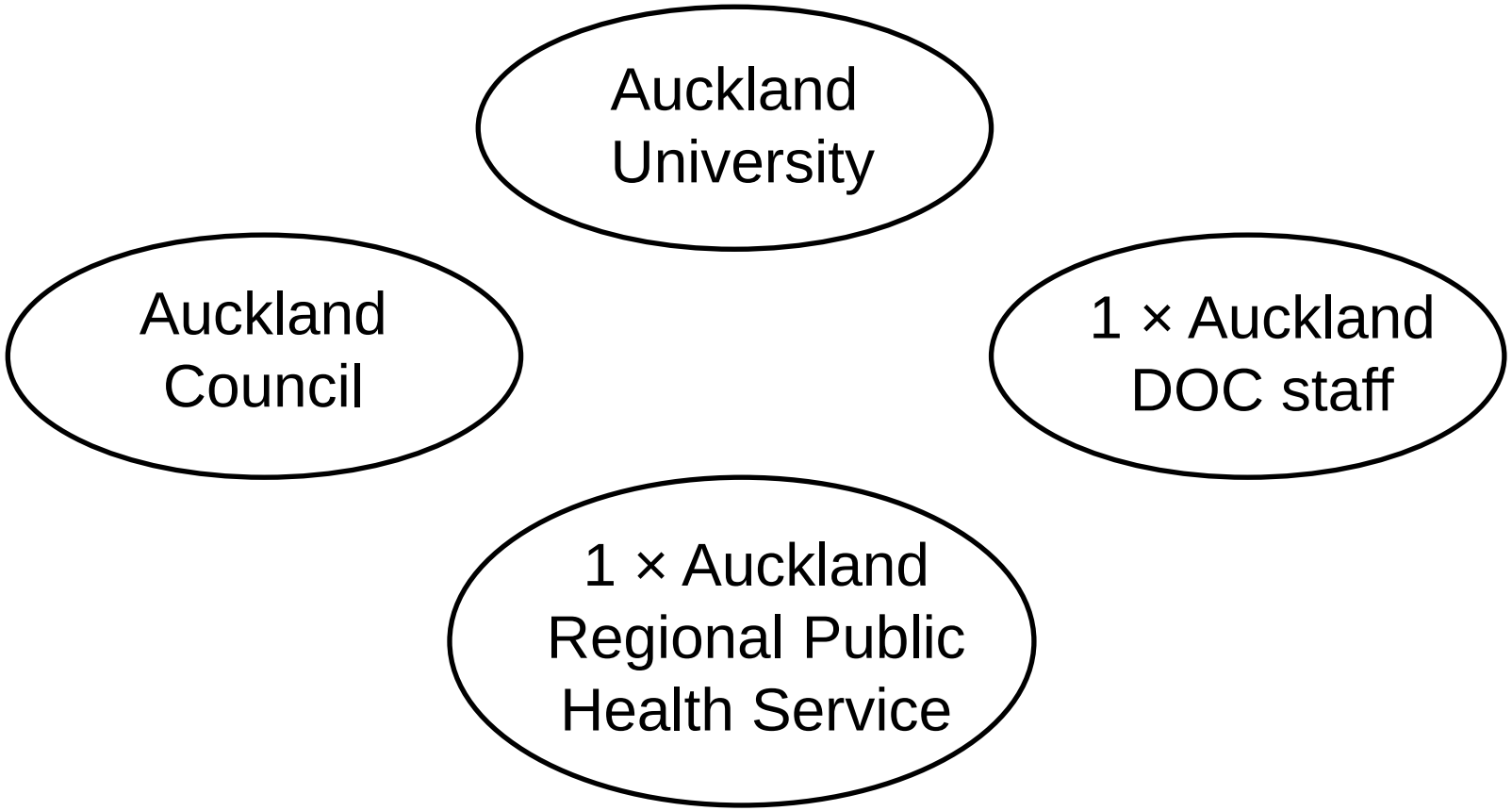
ERMA Public Hearing Dec 2010

- Opposing presentations from Auckland University and Auckland Council
- Neutral presentation from DOC
- Supporting presentations from (DBSRG inc. Ngati Whatu Nga Rima o Kaipara Trust); Landcare Research; Federated Farmers

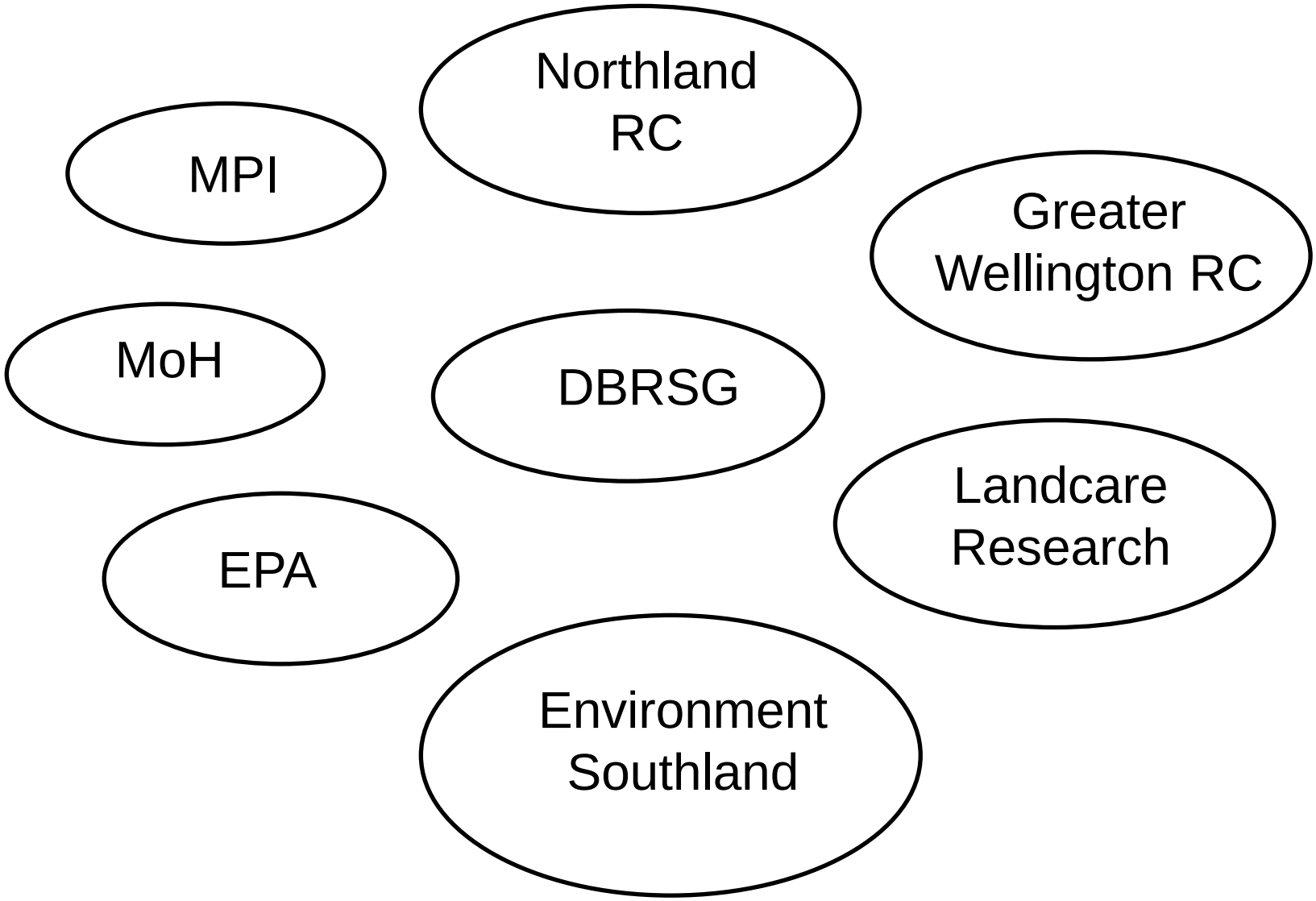
Objections at Hearing

- Possible negative interactions with native dung beetles in native forest fragments
- Ditto with indigenous fauna in native grassland
- Nutrient cycling in native grasslands
- Increase in predators such as rodents
- Species considered as a group – should be considered separately (risks and benefits)
- Negative effects on earthworms
- All discussed at hearing
- Decision to grant approval for all 11 species

Main opposition after the ERMA decision



Continued Support



Brief Summary/Timeline of Auckland University Actions

2011 2012 2013

Papers to Landcare Research Board

Board continues with project taking precautionary approach: international reviews of science, TAG

Complaints to MPI/SFF

Rebuttal from MPI

Complaints to EPA

EPA put major effort into rebuttal

Parliamentary Questions

Responses – no concerns

Articles in newspapers etc

On-going

Peer reviews of new trials/reviews

On-going

Responses to Opposition

- DBRSG: responses to journalists
- DBSRG: responded to issues on FAQ page of their website www.dungbeetle.org.nz
- Landcare Research: initially via Board papers
- Landcare Research: information to DBSRG
- Landcare Research: talk to stakeholders
- Technical Advisory Group + new research

Technical Advisory Group (TAG)

- Chaired by DBRSG
- Representatives from Landcare Resarch, AgResearch, Ministry for Primary Imdustires, Auckland Council, Environment Southland, Beef + Lamb, DairyNZ, Fonterra, Animal Health Board
- Declines from Auckland University, Auckland Regional Health Public Health Service

Key Issues from TAG

- Animal diseases e.g. Tb – could beetles create transmission route to possums; could dung burial increase disease?
- Gastro-intestinal nematodes: survival increased by burial – greater infection rates in stock?
- Human health risks directly from beetles or from dung burial?
- Could some benefits be quantified in field trials e.g. run-off reductions, reduced nematodes?

New Research for TAG: First Trials

New Research for TAG: Continued

- First trials indicated possums-dung beetle interactions low risk – but TAG recommended field survey of gut contents.
- Nematodes: caged field trial and review of international studies
- Human health risks: MoH commissioned review from ESR
- Caged field trials – run-off

Possum gut study

- Maunu, Whangarei – Mexican dung beetle abundant
- 156 pats surveyed
- Thirty possums trapped – adjacent to pasture
- Guts dissected

Beetle abundance

- Pats examined for beetle presence and signs of activity (shredding of dung; soil casts; tunnels).

No. pats	Percentage with beetles and/or activity	Mean beetles/pat
156	89%	2.22

N	Percentage with grass	Mean amount of grass	Percentage with invertebrates
30	60.0%	20.0%	63.3%

Taxa	Percentage with invertebrates	Range
Stick insects	23.3%	1-2
Ants	20.0%	1-13
Beetles	10.0%	1-4
Flies	10.0%	1-2
Moth larva	3.3%	1
Aphid	3.3%	1
Mite	3.3%	1

Summary

- Possums forage for grass in pastures.
- No evidence for dung beetles being a part of their diet (*even when common where the possums were foraging*).
- Invertebrates commonly found in possum guts in low numbers – probably not being deliberately consumed.
- Dung beetle to possum disease pathway, or increase in time foraging in pasture for dung beetles, **not supported.**

Nematode Field Trial: Expt. Design

- Secure field cages. Diameter 55 cm.

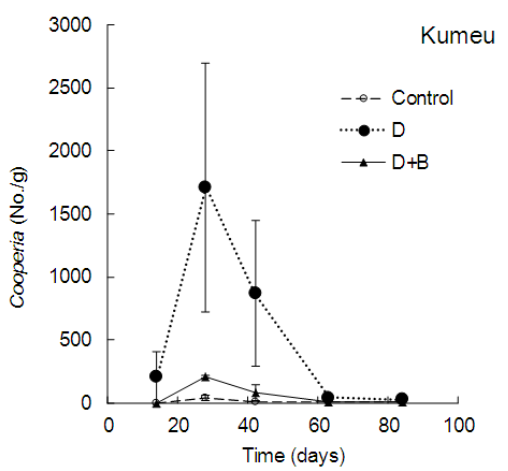
- Three treatments (dung+beetles, dung-only and controls). Three replicates/farm.
- Three farms: sandy loam, clay loam and compacted clay.

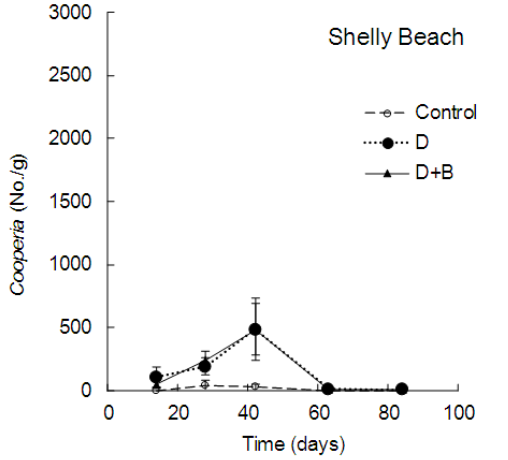
Nematode Trial

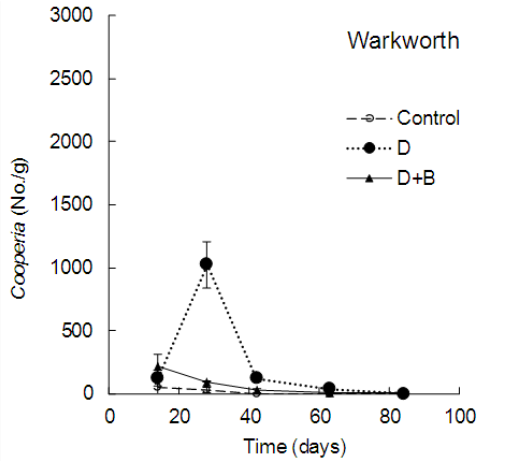
- Used *G. spiniger* (2), *Onthophagus binodis* and *Digitonthophagus gazella* (40 each).
- Nematode infected dung added once
- Grass clipped each 2-3 weeks, and L3 nematodes counted.

Nematode results

- Numbers reduced with dung beetles at 2 sites.
- Lower at site with sandy soil, and not different +/- beetles.
- Sandy soils: mortality in dry conditions, but rain allows migration from buried dung.
- No “time-bomb” effect - results consistent with international studies (from detailed review)







ESR Public Health Review

- Dung beetles …. will decrease the transport of pathogens from ruminant dung … to people.
- Risk of transmission from contaminated groundwater sources in immediate vicinity of pasture (these sources already vulnerable if not treated - over time as soil depth increases with dung beetle activity, this increase may reverse).
- The potential increase of transport to groundwater is likely to have a lesser effect than the potential benefit of decreased transport to surface waters.
- The authors do “not see any need to undertake further research before the release of the dung beetles.”

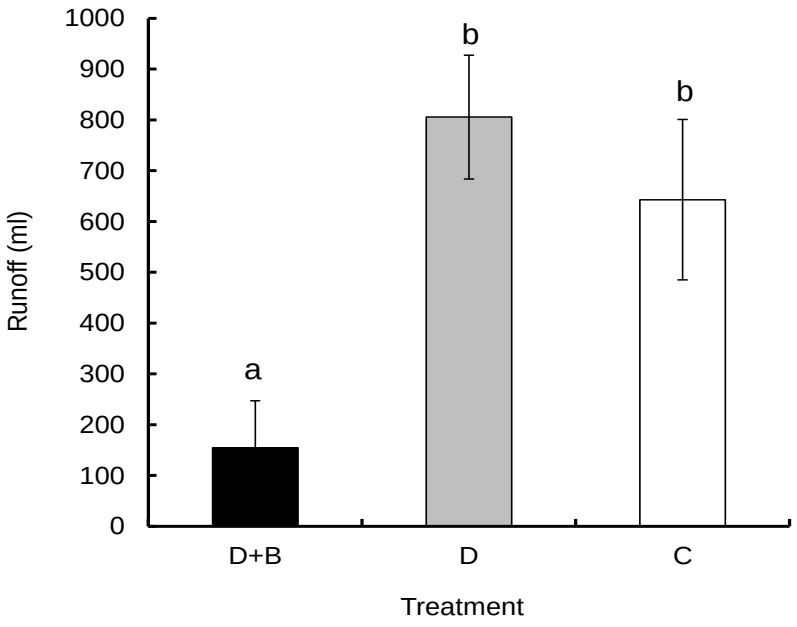
Run-off Trial

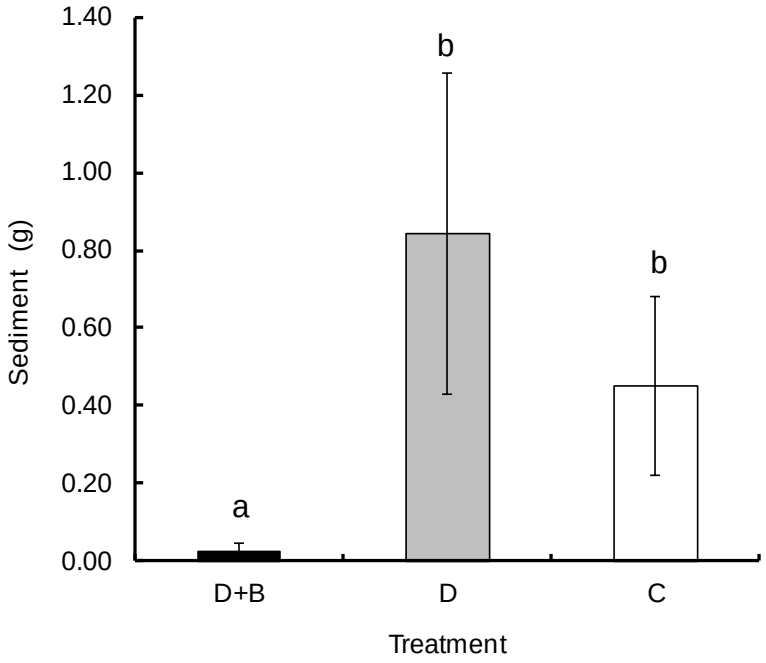
- Used large beetle, *Geotrupes spiniger* (5 female; 5 male)

- Rainfall simulator
- 40mm in 10 min. (likely <1 in 100 y)
- 20mm (<1 in 60-100 y)

Run-off Trial Results

- Large reductions in run-off volume in the presence of dung beetles.
- Reduced sediment load in the lower (still extreme) rainfall simulation with beetles.





Summary of Post-Hearing Research

- Low risk of possums interacting with dung beetles, and increasing Tb transmission
- Dung burial unlikely to increase percolation of microbes
- Stock infection rates with GI nematodes likely to be reduced
- Low risks to human health (the reverse likely)
- NZ benefits to run-off/sediment and GI nematode levels from dung beetle activities
- More can always be done – but in Sept 2013 the TAG recommended releases go ahead

Two Species Released – Southland and Greater Wellington

Releases near Wellington, Oct 2013

Exotic species shortlisted for NZ

Bubas bubalus
17mm

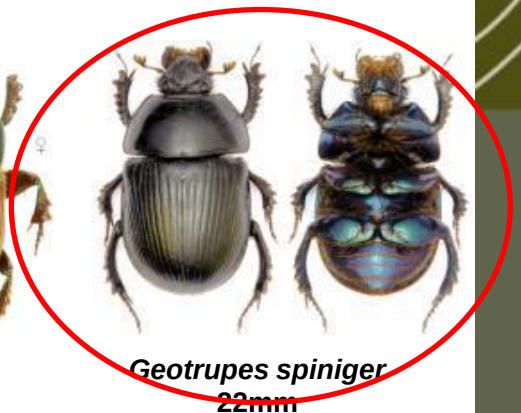
Bubas bison
16mm

Copris hispanus
18mm

Copris lunaris
18mm

Euoniticellus fulvus
10mm

Onitis alexis
20mm



Geotrupes spiniger
22mm

Onthophagus taurus

9mm

O. (Digitonthophagus) gazella
11mm

Onthophagus binodis
12mm

O. (Paleonthophagus) vacca
10mm

Monitoring Plans

- Being developed – with DBSRG, GWRC in particular
- Multi-disciplinary: Universities, CRIs, regional councils, farmer groups, schools etc
- Challenging as benefit/risk issues cross many traditional skill boundaries
- Timeframe – initiate in next 3-5 years (confirm establishment first)

The Slow Down and Costs?

- Cost in time – 2.5 years delay
- Reduced no. species
- Cost in $$ - at least $600,000 to Landcare Research
- DBRSG, EPA and other government bodies, regional councils etc
- Opposition (esp Auckland Council and Auckland University) - possibly similar in terms of staff time?
- Probably over $2 million …?

Lessons Learnt?

- More transparency – e.g. in risk assessment process?
- EPA – simplified applications not necessarily a good idea?
- But dung beetles made for a difficult application cf weed biocontrol agents – more multi-disciplinary

Acknowledgements

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