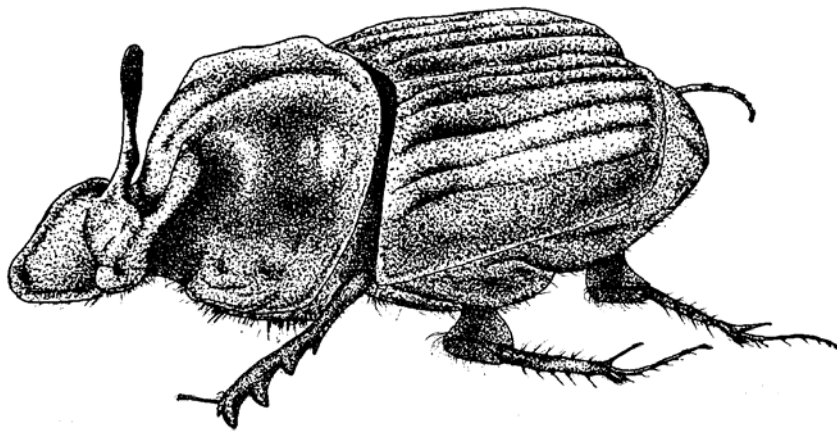


THE DUNG BEETLE MONITOR

**A monitoring guide for Schools,
Landholders and Landcare
groups**



This monitoring guide is published by the Northern Tablelands Dung Beetle Express – an initiative of Granite Borders Landcare and the Southern New England Landcare Coordinating Committee Inc., and supported by Northern New England and Armidale Rural Lands Protection Boards.



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This is a revision of material written for the Northern Tablelands Dung Beetle Express project. The original document was produced by Shaun Baigent, 2001.

Cover illustration

Onthophagus australis (Shaun Baigent)

PART I – INTRODUCTION

Purpose

This publication is intended for schools, landholders and community groups to monitor the status of dung beetle populations. Monitoring populations of a particular group of animals over such a large area requires a great deal of labour. Schools, landholders and community groups spread throughout the area have the potential to make a major contribution.

Instructions are included for the monitoring, collection and identification of dung beetles. Also included are detailed instructions about the information you should record.

Additional information about dung beetle biology and suggested activities for use in schools is also included.

Dung Beetles – What are they?

Dung beetles play a major role in the reduction of many insect pests including bush and buffalo flies. They contribute to improved pastures and cleaner water ways by burying dung. This burial creates tunnels increasing soil aeration, water infiltration and nutrient cycling. They are an insect that feeds on the fluids of fresh dung and breeds in animal dung. In doing so they can quickly dispose of dung pads - it can take as little as a few hours. This removes the breeding ground for flies and midges and thus reduces the occurrence of the diseases that they spread.

There are number of different species of dung beetle, over 350 of these are native to Australia. Native dung beetles generally prefer macropod dung so a number of dung beetles adapted to cattle dung have been introduced.

More information about the biology of dung beetles is available in the book *Common dung beetles in pastures of south-eastern Australia* or by visiting our website www.dungbeetles.com.au

Dung Beetles in New England

A number of introduced beetles have been released in the New England region and the aim of monitoring is to ascertain which species have become established and whether introductions of other species would be beneficial.

Of the species released in the area, The Northern Tablelands Dung Beetle Express has identified 10 introduced species and one introduced predatory, mite consuming species.

The project has also identified 9 native species and discovered one species which is currently unidentified.

Introduced species

Euoniticellus africanus

Euoniticellus intermedius

Onitis alexis

Onitis pecuarius

Geotrupes spiniger

Onthophagus binodis

Onthophagus gazella

Onthophagus nigriventris

Sisyphus rubrus

Sisyphus spinipes

Native species

Onthophagus atrox

Onthophagus australis

Onthophagus capella

Onthophagus chepara

Onthophagus dandalu

Onthophagus fletcheri

Onthophagus granulatus

Onthophagus quinquetuberculatus

Onthophagus yackatoon

The Northern Tablelands Dung Beetle Express Project

This guide has been produced as part of a much bigger project aptly called the Northern Tablelands Dung Beetle Express, which is an initiative of Granite Boarders Landcare Committee, Southern New England Landcare Coordination Committee and the Armidale and Northern New England Rural Lands Protection Boards. The project is also supported by GLENRAC and GWYMAC Landcare Committees. The project was originally funded by the Natural Heritage Trust and the Australian Geographic. At the time of production of this guide the project is funded by the Mid North Coast Catchment Management Association, Meat and Livestock Australia, Northern New England Rural Lands Protection Board and several smaller contributors. The aim of this project is to facilitate the identification and monitoring of dung beetle colonies and coordinate the redistribution of colonies across the New England region.

What you can do

While predators such as feral pigs, foxes, cane toads and birds have some impact on dung beetle populations, many agricultural parasiticides pose the single biggest threat. While it may not be possible to cease using these products there are ways of minimising their impact. Where possible use a chemical which has been tested and proven to be safe for dung organisms. If this is not possible try and avoid use during periods of peak beetle breeding and consider whether the entire herd needs to be treated.

PART B – Instructions for monitoring

Preparation for monitoring

Before you go into the paddock you will need the following equipment:

- These guidelines
- Buckets – 1 per group
- Shovel or spade – 1 per group
- Small sieve – 1 or more per group
- Clean lidded jars with holes in the lids
- Gloves
- Water for buckets
- Pens/pencils
- Labels for jars

What to record

It is important that everyone involved with this project records the same information about their monitoring activities. This will make it easier to collate and analyse the information collected from various people. For this purpose copies of recording sheets are provided, you can photocopy more when you run out.

Weather details are important to record as it has been demonstrated that dung beetles are affected by different weather conditions. They are generally more active in warmer and wetter weather.

Dung beetle activity in the paddock can be sampled by the following method:

- Mark out an area 10 m² within the paddock
- Record the number of dung pads in this area
- Record the number of dung pads with dung beetle activity in this area
- Calculate the proportion of dung pads with dung beetle activity

$$\frac{\text{Proportion of pads with dung beetle activity}}{\text{with dung beetle activity}} = \frac{\text{number of pads with dung beetle activity}}{\text{total number of pads}}$$

It is recommended that this procedure is undertaken in an area separate to where individual dung pads will be sampled.

For younger secondary and primary school students it is recommended that they use codes or make up simple names for the beetles. However, please let us know what these are when reporting results.

Schools could send a copy of the results to the landholders involved (ie the people whose places they visited) as a courtesy.

Record sheet for dung beetle monitoring

General details

Name_____ Date_____

School/Organisation_____

Site details

Farm name_____ Paddock name_____

Nearest town_____ Distance to town_____

Direction from town_____ Grid reference_____

Climate

Temperature_____ Rain_____ Wind direction_____

Wind strength_____ Sky (sunny/overcast)_____

Dung beetle activity

Proportion of pads with dung beetle activity_____

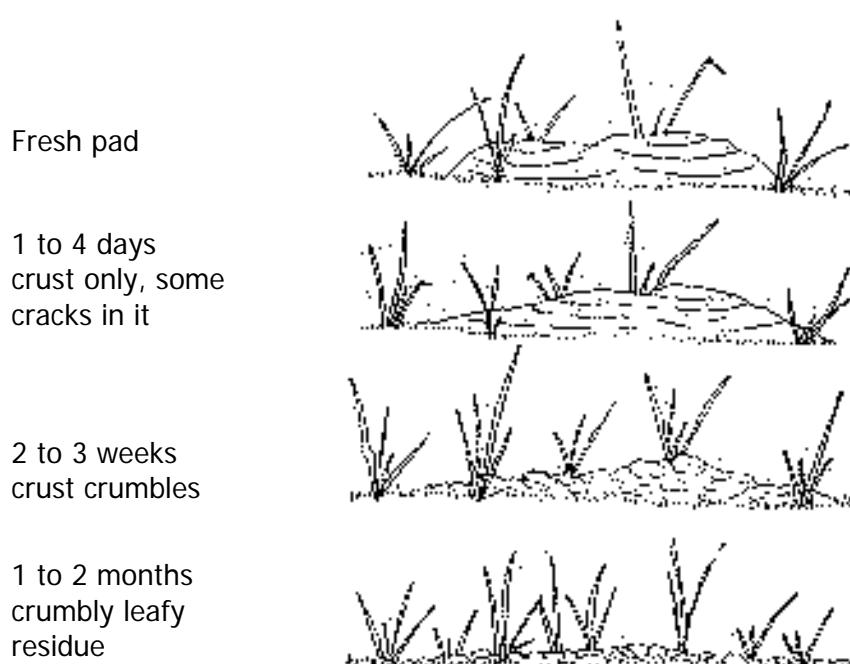
CATTLE PAD	SPECIES FOUND	NUMBER OF EACH SPECIES

Selecting cattle pads

The careful selection of pads is very important in order to maximise your chances of finding dung beetles.

- Sample pads that are 1 to 2 days old and have signs of dung beetle activity (soil castes around the pad, cracks in crust). Pads that are younger than this will generally not have had enough time to be colonised by beetles.

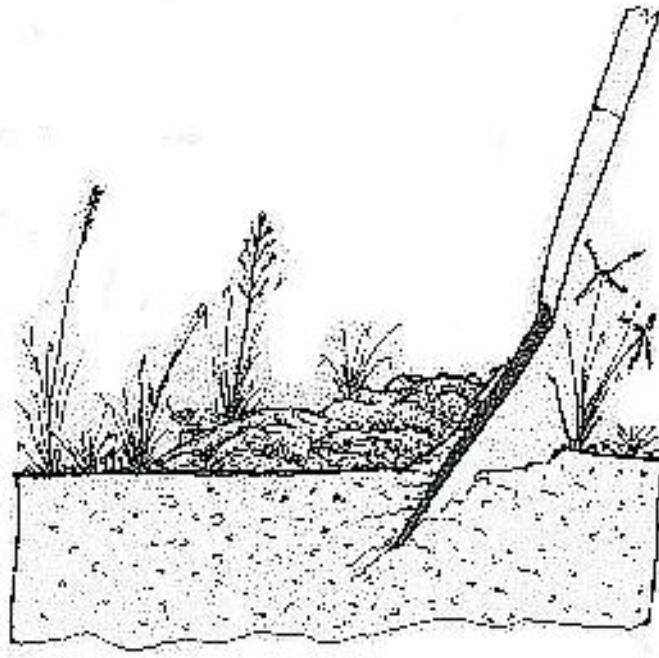
The following diagram represents the break down of a pad by dung beetles.



- Four or more pads should be sampled from the one paddock. Anything less than this number may not detect all the species that are in the paddock, though it will still provide an indication of what is there.
- It is recommended that the same paddock be sampled at different times of the year (1 to 2 month intervals). This will reveal the presence of beetles that are active at different times of the year.

Sampling of cattle pads

- It is important that all dung pads are approached quickly and quietly. Beetles are very sensitive to vibration and will quickly bury themselves if they hear someone approaching.
- With a spade or shovel dig up the whole pad with about 5 cm of soil from underneath it, and place the whole lot in a bucket of water.



- The beetles will float to the surface. Using a sieve pick these out and place them in jars.
- Place lids on the jars.
- While handling beetles be careful that they don't fly away.

Killing beetles

- Beetles can be killed to form part of a collection or for closer examination if they are hard to identify. However, it is desirable to keep the killing of them to a minimum as it reduces the numbers in the field.
- To kill them humanely place them in the freezer overnight.
- For beetles that are to be added to a collection, remove from the freezer, thaw, arrange and then pin.
- Beetles that aren't going to be added to a collection can be dried in an open container.

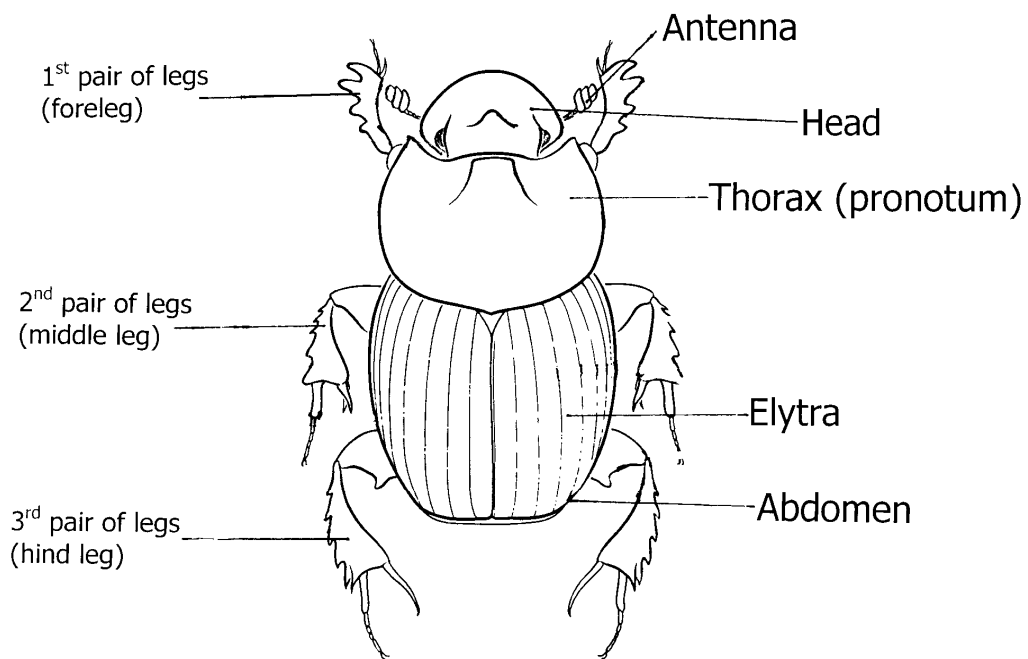
Identification of beetles

- If possible identify beetles in the field. This allows more successful release of beetles back into the paddock. If this is unsuccessful live beetles can be taken back to the school or home in their jars.
- Make sure the jars are labelled before they are removed from the paddock with pad, paddock, date and name of collector.

- For each pad sort the beetles so that the same beetles are all in the one jar.
- The features of the beetles that are most useful for identification are:

- size
- colour or markings
- Horns on the pronotum and/or head
- Spurs on femur of hind leg

These features are highlighted on the following diagram.



(Courtesy of CSIRO)

- With the aid of the magnifying glass examine these features (and others) and compare them with photographs of beetles from our website. These are the most common beetles in the area.
- If the beetles do not match any of these look at other species in the book *Common dung beetles in pastures of south-eastern Australia*.
- For many of the species males and females have different features. Some of the females are very hard to identify, don't guess – send them to us for identification.
- It is important to note that beetles other than dung beetles may be found in dung pads.

- Beetles that you can't identify can be sent to the Project Officer. Before sending beetles kill and dry them for several days. Place them in a small box, such as a matchbox, with paper towel or bubble wrap to prevent damage to the specimen.

- **Creating a collection**

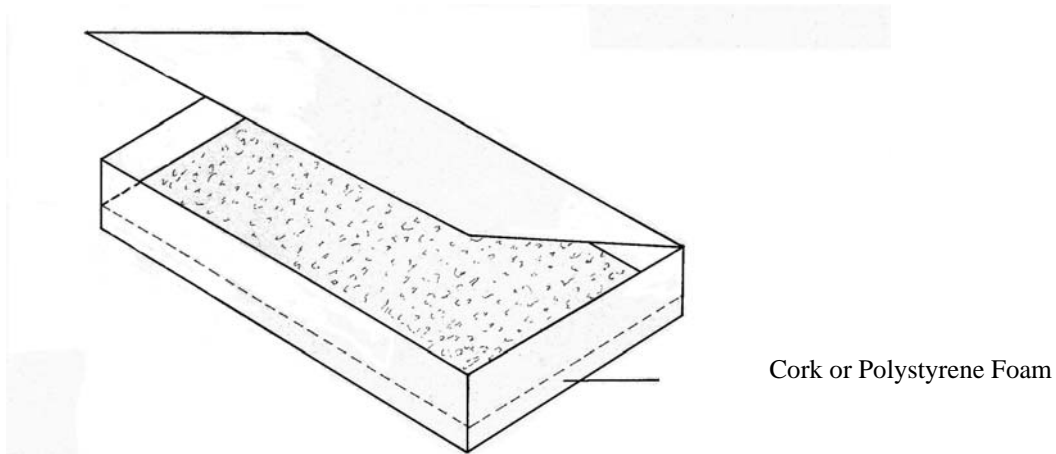
A collection of dead beetles is a very useful tool for the identification of beetles. Anybody who hasn't had any experience with identifying beetles can get a much better idea of what they are looking for by studying a collection of beetles before they go into the field. Such beetles are pinned and stored in a box to protect them from being damaged.

To create a collection you will need the following materials:

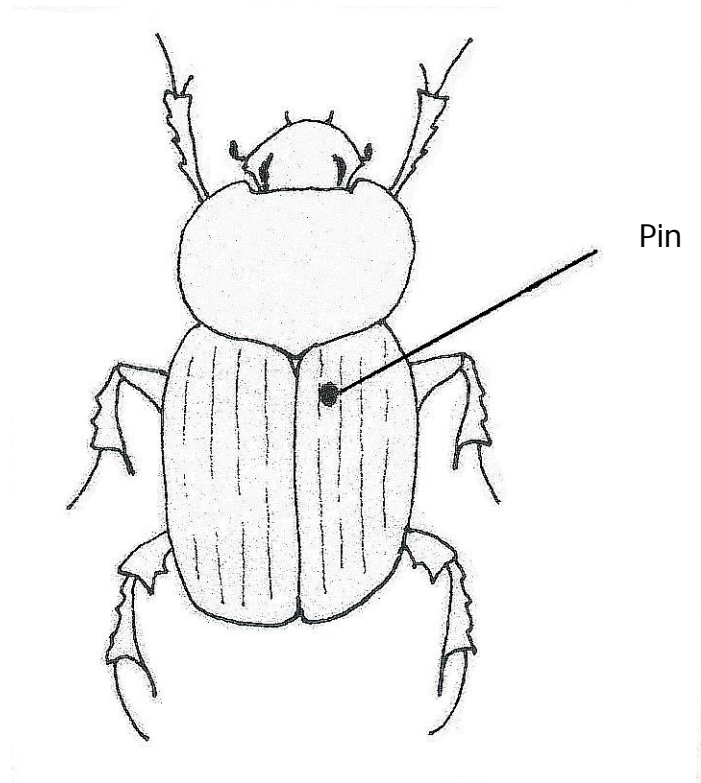
- A shallow lidded box, such as a plastic shirt box
- A piece of cork or polystyrene foam
- Entomology pins (don't use sewing pins as they will rust)
- Blank paper
- Camphor or Naphthalene
- Beetles which have been thawed out and are still pliable

PROCEDURE:

- Glue the piece of foam or cork into the bottom of the box, as shown in the diagram below.



- To pin the beetles to this foam or cork gently push one pin through the right wing cover, as shown in the diagram below.



- Display the beetles by gently arranging the legs so that identify features are visible
- On small pieces of blank paper neatly label each beetle with:

- | |
|---|
| <ul style="list-style-type: none"> - Species - Place of collection - Date of collection. - Collectors name. |
|---|

- Place these labels on the pin between the beetle and the bottom of the box, with the writing side up.
- Place camphor or naphthalene in the corner of the box, secured with a pin. This will keep pests away from the beetles and will need to be replaced every 6 months.

PART C – Information and activities **primarily for schools**

This Guide and the NSW curriculum

This guide is designed to be applied to upper primary and all levels of high school.

The guides content is primarily aimed at the science and agriculture curriculums, though some of it may also be applicable to other subject areas, particularly geography and maths.

Below is an outline of the science curriculum objectives and content that can be achieved through the use of this guide.

Objectives achievable across all syllabi:

Primary Focus Areas

- Knowledge and understanding of the nature and practice of science
- Knowledge and understanding of the application and uses of science
- Implications of science for society and the environment

Skills

- Conducting investigations
- Planning investigations
- Communicating information and understanding
- Developing scientific thinking and problem solving skills
- Working individually and in teams

Advanced Objectives

- Knowledge and understanding of models theories and laws, structures and systems:
 - Classification
 - Multicellular organisms
- Knowledge and understanding of interactions
 - Ecosystems

Supplementary information on the biology associated with dung beetles for teachers

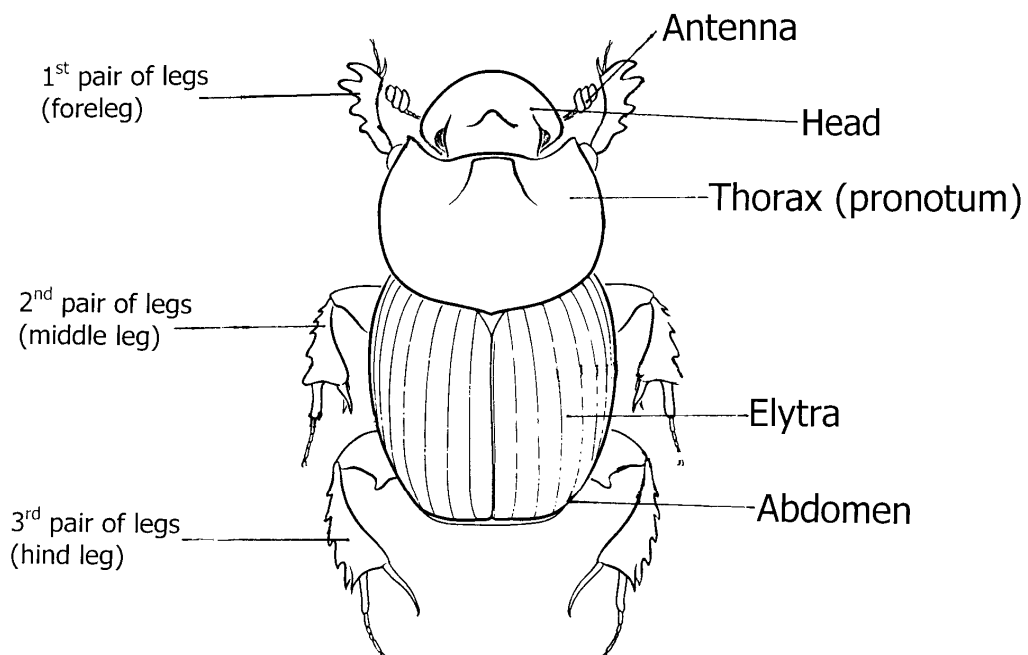
Structure of dung beetles and insects

Dung beetles are insects, like other insects they have the typical insect features:

- Exoskeleton
- 3 pairs of legs attached to the thorax
- 3 body segments (head, thorax and abdomen)
- 1 pair of segmented antennae

Note: The thorax of dung beetles is referred to as the pronotum.

These are illustrated below



(Courtesy of CSIRO)

Classification of dung beetles

What makes them a beetle?

All beetles have 2 pairs of wings, the first, outer pair are hardened, forming a casing around the second pair of wings and the abdomen. These specialised wings are called **elytra** and are not used for flying. The elytra are lifted out of the way when the beetle flies, using the second pair of wings that are under the elytra.

All beetles are members of the order **Coleoptera**. Within this order dung beetles come from the super family **Scarabaeidae**.

Around 40% of all insects in the world are beetles and there are more beetles in the world than any other animal, excluding other insects. There are about 60,000 different beetles in Australia!

Life cycle of dung beetles

Information on the life cycle of dung beetles is provided in the book, *Common dung beetles in pastures of south-eastern Australia*. There are also diagrams representing the life cycle and activity of dung beetles that can be used to make over-heads in this guide.

Dung beetles and soil nutrients

The Northern Tablelands has an estimated carrying capacity of 11,420,677 Dry Sheep Equivalents (DSE). Annually, approximately 1,027 tonnes of Phosphorous and 4,625 tonnes of Nitrogen is lost from pastoral systems due to unburied dung. Cattle dung also contains many other valuable nutrients including Potassium, Iron, Copper, Calcium and Sodium. Studies have shown that 15% of unburied organic matter containing these nutrients has the potential to end up in water ways.

Dung beetle activity quickly buries the pad thus reducing these losses and returning valuable nutrients and organic matter to the soil at the plant root zone. These nutrients are now available to aid pasture growth.

Thus dung beetles improve the efficiency of nutrient cycling, reducing the cost of fertilisers. Studies in New Zealand have revealed that more of the phosphorous from buried dung is available to plants than for an equivalent amount of applied superphosphate.

Dung beetles and Bush and Buffalo Flies

Flies are a major pest and nuisance to both humans and livestock. They have been demonstrated to be the cause of many plagues throughout history.

Flies can carry many diseases that are dangerous to humans and livestock, these are listed below.

Streptococcal	Leprosy	Tuberculosis
Recurrent fever	Amoebic dysentery	Helminths
HIV	Arbovirus	African horse sickness
Rinderpest	Swine fever	Pasteurellosis
Brucellosis	Pink eye	Bovine mastitis
Anthrax	Chlamydia	

Fortunately most of these don't occur in Australia.

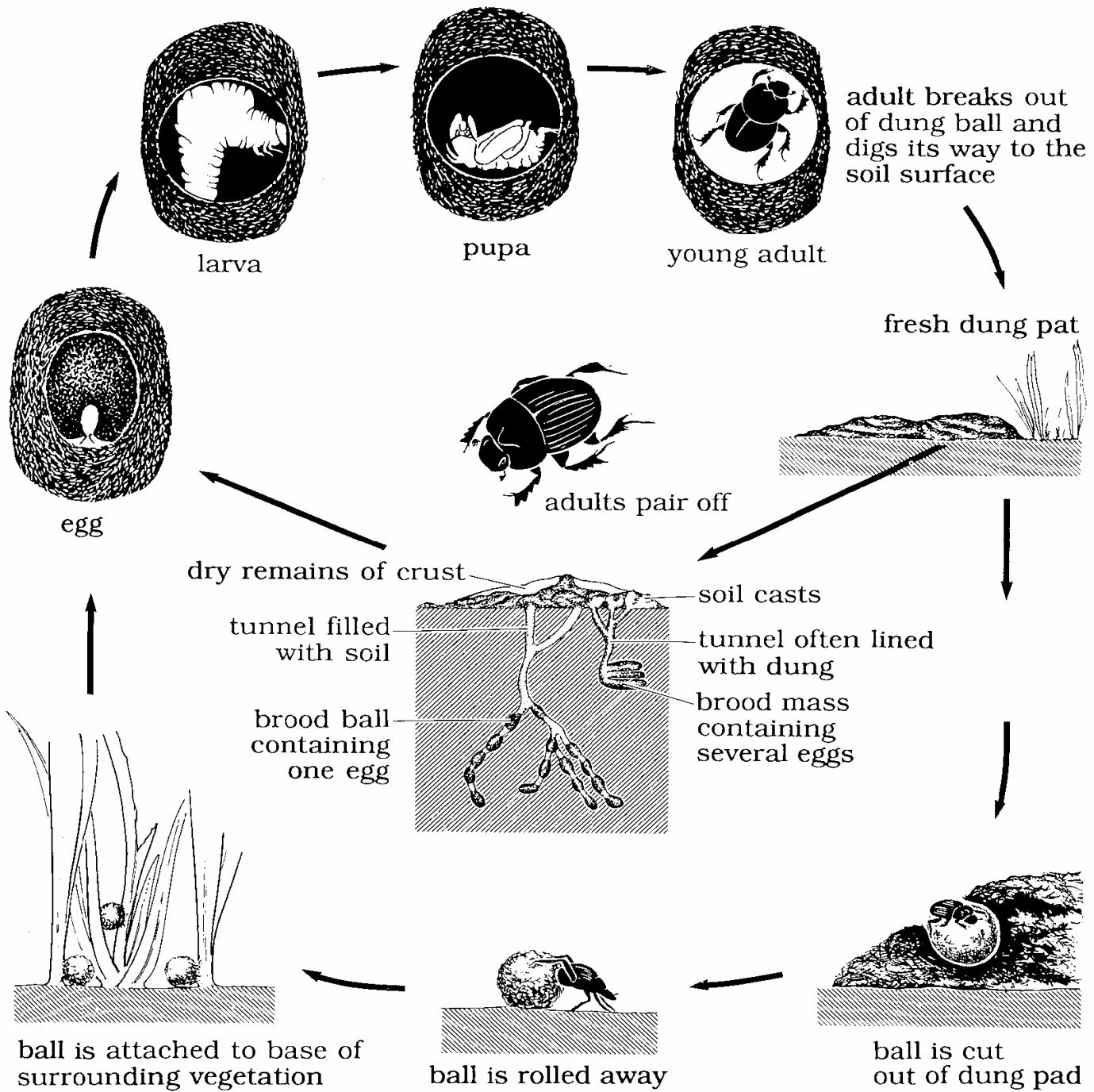
There are many different ways that have been implemented to reduce fly numbers, particularly the use of traps and pesticides. However, these practises only reduce the local number of flies, they will always return from other areas and will not stop the breeding of those that escape the treatment. They are also relatively labour intensive practices.

The major breeding site for bush and buffalo flies in the New England region is cattle dung, with each pad potentially producing 3,000 flies in 2 weeks and each beast producing 10 to 12 pads a day. That's a lot of flies!

Large numbers of dung beetles can completely bury a cow pad in a few hours. This stops flies from using that dung for breeding as their larvae require 5 to 7 days to mature. With enough dung beetles, flies could be eliminated.

There is one site near Toowoomba in Queensland, where the dung beetles are so active that not a single buffalo fly was found in a herd of 25 cows!

Life Cycle of the Dung Beetle



Activities that could be used in schools

A number of activities and worksheets have been created that relate to the biology of dung beetles. These have been designed to be used across all levels of high school and may be applicable to upper primary classes. Suggestions for other activities that have not been detailed are included at the end of this section.

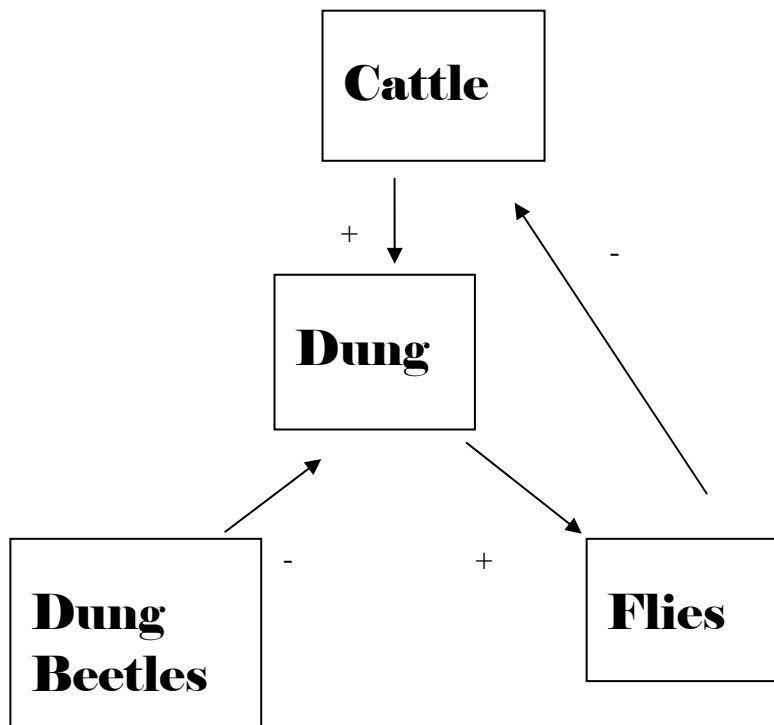
Contents

- **Ecosystem interactions (basic)**
- **Ecosystem interactions (advanced)**
- **Maths activities**
- **Classification – creating a key**
- **Structure of insects**
- **Suggestions for other activities**

Ecosystem interactions (basic)

The following diagram represents the relationships between four components of a typical paddock. A + tells us that if the amount of a particular component increases then the amount of the component that the arrow is pointing to will also increase.

For example, if you increase the number of cattle the + next to the arrow pointing to dung tells us that the amount of dung will also increase.



Answer these questions using this diagram:

- 1) If the farmer increases the number of cattle in the paddock what will happen to the number of flies?

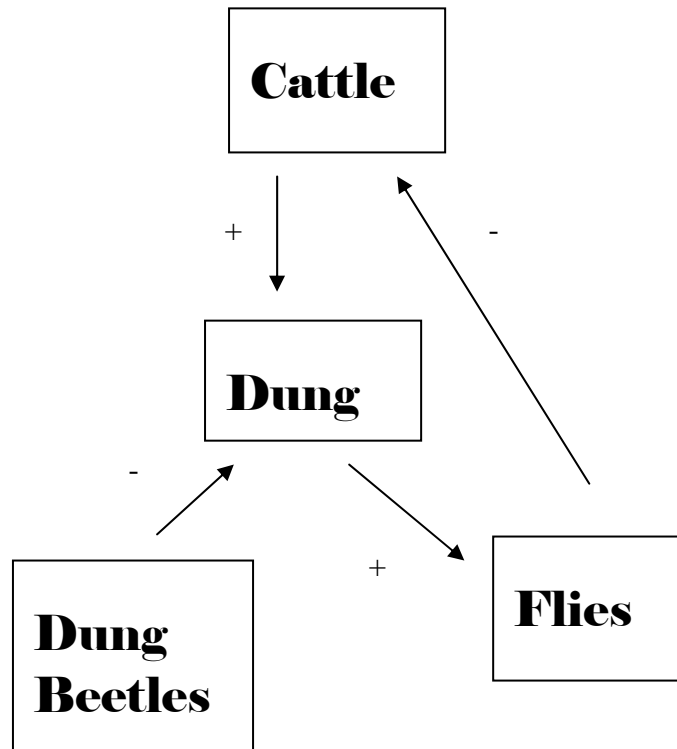
- 2) What will be the result if the farmer increases the number of dung beetles?

3) What are two changes that could cause the amount of dung in the paddock to increase?

Ecosystem interactions (advanced)

The following diagram represents the relationships between four components of a typical paddock. A + tells us that if the amount of a particular component increases then the amount of the component that the arrow is pointing to will also increase.

For example, if you increase the number of cattle the + next to the arrow pointing to dung tells us that the amount of dung will also increase.



Add the following features to this diagram using arrows and signs as above to represent the relationships between them.

- Soil nutrition
- Pasture
- Parasiticide use
- Bird predators

Maths Activities

- 1) How many flies can one cow produce in a year, given that it produces 11 cow pads a day and 3000 flies can be produced from each pad?

- 2) Graph the population growth for a bush fly over five generations, starting from one female, given that each female produces 50 eggs, half of which are female and 30 per cent of which survive.

- 3) Graph the population growth for a release of 200 female dung beetles (*Euoniticellus africanus*) over five generations, each female produces 70 eggs, 30 per cent of which survive and half of which are females.

- 4) In this same paddock there is a herd of 10 cattle. How long will it be before the population of dung beetles will be large enough to remove all the dung produced by these cattle in a day, given that 500 beetles are needed to remove each pad and the beetles only produce four generations in each year?

Classification – Creating a key

Keys are a very useful for the identification of living organisms. It is recommended that you complete this task after the activity on insect structure.

Your task is to create a dichotomous key for these four dung beetles. Below is an example of how to use a dichotomous key. This key was created by Professor A.F.L. O'Farrell of the University of New England.

- 1 Imaginary creatures (2)
 - Real creatures (4)
- 2(1) Orcs and related forms Orcidae
 - Not orcs or related forms (3)
- 3(2) Hobbits and Elves Hobbelvidae
 - Vampires and werewolves Vamwereidae
- 4(1) Animals (5 etc)
 - Plants (10 etc)

If you collected an elf you would decide at couplet 1 whether it was real or imaginary and go to couplet 2. You decide it isn't an orc so you go to couplet 3 where you find it belongs to the group "Hobbelvidae".

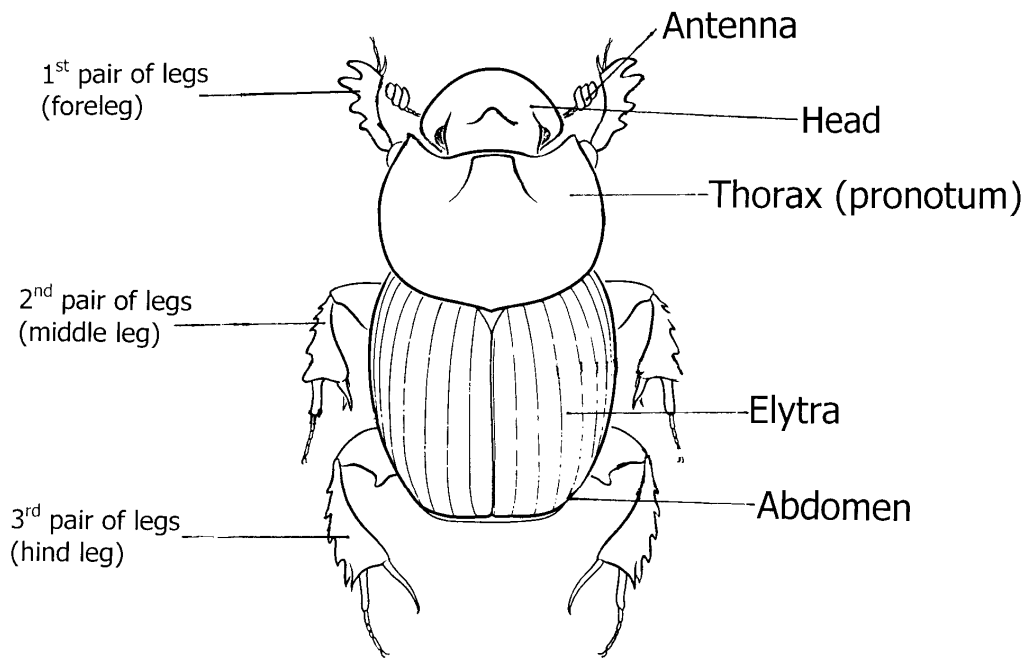
To create your own key just follow these simple steps.

METHOD:

STEP1 – Measure each of these parts of all four beetles:

- | |
|---|
| <ul style="list-style-type: none">- Length (head to end of abdomen)- Number of spurs (on femur of hind leg)- Frontal horn (present/absent)- Extended abdomen(present/absent) |
|---|

Record these measurements in the table below.



(Courtesy of CSIRO)

Beetle parts	Length	Number of spurs	Frontal horn (present/absent)	Extended abdomen (present/absent)
<i>Onitis alexis</i>				
<i>Onitis pecuarius</i>				
<i>Euoniticellus intermedius</i>				
<i>Euoniticellus africanus</i>				

Note: Extended abdomen refers to the abdomen being visible below the elytra at the tail of the beetle.

STEP 2 – Divide these into two groups of two using ONE of the beetle parts measured in step one. The species within each group must have the same measurement for this part and the measurement for this part must be different for group one and group two.

Example: Birds and dogs are two groups that can be separated on the basis of the part “wings”. ALL birds have them and ALL dogs don’t.

Part that is used to separate the groups_____

	Species in each group	Measurement of the above part
GROUP 1		
GROUP 2		

STEP 3 – Separate the individual species of each of these groups using the same method as in step two.

GROUP 1

Part used to separate_____

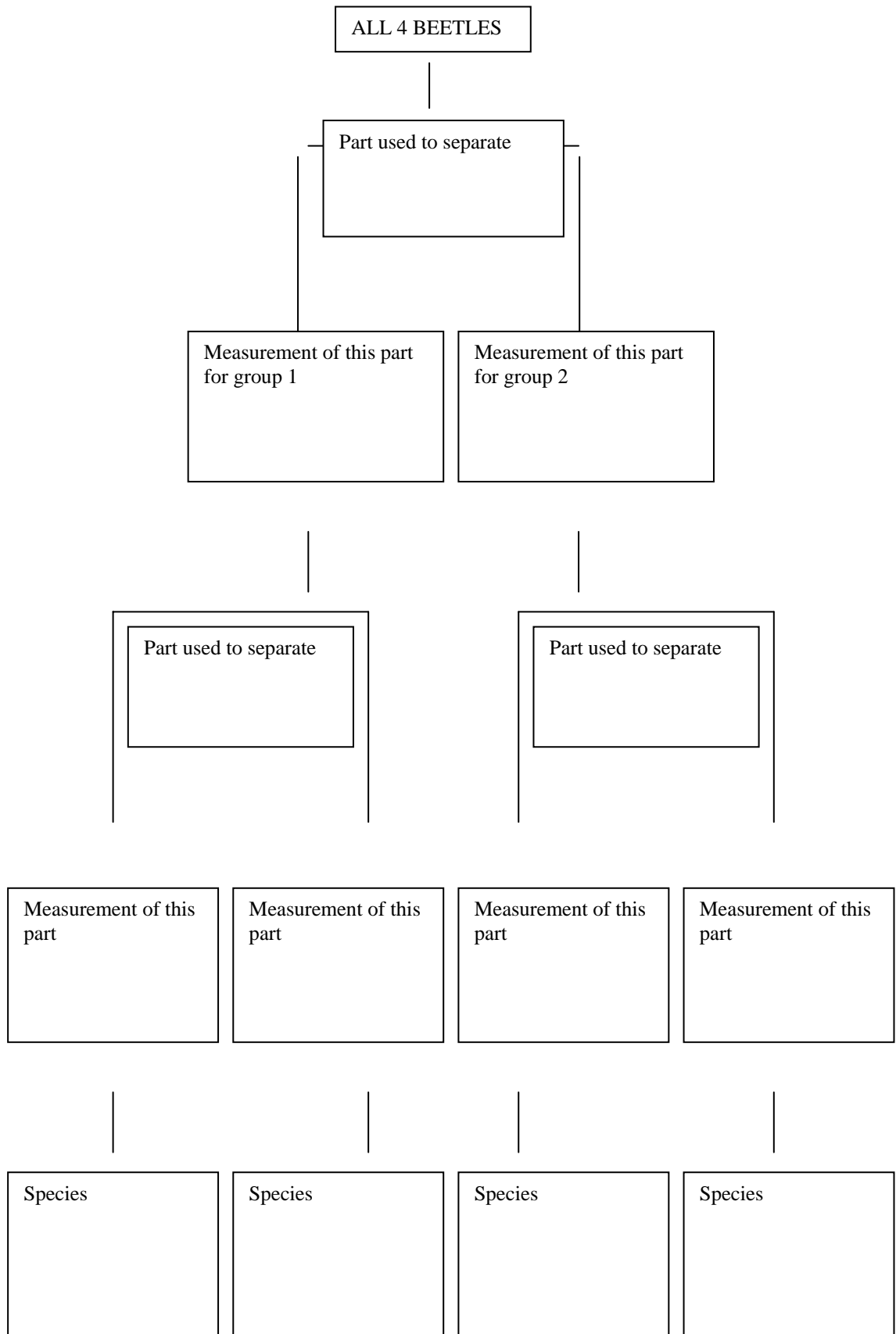
Species	Measurement of the part

GROUP 2

Part used to separate_____

Species	Measurement of the part

STEP 4 – Draw a tree to represent the splitting of groups from steps two and three.



This tree can now be used as a key to identify any of these four beetles.

Note: For more advanced (senior) classes use more beetles to create the key, from either the book or specimens in a collection (preferable). You could also create a written dichotomous key from this pictorial key.

Structure of insects (library exercise)

With the aid of the teacher and biology books label the parts of the following diagrams of a dung beetle and a fly. Then answer the questions.



QUESTIONS

1) How are these two insects similar?

2) How are these two insects different?

3) What features do all insects have?

4) From the shape of each of these insects front legs which do you think would be the best at digging, the dung beetle or the fly? Why?

5) From the general structure of each of these insects which do you think would be the best at crawling along tunnels, the dung beetle or the fly? Why?

Suggestions for other activities

- Plan an investigation to determine if there is any association between the beetles and environmental variables. You could measure variables such as the soil pH and moisture content.
- Use of data logger to measure environmental variables.
- Process and analyse your results from monitoring activities that you have carried out to see if there is any relationship between any environmental variables and the dung beetles.
- Use as a topic for a student research project.
- Analyse the different behaviours of different beetles that will influence their distribution and abundance, and the competition between them. Most of the different species have slightly different behaviours.
- Graphing of the results of monitoring activities.
- Mapping of the occurrence of the species found.
- Experimenting with capture/recapture and mark/tagging methods to estimate population numbers.
- Set up of links between schools to swap live beetles for release to establish new colonies of beetles. This will involve consulting professional bodies to ensure that beetle redistributions don't result in the spread of weed seeds or soil borne diseases such as OJD, BJD and Footrot.