


BIOSCAN ENTOMOLOGY IN SCHOOLS



**A dung beetle and bush fly monitoring program
Resource kit for upper primary and lower secondary schools**

Sponsored by
The Science and Technology Awareness Program



DITAC

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&
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DEPARTMENT OF AGRICULTURE
WESTERN AUSTRALIA

Acknowledgments

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* Authorship is in alphabetical order

WHY BIOSCAN ?

This question can be simply answered, but the answer is also quite complex. Numerous biological control programs are in place throughout Australia. The Dung Beetle Program has been of national importance since the 1960s, first instigated by CSIRO and now carried on in Western Australia by the Department of Agriculture. This program was devised to control pasture fouling by livestock brought here by European man, and in doing so, control the dung breeding flies that wreak havoc with livestock production.

As with all biological control programs it is essential to understand the interaction between the pest (dung and flies) and the control agent (dung beetle). Once the control agent(s) has been released there should follow a reduction in the 'pest'. But how can we measure this?

Monitoring the effects of a control agent is extremely difficult. It requires numerous resources, especially in terms of labour and money. These factors have resulted in many follow up programs on biological control agents being incomplete. In many cases the researcher must rely on measurements in selected areas or on anecdotal evidence. To get an overall picture of the effect of a biological control agent is next to impossible. This is why school participation is so important.

The idea of enlisting community groups in these endeavours has much merit. It is hoped that BIOSCAN will be adopted by numerous rural schools throughout Western Australia in an effort to address the problems of pasture fouling and fly control facing farmers and the general public. Schools can help us monitor dung beetle distribution and abundance and inform us where the bush fly is at its worst. In return we would like to help you understand an important aspect of science and acquaint you with some insect activities that will be informative and enjoyable.

Ian Dadour
BIOSCAN COORDINATOR

CONTENTS

	Page
Acknowledgements	i
Why BIOSCAN?	ii
PART A — Bioscan — a dung beetle project for schools	
What is BIOSCAN?	1
BIOSCAN: Some questions answered	3
What's in it for the teachers?	5
History	6
PART B — Student knowledge and understandings	
Prior student understandings useful for BIOSCAN participation	1
Educational outcomes possible through BIOSCAN	1
Some cross-curriculum objectives relative to BIOSCAN	4
PART C — Supplement for teachers: more information on dung beetle biology	
What is a dung beetle?	1
Basic morphology	1
Life stages of the dung beetle	2
The role of dung beetles in pastures	5
Keys and classification	8
References	10
PART D — Student activities	
Pre-BIOSCAN student development suggestions	1
Habitat explorer report	6
BIOSCAN field excursion	12
BIOSCAN Record Sheet 1	16
BIOSCAN Record Sheet — Fly and Dung Beetle Trap Data	18
BIOSCAN Record Sheet 2	19
BIOSCAN Record Sheet — Fly and Dung Beetle Trap Data	21
BIOSCAN Activity Sheet 1	22
BIOSCAN Activity Sheet 2	26
BIOSCAN Supporting Activity Sheet 1	30

BIOSCAN Supporting Activity Sheet 2	33
BIOSCAN Supporting Activity Sheet 3	35
BIOSCAN Supporting Activity Sheet 4	39
BIOSCAN Supporting Activity Sheet 5	41
BIOSCAN Supporting Activity Sheet 6	43
BIOSCAN Supporting Activity Sheet 7	46
BIOSCAN Supporting Activity Sheet 8	49
BIOSCAN Supporting Activity Sheet 9	53
BIOSCAN Supporting Activity Sheet 10	55
BIOSCAN Supporting Activity Sheet 11	58

PART A
BIOSCAN – A DUNG BEETLE PROJECT FOR SCHOOLS

A-1 What is BIOSCAN?

A-1.1 Research objectives

From statewide sampling, BIOSCAN will assist in :

- (i) identifying and mapping those regions with dung beetle activity and monitor the establishment and spread of introduced dung beetle species; and
- (ii) monitoring the prevalence of the bush fly (*Musca vetustissima*) in relation to the level of dung beetle activity in the State.

A-1.2 Introduction and outline

The BIOSCAN Project, using the BIOSCAN Educational package, provides an opportunity for school students to participate in a 'hands on' research program of real significance to scientists in the Western Australian Department of Agriculture, to Western Australian farmers and to the Western Australian community as a whole.

Dr Ian Dadour, of the Entomology Group, Department of Agriculture, is organising the program, which will supply him with information of major scientific importance.

A-1.3 What's involved

Students will collect field data on bush fly and dung beetle populations for a real purpose – helping Western Australian agricultural scientists to establish the present status of the introduced dung beetles and the possible effects they may be having on the 'pesky' bush fly — a pest that irritates people and animals alike during the seasons of spring and summer.

Participating schools using a trapping technique will monitor both dung beetles and bush flies. The bush fly traps which operate for 1 hour, will be set once weekly or fortnightly over a seven-month period (September to March). Traps for dung beetles will be opened for 24 hours and set up either weekly or fortnightly over the spring, summer and autumn months (September to June).

Secondary school students will sort the dung beetles and bush fly species. Primary school students will sort the dung beetles into colours, and the bush flies firstly into sizes and then further divide them into males and females before counting them and identifying them. They will then send an example of each type trapped, for

verification of the identification. (The traps are supplied as part of the BIOSCAN Educational package.)

Records of numbers of fly and dung beetle species and conditions of the trapping habitat will be kept by each school.

A quarterley newsletter will be sent to all participating schools, updating information on BIOSCAN. The information you send us will be analysed for the whole south-west. This way you can see the distribution of introduced beetles and where flies are at their worst and best.

A-2 Bioscan: Some questions answered

Q. Could introduced dung beetles become a menace?

A. Dung beetle mouthparts extract the liquid from dung. They can only eat dung and can only breed in dung. Without dung they die.

Introduced dung beetles so far have avoided wooded areas, and the pelletised dung of native marsupials is unsuitable for their needs. It is not known if in the future, with increased numbers of introduced 'wet season' dung beetles, whether any of these will colonise forested regions, or whether the introduced species will consume marsupial droppings. This is the preferred food of native species.

It should be noted that many Australian native dung beetles, unable to colonise cattle dung in open pastures, can rapidly colonise cattle dung dropped in forested regions.

It is thought that the introduced dung beetles are too specialised in their needs to become a menace.

Q. Could introduced dung beetles import foreign cattle diseases?

A. Introduced dung beetles undergo very strict quarantine procedures. Only sterilised eggs are imported which ensures that no pest or disease is brought into Australia with the introduced insect. The Australian Animal Health Laboratories facility (AAHL) in Geelong is the central body for importing viruses, bacteria, and insects under the strictest quarantine protocols.

Q. How do the dung beetles kill the bush flies?

A. Dung beetles don't attack the bush flies directly. They compete with them for dung. Dung beetles and bush flies both feed and breed in dung. When the dung beetles work the dung they make it less suitable for flies to breed in. They do this by removing it, burying it below the soil surface in tunnels for breeding purposes, or simply by shredding it so that it quickly dries and becomes unsuitable for bush fly larvae and eggs to complete their life cycle.

Q. What's in it for the environment?

A. Firstly, the burial of dung below the soil surface recycles nutrients, especially nitrogen, back to the roots of plants, reducing the need for applications of artificial fertilisers.

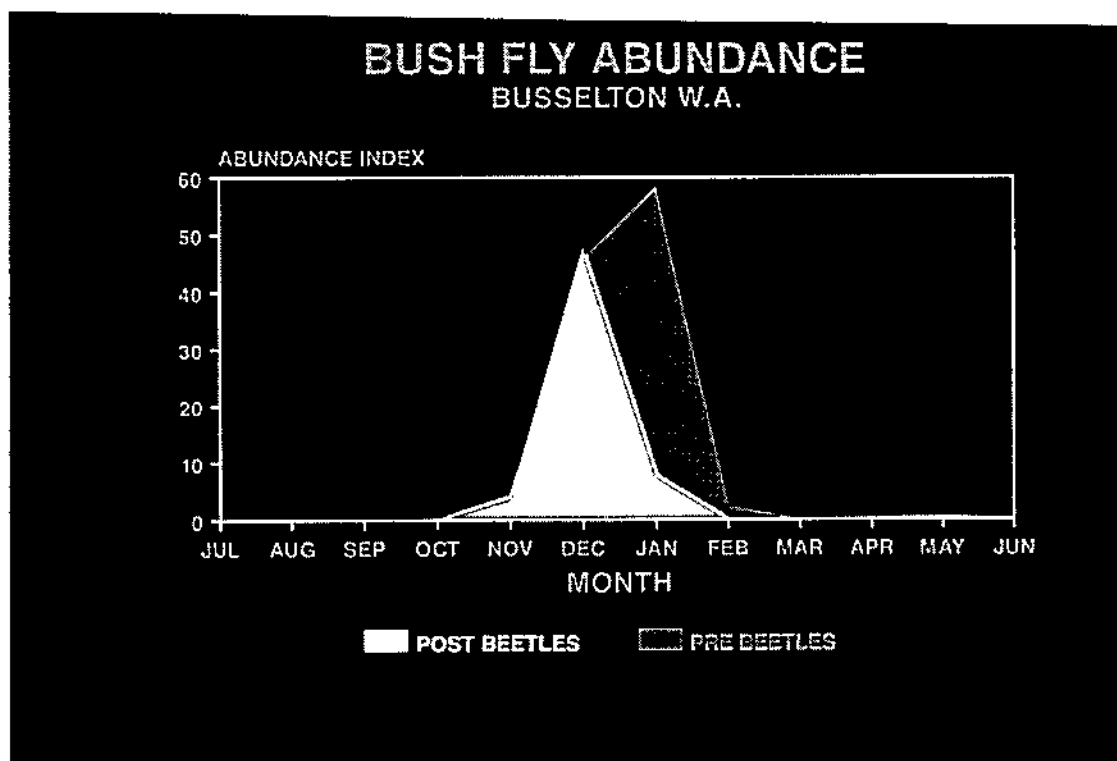
Secondly, the tunnelling action of the beetles increases the aeration of soils. This is particularly valuable where heavy, hard hooves have compacted the soil.

Thirdly, the tunnelling action assists the infiltration of rainwater into the soil. This is especially important where the soils are hard or compacted and water tends to run off the slopes causing erosion.

Q. Why introduce so many different types of dung beetle?

A. Western Australia has a wide range of temperature and rainfall zones. Beetles have been collected from similar climatic zones overseas. The Climex (CSIRO) computer model compares climatic zones using species, relative humidity, temperature and rainfall parameters.

Also, dung beetle adults are not active all year round. Different species of dung beetles may not have the adult stage of their life cycle at the same time. Some species have their active adult peak from spring through to summer, others summer to autumn, others autumn to winter, and others winter to spring. The initial introductions of dung beetles were targeted at the bush fly population peaks (that is, spring and summer).



*Figure 1. Graph of bush fly and dung beetle numbers versus time
Illustration: CSIRO*

Research has identified the need for dung beetles that have an activity period in early to late spring, targeting the corresponding period of early fly breeding. Eventually it is planned to fill all the seasonal niches with various dung beetle species so that the bush flies' over-wintering sites are eliminated and fresh dung is cleared from pastures as soon as possible and over as much of the year as possible.

Q. What's in it for farmers?

A. The clearing of dung from pastures has already been mentioned as a benefit for farmers. A cow pat left to decompose in the pasture may take one to three years to disappear, but dung beetles can clear it from the pasture in three to six hours. It costs about \$15/ha for harrowing to clear dung — this may be done up to two or more times a year. A reduced bush fly population would improve the farmers' quality of life too.

Another benefit from the clearing and burial of dung is the reduction of stock parasites which use dung as part of their mechanism to infest stock. This would save money on veterinary treatments.

A-3 What's in it for the teacher?

Part of the BIOSCAN package contains educational activities that will help in running a theme approach for the program.

The 'hands on' activities will be a great *hooker* to involve students in science, social studies and language activities, either as a class or as a small extension group.

The Department of Agriculture will provide support in solving any problems encountered.

A-4 History

Following the settlement by European man and the introduction of cattle into Australia, a new type of environment was created which did not suit the then-present dung beetle (Scarabaeinae) fauna. This imbalance caused by an accumulation of cattle dung, has led to an increase in the favoured breeding site of the bush fly *Musca vetustissima*. Native dung beetles, mostly found in the natural vegetation of south-western Australia, normally feed on the faecal pellets of marsupials and leave cattle dung relatively untouched.

The dung pads of cattle dry hard and remain in the pasture for months or even years. Cattle will not graze in the immediate vicinity of a pad unless desperate for feed — so farmers lose a significant amount of grazing land. This has meant that farmers could not run as much stock and so lost (and are still losing) money.

To increase the breakdown of cattle dung in pastures, CSIRO, between 1972 and 1986, released 14 species of dung beetle from Europe and Africa into south-western Australia. Nine species are known to be established of which seven species are common. Since 1978 these introduced species have become the dominant members of the dung beetle fauna in pastures in south-western Australia. The increased recycling of dung into the soil by dung beetles has reduced pasture fouling and consequently has reduced the need for harrowing.

These introduced dung beetles, by increasing the breakdown of cattle dung, also reduce the number of sites available for bush fly breeding. As well, when beetles are abundant in a dung pad they compete with the bush fly which is then killed because there is insufficient undisturbed dung for the bush fly to complete its life cycle. The CSIRO Division of Entomology in Western Australia has demonstrated an 88% reduction in bush flies in January in the Busselton region, caused by the activity of introduced dung beetles.

In December 1989, a three to six-year program was initiated to introduce three species of dung beetles (active from September to early January) from Spain to Western Australia to control bush flies. This is a collaborative program between the Department of Agriculture Western Australia (DAWA) and CSIRO.

PART B

STUDENT KNOWLEDGE AND UNDERSTANDINGS

B-1 Prior student understandings useful for BIOSCAN participation

B-1.1 Science understandings

- Living things exist in a variety of forms and live in a variety of places.
- Living things vary greatly in their structure, behaviour, habitats and lifestyles.
- Living things can be grouped on the basis of observable characteristics.
- Living things can be placed into groups on the basis of similarities and differences in their structure, behaviour and appearance.
- Living things usually go through a cycle of birth or germination, growth, reproduction and death.
- Living things have their own roles in a community such as decomposer, consumer and producer.

B-1.2 Physical geography understandings

- Climatic variation between seasons and locations.
- Temperature differentials and their impacts.
- Precipitation.
- Effects of latitude and longitude.

B-2 Educational outcomes possible through BIOSCAN

Students will have gathered scientific information of real value which will contribute to research at the Department of Agriculture (Entomology Unit) on aspects of dung beetles. In the process, these students will have had an opportunity to experience realistic work in the field of ecology.

B-2.1 Direct learning outcomes

- Successful following of instructions for assemblage of and maintenance of fly traps.
- Following of instructions for assemblage and maintenance of dung beetle traps.

- Following of instructions for construction of forceps.
- Development of observational skills to identify different species of dung beetles.
- Classification of dung beetle and fly species through observation.
- Use of (dichotomous) keys to assist with classification of flies and dung beetles.
- Gaining knowledge of the ecology (study of plants or animals in relation to their environment) and life cycles of dung beetles and bush flies.
- Developing an understanding of adaptations of organisms.
- Developing an understanding of strategies for sourcing food.
- Developing an understanding of the relationship between beef and dairy farmers, town people, tourism and our economy.
- Developing an understanding of the use and importance of scientific research.
- Identifying and recreating the requirements for successful maintenance of a dung beetle enclosure (vivarium).
- Developing skills in using hand lenses.
- Recognising the importance of biological control as an alternative to chemical and mechanical controls.
- Recognising the need for accuracy in measurements, thoroughness in preparation, and care in observation and classification.
- Developing an understanding that an alteration of the environment may create situations that favour one species so that they can become of pest proportions while other species may be disadvantaged.

B-2.2 Related learning outcomes

B-2.2.1 Science – The nature and impact of science

- Being a 'scientist' involves using scientific processes and having scientific attitudes.
- Many discoveries in science have been very useful in solving practical problems.

- Australian scientists have contributed greatly to our lifestyle and the welfare of the country.

B-2.2.2 Science – Life and living

- Living things exist in a variety of forms and live in a variety of places.
- Living things vary greatly in their structure, behaviour, habitats and lifestyles.
- Living things can be grouped on the basis of observable characteristics.
- Living things can be placed into groups on the basis of similarities and differences in their structure, behaviour and appearance.
- Living things have characteristics which help them survive in their environment.
- Adaptations help living things survive in a particular environment.
- Living things usually go through a cycle of birth or germination, growth, reproduction and death.
- Many living things depend on other living things for their survival.
- Living things have their own roles in a community such as decomposer, consumer and producer.
- Humans have altered and are altering environments through their activities.
- The balance of life in ecosystems can be (and is) greatly affected by human activity.
- Living things are affected by physical factors in their environment.
- An ecosystem consists of a community of living things and their non-living environment.
- Many living things respond to changes in the seasons.
- Energy and matter pathways in nature include the water cycle (and the nitrogen cycle etc.).

B-3 Some cross-curriculum objectives relative to bioscan

B-3.1 Primary

Social Studies Year 4 — *Choice* — People use scarce natural and man-made resources to produce goods and services.

Social Studies Year 5 — *Farming* — Many factors determine the success of farming. Farm people and town people depend on each other.

Social Studies Year 6 — *Sharing the environment* — Change occurs in all environments and societies as a result of natural, technological, and ideological factors. People make different uses of the natural environment.

Social Studies Year 7 — *Interacting with the environment* — Change occurs in all environments and societies as a result of natural, technological, and ideological factors. In attempting to satisfy wants, people adapt to and modify the natural environment and modify its resources.

B-3.2 Secondary

Social Studies Year 8-10 — *Earth and People 1.1* — Recognise that the natural environment is composed of physical features, soil, living things and atmospheric conditions.

Social Studies Year 8-10 — *World Environmental Issues 6.1* — Identify the component parts of environmental systems. Explain changes made to world environmental systems by people producing food.

Science Year 8-10 — *Ecology Unit 3.4* — Whole unit is relevant to environmental issues.

Science Year 8-10 — *Biological field studies 5.1* — Understand the relationships among humans, other organisms and the environment and describe ways in which the balance in nature may be upset; describe, identify and selectively collect plants and animals from a particular environment; demonstrate the ability to measure and or estimate biological populations; demonstrate the ability to measure non-living factors in the environment; research information, test hypotheses and communicate ideas in both written and oral form.

Specific objectives: Define ecology and use the terms *environment*, *habitat*, *community*, *population* and *ecosystem* in context; describe relationships in an ecosystem including the role of humans; explain the need for and the role of humans in environmental management; describe some ways in which humans have upset the balance in nature.

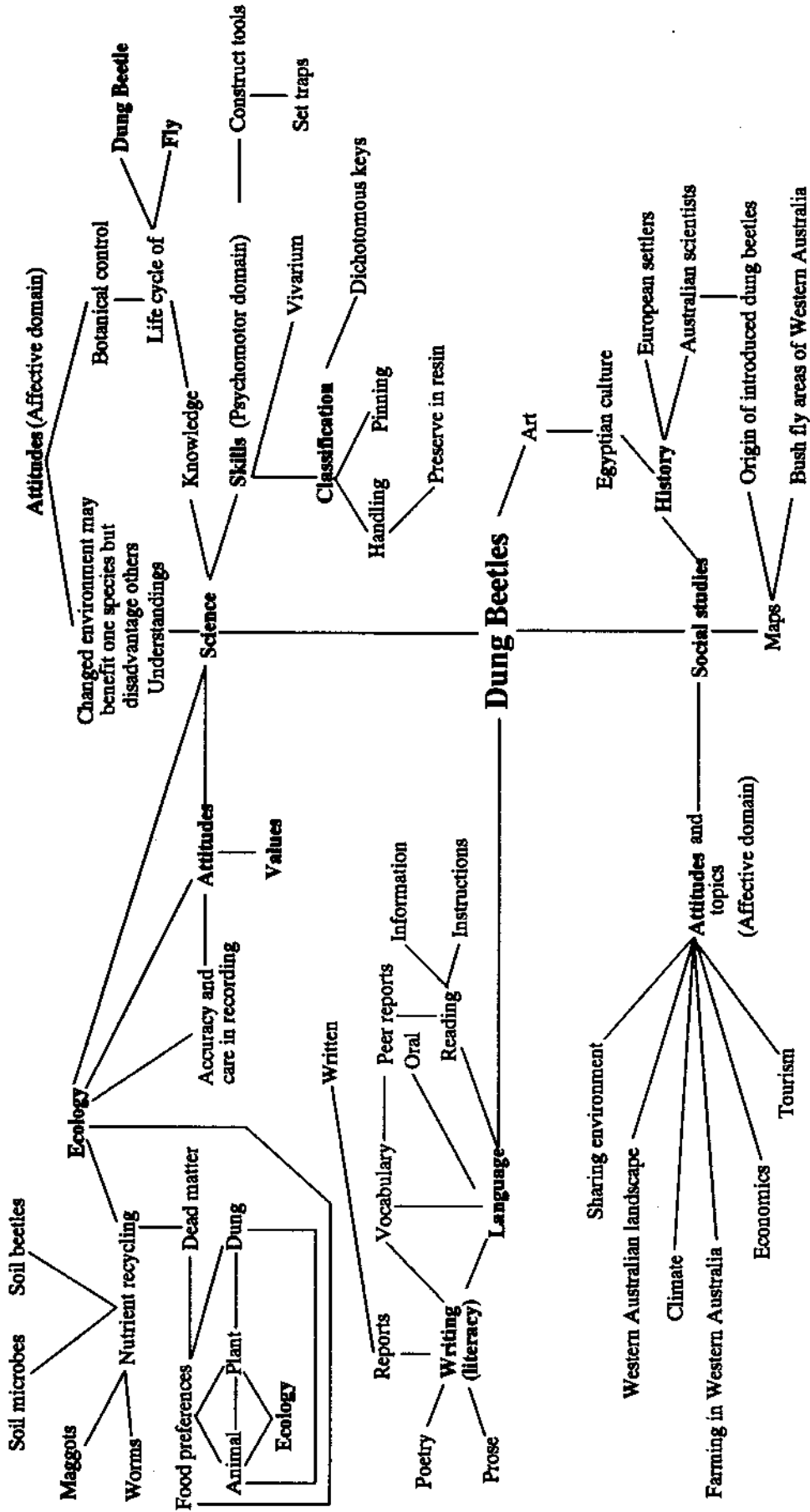
Science Year 8–10 — *Energy Past, present and future 6.1* — Recall that usable energy on earth can be classified as fossil, biomass, hydro, wind, tidal, geothermal, wave, nuclear and solar.

Science Year 8–10 — *Biological change 6.2* — Understand the influences of heredity and environment on the characteristics of organisms, including humans; Describe the effect of introduced species on natural populations in Australia in terms of changing food webs and any other effects.

Science Year 8–10 — *Science enrichment 6.5* — Research in their field of interest; review literature in the field and prepare a synopsis; present a research proposal to outline - hypothesis, equipment, experimental and data collection, expected results; conduct the investigation, prepare a report on the investigation; and prepare an oral report for review by peers.

An ideas key follows this section for general information.

AN EXAMPLE OF IDEAS KEY



PART C

SUPPLEMENT FOR TEACHERS

MORE INFORMATION ON DUNG BEETLE BIOLOGY

C-1 What is a dung beetle?

Dung beetles can be rather arbitrarily defined as those beetles (Order Coleoptera) of the super family, Scarabaeoidea, whose larvae feed on and in dung (that is, the families, Scarabaeidae, Geotrupidae and Aphodiidae).

This definition effectively isolates these scarabs from other families in the super family Scarabaeoidea. It also separates out those beetles that do not feed on dung but are still to be found in and around dung. For example, while some beetles and their larvae can be found in dung, some insects are predacious, and feed upon fly eggs and larvae present in the dung, but not dung. These families include the Histeridae, Carabidae, Hydrophilidae and Staphylinidae which can be found hunting in and on the dung patch. Some of the saprophytic (humus feeding) members of the Tenebrionidae, can also be found feeding under dung.

C-2 Basic morphology

The dung beetle is made up of three visibly separate components. Please refer to *Common dung beetles in pastures of south-eastern Australia* in BIOSCAN kit.

C-2.1 The head

The obvious features of the head are the mandibles, two compound eyes and a pair of antennae. The head is usually saucer-shaped and the resulting 'shovel' (the clypeus) is used effectively by the beetle. The head may also be ornamented with horns, bumps, ridges and notches, which are useful taxonomic aids (as well, these may be exaggerated in the male beetles — these males are known to use the horns to overturn other rival males during competition for mates and to block tunnels from entry by competitors and predators).

C-2.2 The thorax

The cuticle of the thorax of the dung beetle is barrel-shaped and is the anchorage point of the two pairs of wings and the three pairs of legs. The conspicuous part of the