Year 4

Biological Sciences

Agriculture in Education:
an educational resource for Year 4 Biological Sciences

Where would we Bee without them?

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AGRIFOOD SKILLS AUSTRALIA

Where would we Bee without them?

Year 4 Biological Sciences

Content Description	
Living things have life cycles	ACSSU072
Living things depend on each other and the environment to survive	ACSSU073

Source: Australian Curriculum v8.1
http://www.australiancurriculum.edu.au/science/curriculum/f-10?layout=1 - level4

learn

Learning Outcomes

At the end of the unit, students will be able to:

- Discuss the role of bees in pollination;
- Discuss our reliance on bees for food;
- Describe relationships between bees and plants;
- Identify and describe the body parts of a honey bee;
- Explain the division of labour within a bee colony;
- Sequence the stages of development from egg to adult;
- Understand how the small hive beetle can damage bee colonies;
- Suggest reasons why bee populations are declining.

Description

This learning activity introduces students to the world of bees and their vital role in our food production. It explains the introduction of honeybees to Australia and how they differ from native bees. It focuses on their features, short life cycle and the specific roles of the queen, worker and drones within the complexities of a bee colony. Background notes provide a useful summary.

The video – *Where would we Bee without them?* explains how bees cross pollinate fruit and vegetable flowers in their search for nectar, how they carry out the various nurturing and cleaning tasks required for the bee colony to survive and how they produce honey. Students see worker bees hard at work gathering pollen and nectar from pumpkin flowers and are introduced to the biosecurity risks from parasites, such as the Varroa mite and the small hive beetle, that are decimating bee populations around the world.

The following activities provide opportunities for both individual and group investigation. Teachers can select which activities to include depending upon student's existing knowledge and whether students have already done the *Making a bee pollinator* activity.

An increasing amount of information is available online about bees. Suitable resources have been identified within each of the activities.

discuss

Teacher Background Information

Bees in Australia

There are two main types of bees in Australia - the well known European honey bee - (genus - Apis and species - mellifera)[1] and the less well known native bee of which there are over 1,500 species. Beekeeping in Australia is a relatively small industry, but it has an enormous impact on Australian agriculture. About 65% of our horticultural and agricultural crops are dependent upon bee pollination and this activity is valued at over $1.2b pa. This far exceeds the value added through honey and hive products in Australia, which nevertheless generates between $70-$90 million pa.

Australia is one of the world's most sought after sources of honey, producing about 30,000 tonnes of honey pa. Output is dependent upon seasonal weather conditions, but Australia has long hours of sunshine and many varieties of native trees with nectar laden blooms resulting in honeys with unique flavours.

Australia's honey industry is also one of the healthiest world wide. Honey bee breeders have produced pure strains from the European bees that were originally introduced into Australia. Controlled breeding programs on Rottnest and Kangaroo Islands, just off the coasts of WA and SA respectively, provide high quality brood stock that is highly sought after by overseas countries.

There are over 524,000 honeybee hives in Australia today with about 180,000 used for pollinating Australia's growing almond industry. The health of our bees is of critical importance.

Bee security

Bee security is a major concern in Australia as bees as play such an important role in the pollination of flowering plants and in ensuring that farmers can produce crops, fruit and vegetables and healthy pastures.

Australia is fortunate being an island continent, but with more frequent and rapid movement of people and goods around the world, the risk of introduced pests and diseases is growing.

Other threats to bee populations world wide include increased urbanisation, removal of natural habitats, unsustainable agricultural practices such as large scale monoculture and the use of pesticides.

What can be done?

Research: A great deal of research has been undertaken in Australia and much more is being carried out to understand bee behavior, social behavior and to identify and manage threats. One such example is the ground breaking research using micro-sensing technology is currently being undertaken in Australia by the CSIRO to ensure that our bees maintain healthy in the face of these threats.[2]

What really has scientists, farmers and bee keepers worried, is a mite called the Varroa mite which is devastating honey bee populations around the world. This tiny mite, the size of a pin head, feeds on the blood of adult honey bees and their larvae and causes deformities, reduces the lifespan of bees and can destroy entire colonies. This threat is highlighted in the accompanying video to this resource *Where would we Bee without them?*

Fortunately, the Varroa a mite has not yet reached Australia, but it is already in neighbouring countries such as New Zealand, Indonesia and PNG and it may just a matter of time before it enters Australia.

1 Apis - Latin for "bee" and mellifera - "honey bearing."

2 CSIRO- Swarm testing: tiny technology creates a buzz http://www.csiro.au/en/Research/BF/Areas/Protecting-Australias-agricultural-industries/Robot-technology/Swarm-sensing

discuss

Another serious threat is the small hive beetle (SHB) Aethina tumida Coleoptera. It belongs to the same family as a number of other beetles native to Australia, but this predator is a scavenger of honey bee colonies. It originated in sub Saharan Africa and has been destroying bee colonies here since 1982.

The small hive beetle can be an extremely destructive pest to honey bee colonies as it damages the honeycomb, stored honey and pollen. Beetle larvae may tunnel through combs of honey, feeding and defecating, causing discoloration and fermentation of the honey. It can cause bees to abandon their hive.

After much research in Australia, the small hive beetle is being managed through biological control using microscopic roundworms (nematodes) that live naturally in most soils. Despite this, the small hive beetle remains a threat. All bee keepers – whether commercial or hobby bee keepers, need to know how to manage it.

Encourage bees: There has been a huge resurgence in beekeeping in Australia recently – both honey bees and native bees, as more people understand the role bees play and how dependent we all are upon them. Australia has over 12,000 registered bee keepers, with possibly up to 30,000 recreational beekeepers and backyard enthusiasts. More and more people are looking at creating a habitat to encourage native bees into their garden. Much is now being done to educate beekeepers and the wider community on the pests and diseases that can attack specific stages of the life cycle of the honey bee.

Native Bees: There are over 1,500 species of Australian native bee. They vary in colour and range from 2mm to 24 mm in length. In comparison to the European honey bee, most are solitary. They do not live in colonies with a queen, worker and drones. Instead, the queen mates, builds her own nest and cares for her eggs in small nests. Solitary bees do not store honey in their nests – they only collect enough nectar to feed their young. They are not aggressive but they can sting, but because of their small size, their sting is usually ineffective. Larger ones could sting if picked up or trodden on. Unlike the European bee, they can sting more than once, so care has to be exercised.

There are about 10 species of social native bees that do form large social hives with a queen. These are stingless bees and they do produce and store a small amount of aromatic honey – especially in warmer areas. They are very dark in colour and much smaller (less than 5mm long) than honeybees. These social native bees usually nest in trees.

Native bees are fun to have as they are not aggressive and usually don't sting. Many people are establishing native bee hives. Native bees do play a role in pollination, but do not fly as high as honey bees can, so the variety of plants they can pollinate is limited. They produce small amounts of honey, but most of this is needed to feed their babies. They rarely produce enough honey for people to harvest.

Bee informed: We can all support bee health and populations by understanding the role that bees play in pollination and how bee behavior drives biodiversity. All beekeepers, be they commercial or hobby beekeepers, need to know how to maintain bee health, understand and recognise the pests and diseases that can affect honey bees and how to take remedial and preventative action to manage their colonies.

Australia has strict quarantine rules for plants and animals entering Australia from overseas. There are also restrictions on the movement of some plants and animals between various states within Australia. These restrictions are there for a purpose and we should all respect and follow them.

web

- CSIRO - Honey Bees
  http://australianmuseum.net.au/honey-bee
- Wonderful World of Honey - Australian Honey Bee Industry Council
  http://honeybee.org.au/education/wonderful-world-of-honey/
- Aussie Bee: Fifteen Common Questions about Australian Native Bees
  http://www.aussiebee.com.au/faq.html
- Which Native Bees are in your Area
  http://www.aussiebee.com.au/beesinyourarea.html

Setting the Scene

As these activities are designed to raise student interest in the behaviour of bees, teachers need to ensure that students understand not only how painful, but how dangerous bee stings can be to those who are allergic to them. A suggested briefing and useful background information is contained below.

Let the Bees Be

Students should be informed and exercise care with bees at all times. They need to know what happens to a bee when it stings, immediate action to take and the necessary follow up treatment. The following information is adapted from the Australian Museum website – see link below.

Honey Bee stings are barbed. When someone is stung, the sting (with venom gland attached) sticks in the skin and tears away from the bee. This injury kills the bee.

It is important to know that the venom gland continues to pump venom through the sting, so it should be removed as soon as possible. Do not squeeze it as this forces more venom into the wound. The sting can be removed with tweezers or just by carefully scraping it out with a fingernail.

Most Honey bee stings cause intense local pain and swelling. However, if a victim is allergic to bee stings a they could have a more serious reaction difficulty breathing and collapse.

If a person is known to be allergic to bee venom, the sting should be removed and a pressure immobilisation bandage should be applied immediately. Seek medical attention.

Best advice - do not approach a swarm of bees. Let the Bees Be.

There is a considerable amount of information and images on bees available online. These can be downloaded and printed for display around the classroom.

The links below provide a useful reference source for this age group. The two posters are useful for in the activities 4, 5 and 6. They can can be ordered at the link below.

web

1. Australian Honey Bee Industry Council. The Wonderful Story of Australian Honey:
   http://honeybee.org.au/education/wonderful-world-of-honey/
2. Capilano Honey Limited - Learning Corner: Honey, Honeybees and Honey Production
   http://capilano.com.au/capilano-story/about-honey-bees/
3. Capilano Honey Limited - Learning Corner – Teachers Notes, Quizzes, recipes and Puzzles
   http://capilano.com.au/learning-corner/
4. Two posters – The Story of Bees and Honey and All about our Floral Honey
   http://capilano.com.au/contact-us/

Activity 1: Where would we bee without them?

Getting started

Capture students' interest and find out what they know about bees and how important they are.

discuss

Encourage students to provide examples of:

- What bees do;
- Why bees are important;
- What types of honey have they eaten? Why does the taste of vary?
- What they know about the behaviour of bees;
- How to avoid being stung by a bee; and
- What to do if stung.

Students share their responses and record answers in their journals.

task

Safety Around Bees

Suggest to students that they prepare a safety poster for classroom display. This could be done as a whole class exercise or in groups.

- Explain the points raised in the Let the Bees Be information on the previous page.

Students suggest and decide what information the safety poster should contain, how to explain the information clearly and how make it eye catching. Once completed, display the poster(s) in a prominent position in the classroom.

task

Cards for a word wall

Throughout this unit, students will be introduced to new vocabulary. Create a class honeycomb word wall using hexagonal shapes for each new term. Suggested title: Where would we bee without them?

Introduce the idea by asking students what shape would be most appropriate for a Bee-themed word wall?

Discuss:

- A six sided shape is a……
- What are the characteristics of a regular hexagon? Why is so strong?
- In what way is this shape important to the bees?
- Do you think it provides a meaningful symbol for bees and honey? Explain why.

Students can assist in preparing and illustrating hexagonal shapes to use on the word wall. Encourage them to write new words on the shapes and add them to the word wall as they work through the activities in this unit. New words introduced should also be written in their science journal.

Encourage students to incorporate a hexagonal shape in their work, to highlight and reinforce the significance of its shape in the work that goes on in the hive.

Activity 2: Bee Amazed

Teacher Background Information

The European honey bee – Apis metallifera Hymenoptera (order).
The genus name Apis comes from the Latin for bee and the species metallifera – honey bearing.

General Characteristics

Honeybees are one of the most recognisable insects. Their colour can vary but they are usually brown with a banded dull yellow and brown abdomen.

Their bodies are divided into three sections - head, thorax and abdomen, each with a dense covering of soft hair. They have hair on their legs and also around their eyes.

Bees have two pairs of wings and three pairs of legs on the thorax. The fore and hind wings on each side are linked by hooks and groves so they move in unison when the bee is flying and fold away when inside the hive.

Their mouth parts are elongated. These can be extended to draw up nectar and folded back under the head leaving their shorter and tougher mandibles free for other tasks such as chewing pollen, manipulating wax in the hive and attacking intruders. The really amazing adaptation is their their proboscis.

Honey bees range in size from 1.3cm – 1.6cm.

Students will be familiar with those party whistles that unroll when you blow them. The bee's proboscis is like those only without the "toot." When the bee is feeding or drinking it unfolds to form a long tube that the bee uses like a straw. The bee retracts it when not in use to protect it.

The tongue of a honey bee is about 0.5cm long long. To give students an idea of the proportion of the tongue to the overall size of a honey bee, it would be like being able to reach the tips of the fingers of their outstretched hand with their tongue!

Honey bees are very social insects. They live in large hives dominated by a single queen.
The queen is larger than workers or the male drones and is responsible for egg laying and for controlling the hive using pheromones. The majority of the hive is made up of worker bees. They build, maintain and defend the hive, collect nectar and pollen to feed the developing bee larvae and make honey.

Further information is available - *http://australianmuseum.net.au/honey-bee*

The *Bee amazed* activity enables students find out more about the honey bee and to explore its appearance and features.

Equipment needed

- 1 copy per student of Activity 2
- Copy of the word wall cards
- Science Journal for note taking

As a class, view Buzz Pollination - a short video that provides a close up sequence of bee pollination of a flower. Students will benefit from watching it a couple of times. Encourage them to look closely at how the bee is using its wings.

Australian Museum. Bee Scene http://australianmuseum.net.au/movie/buzz-pollination.

Discuss their observations and add any new terms from the video to the word wall.

task

Activity 2: Bee amazed - part 1

Read the information below with your teacher.

The standard common name for a bee is the honey bee. Some refer to it as the European honey bee.

Scientists, known as taxonomists, have come up with an ordered way of classifying (as in a class or group) organisms according to their characteristics. They give them standard names which are often based on Latin or Greek, or even sometimes on people's names.

The classification of the European honey bee is – Apis metallifera Hymenoptera

Bees are part of the:

Order: Hymenoptera - along with other bees, wasps and ants.

Genus: Apis - from the Latin word for bee

Species: mellifera - meaning honey bearing.

Write these three words in your science journal.

Latin is the language that was spoken by the ancient Romans and in Mediaeval times. Many words in the English language come from Latin. For example - the Latin word for a farmer is agricola. What word comes from this? Can you think of some others?

Many Latin words end in 'a' if they are singular (meaning one), but are changed to end in 'ae' it they are plural (more than one). Remember this when you look at the Life Cycle of the Bee in Activity 6.

Some bee facts

- Size - adult honey bees range in size range from 1.3 cm - 1.6 cm,
- Distribution - honey bees are found throughout Australia.
- Habitat – honey bees live in urban areas, forests, woodlands and heath.
- Feeding – honey bees search for nectar on the flowers of many different native and introduced plants.
- A worker bee can carry almost her own body weight in pollen and nectar.

And another amazing fact….Did you know?

The tongue of a honey bee is called a proboscis. It uses it to suck nectar from flowers. It is like a drinking straw, with a thinner tube inside it. It is about 0.5cm long long. It would be like being able to poke your tongue out and reach the tips of the fingers of your outstretched hand!

Who is the famous story book character whose nose grows each time he doesn't tell the truth?

As a class, suggest some more words for the word wall. Decide which group will write on them this time.

Another group will need to do it next time.

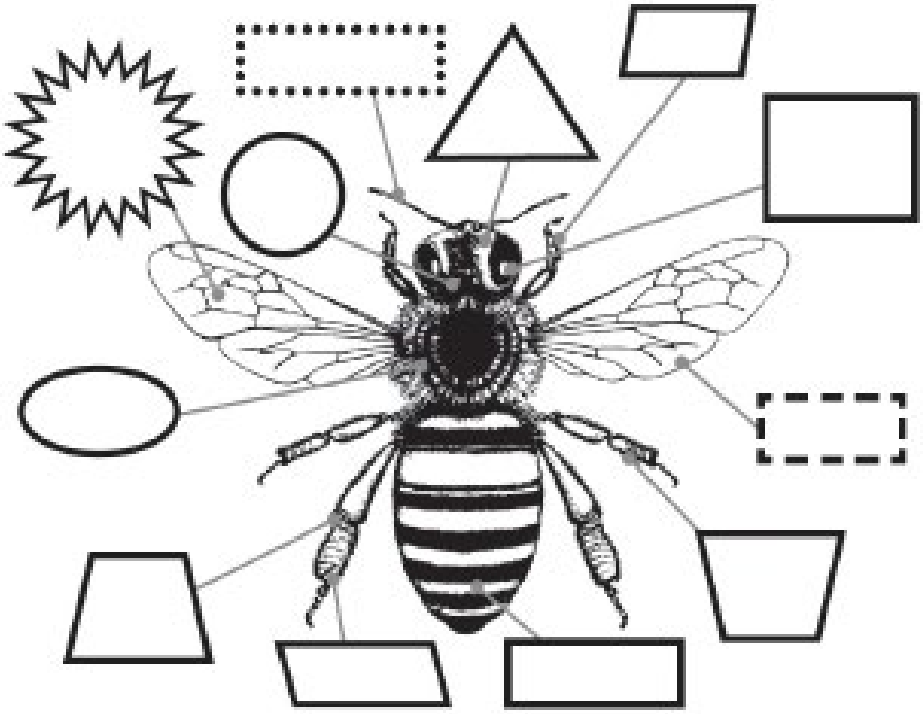
task

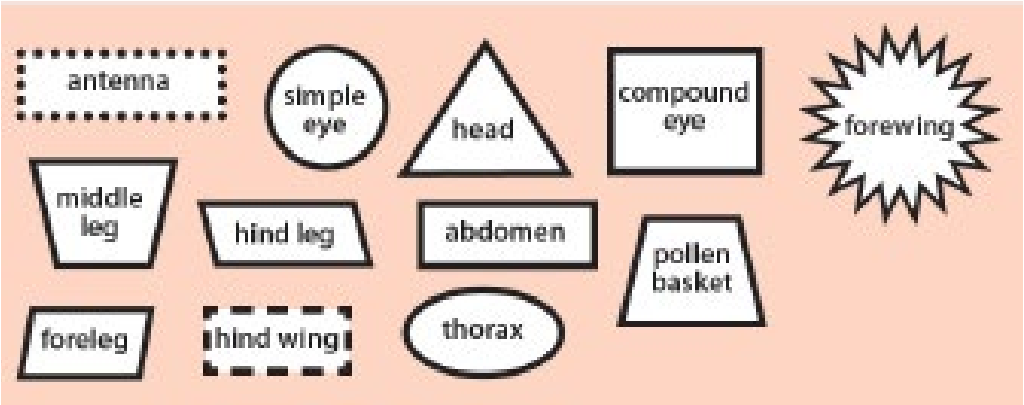
Activity 2: Bee amazed – part 2

Most Hymenoptera have:

- two pairs of clear wings
- mouthparts that can chew
- three body parts – head, thorax and abdomen.

There are clues on the diagram below to help you find the body parts. Label each in the shapes.





Suggest sentences using some of these terms, to explain how a bee collects pollen and nectar.

task

Activity 2: Bee amazed – part 3

What else would you like to know about bees? Complete the sentence below:

I would like to know more about _____

Watch the video – *Where would we Bee without them?*

discuss

Trevor has been keeping bees for a long time and is doing all he can to keep our bee population healthy. He enjoys telling people how clever bees are.

Have you ever heard someone described as being 'the bees' knees? What do you think this means?

task

Trevor told you a lot of things to start thinking about. The six statements below might remind you about some of these. Write some key words in each box.

The last box is different. You can add to this list at any time. It is your record.

Name:	
What bees eat	Where honey bees live
Plants that rely on bees for pollination	Types of bees
How do bees "talk" to each other	How bees make honey

Findings sheet 1

In preparation for the next task you will be working in groups to make a model of a bee and a flower. This will help you to find out more about how bees pollinate flowers.

The short video, The Pollen Makers, will show you more about how pollination works. These bees are Trigonas, now called Tetragonulas - a type of stingless native bee that Trevor talked about in the video - *Where would we Bee without them?*

Your teacher may run this short video through a few times. Look closely at the legs of these little native bees.

Australian Museum Bee Scene Movie Gallery
http://australianmuseum.net.au/movie/pollen-carriers

You now might be able to add some other words to your boxes above.

Activity 3: Bees and Pollination

Teacher Background Information

Pollination is the process by which plants sexually reproduce. It involves the transfer of pollen from the male organs of a plant (stamens in flowers) to the female organs – (stigma, style and ovaries in flowers). Pollen contains the genetic information need for plant reproduction.

Some plants can pollinate themselves with pollen passing to the female organs of the same plant (self-pollination) or to another plant of the same species (cross pollination). Many plants can be pollinated both ways. Pollen can be dispersed by wind and animal pollinators such as insects, birds and bats. The term cross-pollination can also be used more specifically to mean pollen exchange between different plant strains or species. As a result of pollination, plants produce seeds.

It is estimated that 65% of all flowering plants require insects for pollination. This percentage rises further for economically important crops - fruits, nuts, berries, vegetables, textile-related fibres and medicinal products."*Around one in three mouthfuls of food we consume comes from the aid of pollination by honeybees*".[1]

In Australia, crops worth between $4-6 billion rely on honey bees for pollination. In particular, this includes crops that produce fruit, vegetables and textile related crops such as cotton.

Many beekeepers have an important relationship with orchardists and place their hives within the orchards to ensure the almond blossom is pollinated. Almonds and many other tree crops, fruit (or nuts) will only develop when a flower is correctly pollinated – either by an insect of wind. Commercial almond growers plant different varieties of almonds trees in their orchard and the bees carry out the necessary cross pollination for the almond kernels to form.

Of all the pollinating insects, bees are the major ones. Bees play an important role in most ecosystems where there is a cover of green vegetation for at least 3 to 4 months each year. Bats and birds play a greater role as pollinators in rain forests and in high mountain forests where it is too cold for most bees.

Symbiotic relationships - these are mutually beneficial relationships that exist between plants and animals or insects. In the case of the bee, a plant depends on bees to "*be its legs*" and transfer pollen from the male to the female organs so it can reproduce. Bees do this as as they forage.

Plants attract the bee by offering pollen or nectar meals and also by using scent and visual cues to attract them to the flower. In turn, bees need food - pollen to eat themselves and feed their young and nectar to make honey.

Bees have developed adaptations that enable them to carry a considerable amount of pollen for their size – almost their entire body weight. Special hairs are arranged to form pollen 'baskets' on their hind legs. Fine hairs cover the underside of their abdomen and the side of their head. They are ideal pollinators as they visit many flowers as they forage.

1 Source: Pollination Aware: The Real Value of Pollination in Australia (RIRDC Pub. No. 10-081, August 2010)

Definitions:

Nectar - sweet substance that attracts pollinators. Bees collect this to make honey.

Pollen - fine powder of microscopic particles produced by the anthers of the male flower that fertilise the female flower to produce seeds.

Pollination - The delivery of pollen from the anthers of a flower to the stigma of the same flower or to the stigma of another flower. The process by which plants sexually reproduce.

Cross pollination - The transfer of pollen from the male reproductive organ anther of one plant to the female reproductive organ (stigma) of another plant.

Insects and wind are agents of cross-pollination.
Reference: *http://australianmuseum.net.au/pollination*

Preparation

Students may have already done the following activity – *Making a Bee Pollinator*, which has been adapted from the Australian Museum – Bugwise. If so, ask students to recall what their learning and understanding from the task and reinforce terms such as symbiotic relationships, before moving onto Activity 4.

task

Activity 3: Making a Bee Pollinator

Name: _____

Aim:

To make a model of a bee and a flower to investigate how a bee pollinates a flower.

What you need per group:

- Four pipe cleaners
- Paper cup
- 1 teaspoon of powdered paint or dark coloured chalk (choose one colour only)
- double-sided tape and scissors

What to do:

1. Make the 'bee'. Using one of the pipe cleaners twist it so that it looks like a bee. It will need a proboscis (refer Activity 2). Check that your bee fits easily into the bottom of the paper cup.
2. Make the 'flower'.
   - Colour the base of the cup - this is the 'nectar.'
   - Wrap one end of a pipe cleaner with the double-sided tape. Poke the taped end through base of the cup, leaving just enough length at the base to secure it under the cup. This is the 'stigma'.
   - Fold the other two pipe cleaners in half. Poke each through the base of the cup. These are the stamens.
   - Dip both ends of the two 'stamens' into the coloured powder ('pollen'). These are now the 'anthers'.
3. Fly your bee into your cup. Let it touch the pollen as it searches for the nectar. Bees can travel a long way in search of pollen. They can also carry a lot of pollen in relation to their size as they need to feed their young back in the hive.
4. Bees can visit between 50 and 100 flowers on a pollen gathering trip. Let your bee drop in and visit some other flowers on the way home.

Questions:

What happened to your bee?

What happened to the pollen?

Think about the relationship between your bee and the flower? Who needs who?

(Adapted from the Australian Museum - Making an insect pollinator) http://australianmuseum.net.au/document/how-to-make-a-bee-pollinator

discuss

Activity 3: Making a Bee Pollinator - Follow up

Discuss the following with students to reinforce their learning from the pollination activity.

- Ask students what they liked about the activity.
- What questions do they still have?
- What would they do differently if they did the task again?

Display the following statement where all the students can see it.

Honeybees have an important positive relationship with plants.

They carry out pollination of plants when they transfer pollen from one plant to another.

Why is pollination so important?

While discussing the following statements, students can enter words and answers into their science journal.

Another group of students could be preparing additions to the word wall. Some statements can be discussed again after subsequent activities.

- Pollination enables plants to reproduce.
- Pollination enables seeds to develop and grow into fruit. Nuts are a fruit.
- The stems and leaves of edible plants are vegetables.
- If necessary, explain to students, that anything that has seeds, resulting from pollination must be a fruit.
- Bees play a major role in agriculture.
- Pollination provides nectar and pollen for the bees.
- Bees need the pollen for protein.
- Bees need nectar for making honey.
- What is the difference between pollen and nectar?
- Self pollination is the transfer of pollen from the male to the female part of the same plant.
- Cross-pollination is the transfer of pollen from one plant to another of the same species.
- Flowers have certain adaptions to attract bees.
- Bees have certain adaptions so they can carry pollen.
- What is an apiarist?

Make sure new words are on the word wall and are spelt correctly – example - pollen and pollination.

Students should also them in their science journal – long with the definitions of terms such as nectar, pollen pollination and cross pollination.

Activity 4: Who does the work?

Teacher Background – Social structure and adaptations

Queen: Each colony has one queen. She is largest bee in the hive. Her sole purpose is to produce eggs - hence her large abdomen. During her two to four-year life she has one mating period - five to twelve days after hatching. She leaves the hive for about three days and mates with seven to ten drones usually from another hive. She starts laying eggs soon after and can lay up to 2,000 a day and up to one million in her lifetime. She lays eggs through the ovipositor organ at the base of her abdomen.

She is groomed by the workers during her life, but when she stops producing enough worker bees, she is driven out and replaced.

Workers: These are the female bees who don't usually lay eggs. They are the smallest bees in the colony but they do most of the work – food gathering, keeping the hive clean, brood rearing and guard duty. They have spoon like structures, known as pollen baskets on their hind legs. The pollen sticks to the soft hair on her abdomen. Hairs on her first two pairs of legs act like a comb and brush the pollen into the pollen basket on each hind leg. *Scout bees* find the nectar and communicate its location, *forager bees* collect it.

The *ovipositor organ* is modified in the workers to form a sting. Worker bees also have *wax glands* underneath the last four segments of their abdomen. They discharge the wax as tiny scales which build the hexagonal shaped honey comb. The hexagonal shape provides a strong and efficient storage cell.

Drones: These are stingless male bees – hatched from an unfertilised egg. Drones are shorter than the queen bee, but twice as heavy as the female worker. Unlike the workers, drones do not participate in nectar and pollen gathering. A drone's primary role is to mate with a fertile queen. It dies instantly after mating. There are usually only a few hundred drones in a colony that can contain up to 40,000 bees. Sometimes the drones are evicted from the hive at the beginning of winter when breeding ceases.

Food for Bees: When bee larvae first hatch from the eggs, they are fed for three days on royal jelly. This is a milky white fluid made by adult worker bees. The future queens continue to be fed on royal jelly for another 13 days until they emerge as adults. The other larvae are fed on pollen and nectar and this remains their sole source of food.

European bees forage on the flowers of many native and introduced plant species in Australia. This largely determine the flavor of different types of honey.

Making Honey: Honey forager bees collect pollen and nectar in spring when most flowers and plants are in bloom. They suck nectar out of flowers with their *proboscis*. They then store the nectar in one of *two stomachs* in their abdomen and store the pollen on their legs, before carrying it to the beehive. As she sucks the nectar from the flower, the forager worker bee stores it in her special honey stomach where it is mixed with proteins and enzymes and converted into honey, ready to be taken back to the waiting bees in the hive. If she is hungry, she opens a valve in her nectar "sac" and a portion of the nectar passes through to her own stomach to be converted to energy for her own needs. Bees drop the honey into the hexagonal cells of the beeswax comb made from they wax they have also produced.

They repeat the process until the combs are full and fan their wings to evaporate and thicken the honey (nectar is 80% water and honey is about 14-18% water). When done, they cap the honeycomb with wax and move on to the next empty comb and start all over again.

Different Types of Honey: There are hundreds and hundreds of different varieties. Honey can be distinguished by its distinctive taste. This is directly related to where the bees have foraged and which flower the nectar has been collected from.

Monofloral honey is made mainly from the the nectar of one type of flower and has a distinctive colour and flavour. *Polyfloral honey* is the result of bees gathering nectar from many types of flowers. Its taste and colour can vary according to which nectar sources are the most prevalent.

Blended honey comes from more than one source. Most commercial honey is blended honey.

Honey ranges from almost colourless to dark brown. Its flavour ranges from mild to quite strong. Australia is renowned for its quality ad variety of honey, owing to the many species of flowering plants that grow here.

Beekeepers (apiarists) often transport their hives many kilometres to floral sources that they know, from experience, make the type of honey they want to produce.

The Beehive:One hive can contain up to 40,000 bees. Each bee has a role to play to ensure the hive operates effectively. Tasks include foraging, building and capping the hexagonal cells, nursing the young (brood), converting nectar into honey, cleaning the hive and waiting on the Queen.

The hive is kept at a uniform temperature of about 34˚C. Bees increase their honey intake in winter to maintain energy and when temperatures are warmer, they cool the hive by bringing in moisture and beating their wings – somewhat like an evaporative fanning mechanism.

Activity 4: Who does the work - Preparation

The research material for this activity needs to be set up in advance. Provide a range of different stimulus materials to help students in their exploration. Students should be encouraged to use a variety of sources - print, online, photos, short videos, posters. There are many close up images of bees online. These are a valuable resource when displayed around the classroom.

Suggested resources are detailed below and also in the Online Teacher Support Resources at the end of this unit.

Working in groups, students need to plan how to divide up their research and how to share and record their findings.

What to do

Step 1:

Test student understanding at this stage – from what students already know and what they can recall from the video - *Where would we Bee without them?*

Encourage students to write some notes in their science journal during this discussion.

- Ask students to name the three types of bees.
- How can we tell them apart? Is it by colour or size?
- What other differences might there be between them?
- How many bees do they think might live in a hive?
- Is dividing up tasks be a good thing? Why? Why not?
- What tasks have to be done at home – buying food, petrol, making beds? Who does them? What happens if everyone tries to do the same task at the same time?
- What are some of the tasks that need to be done in a honey bee hive?
- Introduce the concepts of division of labour and interdependence.

Step 2:

Explain that students are to to find answers to the questions on Activity sheet 4, using the suggested fact sheets and interactives. They should also refer to notes already in their science journal and add more if necessary.

The information and activities below are suitable for this age group. They need to be shared between groups.

How bees make honey - Australian Honey Bee Industry Council
http://honeybee.org.au/education/wonderful-world-of-honey/how-bees-make-honey/

The following three fact sheets can be printed from the Capilano Honey website - http://capilano.com.au/capilano-story/about-honey-bees/

- The Bee Hive,
- How Bees Communicate,
- Honeybee Social Structure.

Bee Educated - short videos with follow-up interactives - *http://capilano.com.au/bee-educated/*

Under the header - Bees, Honey and Hives, the six suggested interactives are:

- Bees and their Reproduction Cycle;
- The Queen;
- The Worker Bee;
- The Drone Bee;
- Bee Communication; and
- Honey Production.

These and other materials need to be shared between the student groups.

task

Activity 4: Who does the work?

Many bees live together in a honey bee hive. There is a lot of work to be done and the tasks are divided up between the three different types of bee. This is called a division of labour.

Bees rely on each other to survive. This is called interdependence.

Working in your group, find out more about how bees work together in the hive.

Be like the bees…. divide up and share the research task with the others in your group.

How bees make honey - Australian Honey Bee Industry Council
http://honeybee.org.au/education/wonderful-world-of-honey/how-bees-make-honey/

Three fact sheets – the Bee Hive, How Bees Communicate and Honeybee Social Structure -
http://capilano.com.au/capilano-story/about-honey-bees/

Six interactives - Bees and their Reproduction Cycle; The Queen Bee; The Worker Bee; the Drone Bee;

Bee Communication; Honey Production - *http://capilano.com.au/bee-educated/*

Name:	Group members:

Task	Queen bee	Worker	Drone
Size and appearance			
Special features (adaptations)			
What they do			
What they eat			
Some more amazing facts			

Findings sheet 2

Check that your findings sheet shows how busy the worker bees are.

assess

Activity 5: Within the hive

Complete the table below.

Name:	Group members:

Type of Bee	How they differ from each other?	Special tasks
		
		
		
The worker bee is a busy, efficient worker. Draw your own sketch of the worker bee and label its features.		Describe one of the worker bee's special adaptations and what is it used for.

Activity 6: Life Cycle of the Honey Bee - Apis metallifera Hymenoptera

This activity enables students to explore the stages of development of the honey bee from egg to adult and the tasks that are performed to make sure that the brood is safely managed.

Equipment

Class copies of Activity 6: Bee life cycle

Video - Bees Honey and Hives. The Reproduction Cycle
http://capilano.com.au/bee-educated/quizzes/bees-and-their-reproduction-cycle/

Teacher Background Information

The life cycle of the honey bee life cycle goes through four stages - egg, larva pupa, adult.

From egg to adult takes 16 days for queens, 21 days for the female worker bees and 24 days for the male drones.

Within each honey bee colony, the queen rules her workers and drones.

Queens are able to lay both unfertilised and fertilised eggs. The unfertilised eggs become the male drones, while the fertilised eggs become the female workers, or a new generation of queens.

All the eggs hatch into larvae (grubs) after 3 days and larvae are fed a substance called royal jelly, up to 1,300 times a day. Royal jelly is a combination of proteins, sugars and water secreted from glands in the head of the worker bees. This feeding is done by the adult worker bees, known as the brood nurses.

Larvae with the potential to develop into queens (those in larger cells) continue to be fed on royal jelly until they emerge. The first queen to emerge after the metamorphosis process, kills all the other hatching and unhatched queens. The remaining larvae – those that will develop into drones and workers, are fed on bee bread. Bee bread is made from the pollen and nectar brought into the hive by the forager worker bees, plus secretions from the brood nurses.

When a queen dies, or is unable to lay enough eggs, worker bees concentrate on raising a new queen and drive her out. The old queen takes about half of the workers and drones with her - usually just before a new queen hatches.

A few days after the new queen hatches, she also leaves. The drones follow her and she mates with several of them mid-air. The male drones die after mating with the queen. She stores the sperm from her mating flight, returns to the hive and immediately starts laying eggs. The honey bee queen has to lay a huge number of fertilised eggs for a colony to survive. She examines each egg (up to 2,000 a day) before placing it into a cell.

Between them, the worker bees forage for food, build a strong and well-insulated hive, take care of the queen and the brood, feed the drones and defend the colony from enemies. The drones only purpose is to mate with the queen. They cannot make wax, have no proboscis for collecting pollen or nectar and have no pollen pikes on their legs. They are never called on to defend the hive so they have no need for a sting. They rarely even feed themselves.

Honey bee colonies can survive during colder months if they have enough food resources, can keep sufficiently warm by clustering together and are free of diseases and predators. Colonies are smaller in winter and there are no drones. There is less work to do, as no eggs are laid and no brood to care for. When the weather warms up and the flowers start to bloom, honey bees commence foraging again and the queen resumes her egg laying.

Preparation

For the first part of Activity 6, write the four life cycle stages up for all the students to see. Words can be added progressively under each section as the teacher lead discussion progresses. Encourage students to ask questions.

Explain to students that the technical illustration of the stages of development of the honey bee, used in Activity 6, is one way of showing the life cycle of the bee. This illustration also enables students to see how the hexagonal cells lock together, making them strong and easy for the worker bee to seal.

It also shows the tasks and how the brood (eggs, larvae and pupae) are fed.

discuss

Activity 6: Life cycle of the honey bee - Apis metallifera Hymenoptera

The four life stages of the honey bee are egg, larva, pupa and adult. These four stages can be put up so everyone can see them. It would be a good idea to write key words under each of header, as you discuss each stages.

Before starting, think about this. When we talk about more than one lava or pupa, we change the spelling and how we say the words. They become larvae (larv-eye) and pupae (pewp-eye).

Read and discuss the following. Your teacher will add some further information as you move through the four stages, so think about questions to ask.

Stage 1: Egg

There is only one queen bee in each hive. She can lay 2,000 eggs a day and up to 1 million during her life. She lays one egg in each cell in the hive. Eggs are fed royal jelly by the adult worker bees for 72 hours (3 days) until they hatch.

Stage 2: Larva

Once the larvae (grubs) hatch, they are fed bee bread by the brood nurses (workers). Bee bread is a mixture of pollen and nectar that the forager worker bees go searching for each day.

During this stage, there are also some grubs in bigger cells. They get special treatment as they are the future queens. They are fed royal jelly until they hatch into adults.

The larva reaches full growth it spins a cocoon and transforms into a pupa. The worker bee caps the cell.

Stage 3: Pupa

A process called metamorphosis takes place and the pupa changes into an adult bee.

Stage 4: Adult bee

The queens are the first to hatch after 16 days. The one that hatches first usually kills the others. The queen's main task is to lay eggs. The fertilised eggs become female bees (the workers) and the unfertilised eggs become male bees (the drones).

The female workers take 21 days and the male drones take 24 days to develop from egg to adult. Between them, the worker bees search for food, build a strong and well-insulated hive, take care of the brood and defend the colony from enemies. The drones only purpose is to mate with the queen. They don't sting nor do they gather nectar and pollen.

task

What have you remembered? Complete the following sentences:

1. The Latin word for bee is _____
2. The Latin word for honey is _____
3. Choose two other words on this sheet that have also come from Latin? _____
4. There is only one queen in each hive and her role is to _____
5. The male bees are known as _____
6. The workers are the busiest bees because the _____
   _____
7. Bees insulate their hive so that _____
   _____
8. We rely on bees to _____
   _____

task

Activity 6: Life Cycle of the Honey Bee

Name: _____

The diagram shows the various stages in the development of a honey bee from egg to adult. It also shows the tasks that must be done to make sure the brood is safely managed.

From the diagram and from what you have discovered, answer the questions below.

Development of the Bee

Which type of bee is doing most of the work?

Which type of bee is missing?

Is the missing bee larger or smaller than the worker?

What is the brood cell?

How many days does it take for the eggs to hatch into larvae?

Which type of bee is the first to leave the cell?

What is the worker feeding the larvae?

Why does she cap the cell?

Draw lines showing the four stages in the bee life cycle. Write each stage in the correct order.

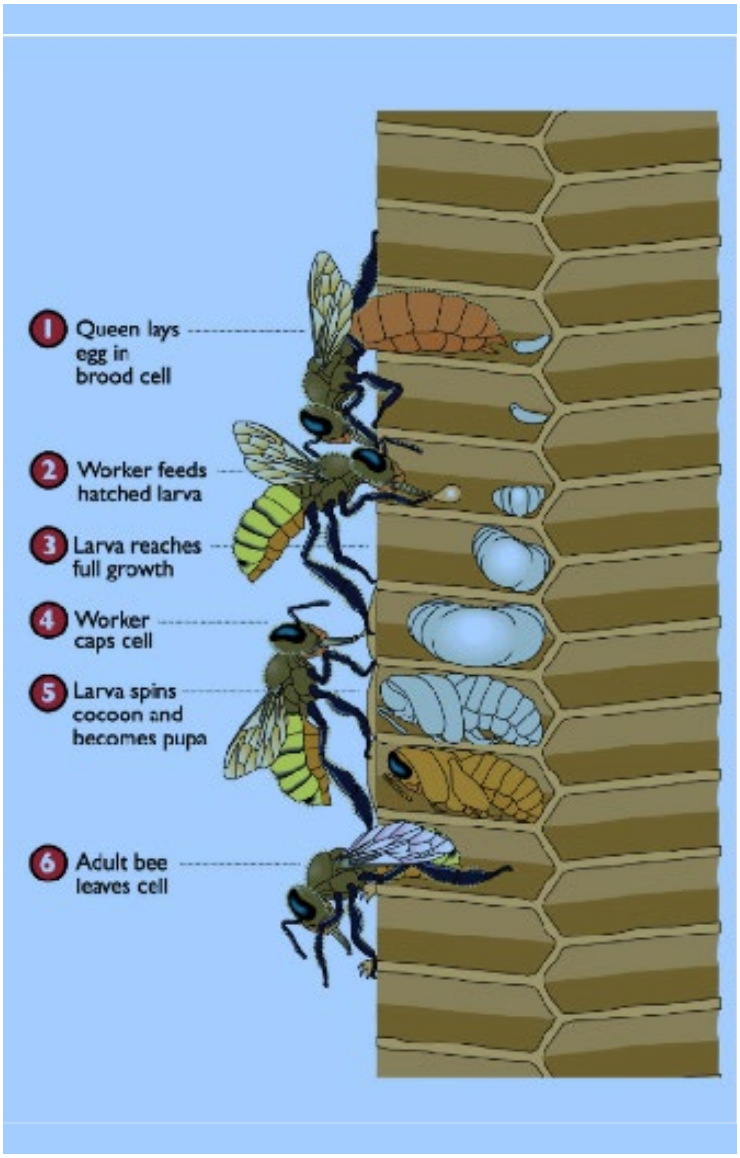
1.

2.

3.

4.

At what stage is metamorphosis taking place?



Activity 7: Threats to our bees – the life cycle of the small hive beetle

Teacher Background Information

There are a number of pests already in Australia that can seriously affect the productivity and strength of bee colonies. There are also a number of other pests such as the Varroa mite, as mentioned in the video in Activity 2 - *Where would we Bee without them?* that are not yet in Australia, but are significant players in the worldwide decline of bee colonies.

The Varroa mite: This is the most serious threat to the viability of the Australian honey bee industry. It is a parasitic mite, the size of a pin head, that feeds on the blood of adult and larval honey bees. It also transmits viral and other pathogens, which kill entire bee colonies. The Varroa mite is already in New Zealand, Indonesia and PNG and it may just a matter of time before it enters Australia.

The *small hive beetle* Aethina tumida Coleoptera is another extremely destructive pest. It belongs to the same family as some other beetles native to Australia, but this predator is a scavenger of honey bee colonies. It originated in sub Saharan Africa and has been destroying bee colonies here since 1982, especially in NSW and Queensland. Under warm and humid conditions, the beetle multiplies rapidly. It damages the honeycomb, stored honey and pollen. Beetle larvae may tunnel through combs of honey, feeding and defecating, causing discoloration and fermentation of the honey. It can cause bees to abandon their hive.

After much research in Australia, the small hive beetle is being managed by apiarists through biological control using microscopic roundworms (nematodes) that live naturally in most soils. Despite this, the small hive beetle remains a threat. All bee keepers – whether commercial or hobby bee keepers, need to know how to manage it.

Life cycle of the small hive beetle: Goes through four stages like the honey bee.

Egg: The female enters a bee hive at dusk and once inside, starts laying her eggs. She lays up to 30 eggs within the capped brood cells or in the small cracks and crevices around the hive.

Larval Stage: Larvae emerge from the eggs within 1-6 days depending on temperature and humidity conditions. This is the most damaging time for the bees, as they immediately start burrowing through the honeycombs and cappings and consume honey bee eggs, pollen and honey. They also defecate throughout the comb and contaminate the honey. The larval stage can last from between 8 and 29 days, again depending upon temperature and food availability. Larvae leave the hive and look for a suitable site in the soil nearby to pupate.

Pupation: The larvae dig from 5–20cm into the soil and build a smooth-walled pupation chamber. Moist soil and warm temperatures are critical for successful pupation and the emergence of the adult beetle. Pupation can take between 2–12 weeks depending on environmental factors. During colder weather pupation can take up to 100 days.

Adult: Once the adult beetles emerge from their pupation chambers, they leave the soil and fly off in search of new honey bee colonies to infest. Adult beetles can 'smell' a bee hive from up to 5 km away. The cycle then starts again.

Bee Security

Bee security is a major concern in Australia as bees as play such an important role in the pollination of flowering plants and in ensuring that farmers can produce crops, fruit and vegetables and healthy pastures. Australia is fortunate being an island continent, but with more frequent and rapid movement of people and goods around the world, the risk of introduced pests and diseases is growing.

Apart from the risk of introduced pests and diseases, Bees are under threat world wide because of increased urbanisation, removal of natural habitats, unsustainable agricultural practices such as large scale monoculture and the use of pesticides.

What can be done?

Research: A great deal of research has been undertaken in Australia and much more is being carried out to understand bee behavior, social behavior and to identify and manage threats. One such example is the ground breaking research using micro-sensing technology is currently being undertaken in Australia by the CSIRO to ensure that our bees maintain healthy in the face of these threats.[1]

The Varroa mite which is devastating honey bee populations around the world has scientists, farmers and bee keepers worried. This tiny mite, the size of a pin head, feeds on the blood of adult honey bees and their larvae and causes deformities, reduces the lifespan of bees and can destroy entire colonies. This threat was highlighted in the accompanying video to this unit *Where would we Bee without them?*

Fortunately, the Varroa a mite has not yet reached Australia, but it is already in New Zealand, Indonesia and PNG and it may just a matter of time before it enters Australia.

Another serious threat is the small hive beetle (SHB) Aethina tumida Coleoptera. It belongs to the same family as some beetles that are native to Australia, but this predator is a scavenger of honey bee colonies. It originated in sub Saharan Africa and was first discovered here in 1982. It can be an extremely destructive pest to honey bee colonies as it damages the honeycomb, stored honey and pollen. Beetle larvae may tunnel through combs of honey, feeding and defecating, causing discoloration and fermentation of the honey. It can cause bees to abandon their hive.

After much research in Australia, the small hive beetle is being managed through biological control using microscopic roundworms (nematodes) that live naturally in most soils. Despite this, the small hive beetle remains a threat. All bee keepers – whether commercial or hobby bee keepers, need to know how to manage it.

Encourage bees: There has been a huge resurgence in beekeeping in Australia recently – both honey bees and native bees, as more people understand the role bees play and how dependent we are upon them. Australia has over 12,000 registered bee keepers, with possibly up to 30,000 recreational beekeepers and backyard enthusiasts. More and more people are looking at creating a habitat to encourage native bees into their garden. Much is now being done to educate beekeepers and the wider community on the pests and diseases that can attack specific stages of the life cycle of the honey bee.

Native Bees: There are over 1,500 species of Australian native bee. They vary in colour and range from 2mm to 24 mm in length. In comparison to the European honey bee, most are solitary. They do not live in colonies with a queen, worker and drones. Instead, the queen mates, builds her own nest and cares for her eggs in small nests. Solitary bees do not store honey in their nests – they only collect enough nectar to feed their young. They are not aggressive but they can sting, but because of their small size, their sting is usually ineffective. Larger ones could sting if picked up or trodden on. Unlike the European bee, they can sting more than once, so care is needed.

There are about 10 species of social native bees that do form large social hives with a queen. These are stingless bees and they produce and store a small amount of honey – especially in warmer areas. They are very dark in colour and much smaller (less than 5mm long) than honeybees. These social native bees usually nest in trees.

Native bees are fun to have as they are not aggressive and usually don't sting. Many people are establishing native bee hives. Native bees do play a role in pollination, but do not fly as high as honey bees can, so the variety of plants they can pollinate is limited. They produce small amounts of honey, but most of this is needed to feed their babies. They rarely produce enough honey for people to harvest.

1 CSIRO- Swarm testing: tiny technology creates a buzz
http://www.csiro.au/en/Research/BF/Areas/Protecting-Australias-agricultural-industries/Robot-technology/Swarm-sensing

Bee informed: We can all support bee health and populations by understanding the role that bees play in pollination and how bee behavior drives biodiversity. All beekeepers, commercial and hobby beekeepers, need to know how to maintain bee health, understand and recognise the pests and diseases that can affect honey bees and how to take remedial and preventative action to manage their colonies.

Bee responsible: Australia has strict quarantine rules for plants and animals entering Australia from overseas. There are also restrictions on the movement of some plants and animals between various states within Australia. These restrictions are there for a purpose and we should all respect and follow them.

Preparation

Introduce this activity by asking students to share the experiences they may have had with quarantine requirements when they came into Australia from overseas, or when they are travelling interstate?

What are these measures? Why do we have them? Why is it so important that we follow and respect them?

By explaining the life cycle of the small hive beetle, students can make comparisons with and reinforce their understanding the four stages of the bee life cycle and the process of metamorphosis. This provides a context encouraging students to think further about the threats to bee populations, the effect of a decline in bee populations on agriculture - especially our horticultural industries, crops and pastures and what can be done to reduce this threat.

Print and distribute copies of Activity 7: Small hive beetle work sheet and Life cycle illustration.

It is suggested that teachers read the following simplified small hive beetle account – *The Good and the Bad* to the class as they follow the four stages of the small hive beetle life cycle.

discuss

Activity 7: Threat to our bees - Life cycle of the small hive beetle

Ask students to think about the likely threat to our bee populations from the Varroa mite that was mentioned in the video - *Where would we Bee without them?* Fortunately, this parasite has not yet reached Australia, but small hive beetle is an 'alien invader' that is already here.

Write up this statement for the class to see - Honey bees provide a service to many of Australia's farmers.

Working in groups, have the student find answers to the following and then share their findings:

- The farming activities that benefit most from bees;
- Why bee populations are declining;
- The difference between feral bees and managed hives. Which might be more at risk of pests and disease?
- What is an apiarist? What role do they have in managing the health of bees?
- What can we do to ensure our bee populations survive?
- How can we stop bees coming into Australia on ships and planes?

To help students understand the negative relationship between the small hive beetle and the honey bee, read this simplified version to the class while they look at the small hive beetle life cycle illustration.

The Good and the Bad

Bees have a good or positive relationship with plants. However, the relationship with pest insects such as small hive beetle is a bad or negative one.

The life cycle of a honeybee can be affected by the life cycle of the small hive beetle. Adult small hive beetles can "smell" a honey bee hive up to 5 km away. Straight after they hatch as adults, the small hive beetle flies off in search of a hive.

Once they have found a honey bee hive, the adult beetles sneak in and look for tiny "hidey holes" in the hive to lay their eggs, where bees can't get to them.

After just 2-4 days the eggs hatch into larvae/grubs. These grubs like to to feed on the baby bees and their "bee food" which is the stored pollen in the hive. When the small hive beetle larvae are big and fat after feeding for 10 – 14 days, they crawl out of the honey bee hive after dark.

They burrow into the soil to pupate. The time they spend in the ground as pupae varies according to how hot and humid is is and can take from a just few more days up to about 100 days. BUT

When the adult beetles emerge from the soil, they fly straight off to find another honey bee hive to invite themselves into and to live and breed in. So the cycle goes on.

Fortunately, there are other predators that can destroy the small hive beetle larvae when they first leave the hive and before they have time to burrow into the ground below. Cane toads often prowl around the base of honey bee hives in the early evening. They wait to pounce on the grubs when they leave the hive.

Also, the small hive beetle pupae cannot survive if the soil is too dry and or too wet. Some ants will kill larvae before they burrow into the soil. These ants take the small hive beetle to their nest to feed their own larvae.

task

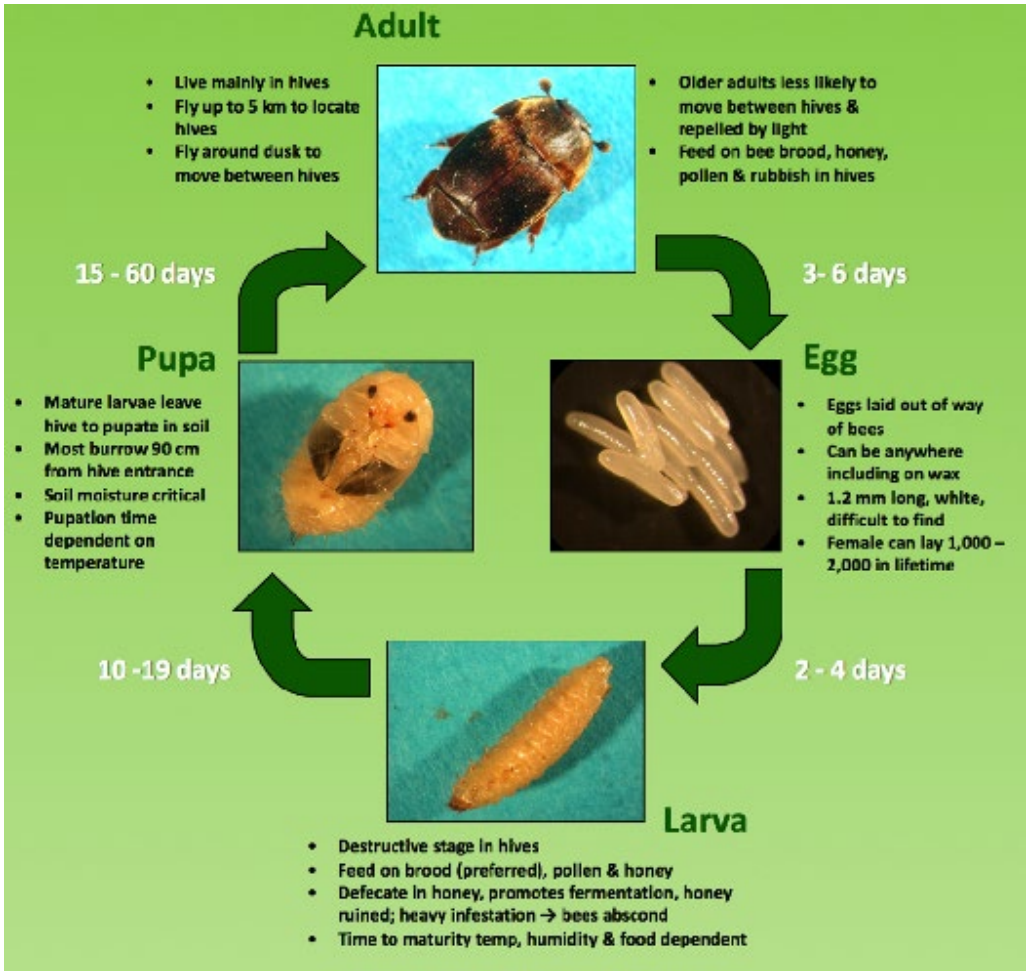
Activity 7: Threat to our bees - Life cycle of the small hive beetle

The small hive beetle is an uninvited guest to a honey bee hive. Unfortunately, a newly hatched adult beetle can 'smell' a honey bee hive from a few kilometres away. They fly in just on dark, find some cosy corners in the hive and 'make themselves at home'.

If they are not found by the bee keeper, they can destroy a hive and ruin the honey.

Your teacher might read you a story about the small hive beetle while you look at the illustrated diagram of the four stages of development of a small hive beetle. Start with the egg and follow the stages.

Life cycle of the small hive beetle



assess

Threats to our bees

From what you have discovered during this unit, fill in the spaces in the table below.

Name:

Threats	Impact

What we can do to stop our bee population declining?

web

Online Teacher Support Resources

1. Aussie Bee - Questions and Answers. Australian Native Bees
   http://www.aussiebee.com.au/faq.html
2. Bee Aware – Bee keeping in Australia - Biosecurity NSW Department of Primary Industries/ Plant Health Australia
   http://beeaware.org.au/industry/beekeeping-in-australia/
3. Bee Educated - short videos with follow-up interactives - Bees, Honey and Hives
   http://capilano.com.au/bee-educated/
4. Bee Scene. Australian Museum
   http://australianmuseum.net.au/bee-scene1
5. Close up images Apis mellifera – series of images CSIRO
   - Brood comb of the honey bee
   - 8 stages of development and brood comb
   - Worker Bee with stored pollen
   - Stinger of honey bee

   https://www.scootle.edu.au/ec/search?q=apis+mellifera&field=title&field=text.all&field=topic
6. CSIRO – Honey bee Health
   http://www.csiro.au/en/News/News-releases/2015/Honey-Bee-Health
7. Farm Biosecurity-Honey Bees Animal Health Australia (AHA) and Plant Health Australia (PHA)
   http://www.farmbiosecurity.com.au/industry/honey-bees/
8. From the Paddock /Ocean to the Plate AgriFood Skills Australia
   https://www.scootle.edu.au/ec/search?q=From+Paddock+to+Plate&field=title&field=text.all&field=topic
9. Honey Bee and Pollination. Rural Industries Research and Development Corporation
   http://www.rirdc.gov.au/research-programs/animal-industries/honeybee
10. Honey Bees - Classification and characteristics. Australian Museum
    http://australianmuseum.net.au/honey-bee
11. Learning Corner: Honey, Honeybees and Honey Production. Capilano Honey Limited
    http://capilano.com.au/capilano-story/about-honey-bees/
12. Learning Corner: Teachers Notes, Quizzes, recipes and Puzzles. Capilano Honey Limited
    http://capilano.com.au/learning-corner/
13. Pollen Trap
    http://csiro.au/en/Education/DIY-science/Biology/Pollen-trap
14. Primary Connections – Friend or Foe TLF ID S7165S7165
    http://www.scootle.edu.au/ec/viewing/S7165/Friends-or-foes-2012/index.html
15. Swarm testing: tiny technology creates a buzz. CSIRO
    http://www.csiro.au/en/Research/BF/Areas/Protecting-Australias-agricultural-industries/Robot-technology/Swarm-sensing
16. Teacher Companion Notes. Capilano Honey Limited
    http://capilano.com.au/new2014/wp-content/uploads/2014/04/00757_CHL_teachers-companion-notes.pdf
17. The Conversation - Varroa mite, the tiny killer threatening Australia's bees
    http://theconversation.com/explainer-varroa-mite-the-tiny-killer-threatening-australias-bees-25710
18. The Wonderful Story of Australian Honey. Australian Honey Bee Industry Council
    http://honeybee.org.au/education/wonderful-world-of-honey/

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Honey flow by Jason Henry, Welcome to the Fold, for AgriFood Skills Australia