Practicals

A game demonstrating aspects of bumblebee natural history

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The Bumblebee Game is an exciting outdoor game, which demonstrates aspects of bumblebee natural history including food chains, food webs and competition for food, predation by crab spiders, parasitism by Conopidae (Diptera) and brood parasitism by cuckoo bees. It has been played successfully with groups of 10-25 people. Although most suitable for 6-14 year olds, adults have had a lot of fun playing this game.
Key words: Bumblebee game; *Bombus*; Conopidae; *Psithyrus*; Thomisidae

Introduction

This Bumblebee Game can be used to introduce the biology of bumblebees (*Bombus* spp.), cuckoo bees (*Psithyrus* spp.), crab spiders (Thomisidae) and parasitic Diptera called Conopidae, as well as more general ecological principles of food chains, food webs, parasitism and social insects. The game can be played with group sizes in the range 10-25 and requires an open space about the size of a tennis court. The apparatus needed is simple and inexpensive – a box of elastic bands, a bag of flour and eight plastic gravel trays or the lids from photocopier paper boxes.

While most suitable for 6-14 year olds, age does not appear to be a limitation to enjoying this game. It has been played with children from primary and secondary schools including sixth formers, and on one occasion by adults taking part in a course for leaders of environmental groups. This adult group played the game by the light of car headlights, after dark, on a frosty November evening – giving an extreme example of how invertebrate ecology can be taught when observations of live bumblebees would be impossible.

This game covers some of the topics within the UK Science National Curriculum (National Curriculum Online) attainment target 2: Sc2 *Life processes and living things*. In particular 'feeding relationships' (attainment level 4), 'recognising that there is a great variety of living things' (attainment level 5), 'pollination' (attainment level 6) and 'food webs' (attainment level 7).

The author usually introduces the game with a lecture on bumblebees. If blackout facilities are available the talk can be done with slides: however on many occasions the talk has taken place outdoors. For outdoor talks, the author has used a diagram of a bumblebee life cycle waterproofed and stiffened by varnishing onto a sheet of hardboard, bumblebee nest boxes and pinned specimens of bumblebees, cuckoo bees and empty nest combs. It can be a good idea to show distribution maps showing the decline of UK bumblebee populations and information on their economic value as pollinators (Prys-Jones & Corbet 1991).

The biology of the animals

Bumblebees are social insects. They forage for nectar and pollen from flowers. Some of this food is used by the bumblebee that collects the food, and the rest is taken back to the brood in the nest.

Bumblebees are predated by a range of animals. Conopidae are parasitic Diptera that search for foraging bumblebees and then, during a short period of contact, stab the bumblebee with a barbed egg. This egg hatches, and the conopid larva feeds inside the living bumblebee. The bumblebee usually dies when the conopid pupates. Up to 50% of a bumblebee population may be parasitised by conopid larvae.

Crab spiders live in flowers, where they can catch foraging bumblebees. Like its namesake the crab, the crab spider walks sideways. Most crab spider species do not build webs, instead they catch insects with their long front legs, and then inject venom. Crab spiders that live in flowers are camouflaged to match the colour of flowers and can change their colour to match the colour of a particular flower.

Cuckoo bees are brood parasites of bumblebees. Analogous to the cuckoo bird, a cuckoo bee invades the bumblebee nest, fights, and sometimes kills the queen. The cuckoo bee then lays her eggs in the bumblebee nest, and uses the bumblebee workers to rear her young. A strong, numerous, bumblebee colony can fight off a cuckoo bee. Cuckoo bees are mimics of bumblebees. It is thought that this mimicry helps deceive the bumblebees. Cuckoo bees are adapted for fighting, with stronger mandibles and a thicker cuticle than bumblebees.

Illustrations and further information about the invertebrates included in this game can be found in Alford (1975), Prys-Jones & Corbet (1991), Chinery (1993a and 1993b), Feltwell (2002) and Roberts (1995).

Before the game

The game is ideally played on a grassy area with a minimum size about that of a tennis court. Using flour, mark out a square

or rectangular area at least 2m x 3m. This represents the nest and should be large enough for all the participants to stand inside it (Figure 1).

Flowers can be represented by gravel trays (size: 35cm x 20cm) or the lids from boxes of photocopier paper. Eight flowers should be arranged around the nest in the positions shown in Figure 2. There should be a distinct clump of four flowers in a rough square, where each flower is 2-4m apart (Figure 3). A further gravel tray should be placed inside the nest to represent the nest's food store.

A handful of rubber bands, which represent nectar and pollen, is placed in each of the trays that represent flowers – not the tray in the nest. Rubber bands should be large enough to fit around the wrist without falling off or being so tight as to possibly impede blood flow.

Figure 1. *The author explaining the rules of the Bumblebee Game to pupils from Kingsbury High School during a Science Club visit to Brunel University in May 2003. The children are standing inside the bumblebee nest, marked with a white line of flour on the grass. (Photo: Dr I Kill.)*

The game

Round one

All the participants start in the nest: they are going to pretend to be bumblebees (Figure 1). They must visit the flowers and collect just one rubber band per flower visit. Having visited a flower, they cannot return straight to that flower without first going to another flower or to the nest. They must place the rubber band around their wrist while at the flower. The time taken placing the rubber band around their wrist representing flower handling time. The rubber bands collected must then be put in the nest's food store, i.e. in the gravel tray in the nest.

After issuing these instructions the participants are given an 'on your marks, get set, go.' Within two minutes it is usually possible to stop the game (hint: call all the bumblebees back to the nest) and point out the following two features of bumblebee foraging biology that the participants will have acted out:

1. Some of the flowers will have run out of food (hint: put an appropriate number of rubber bands in the trays so that they will run out fairly quickly). Explain that this can happen to bumblebees. Bumblebees can take so much food from a flower, that the flower runs out of food.
2. The participants should have experienced flowerhead competition. When several participants try and feed from one flower at the same time, they tend to collide! Flowerhead competition from other bumblebees, as well as from honeybees (*Apis*), butterflies (Lepidoptera) and hoverflies (Syrphidae), is a problem faced by bumblebees in real life.

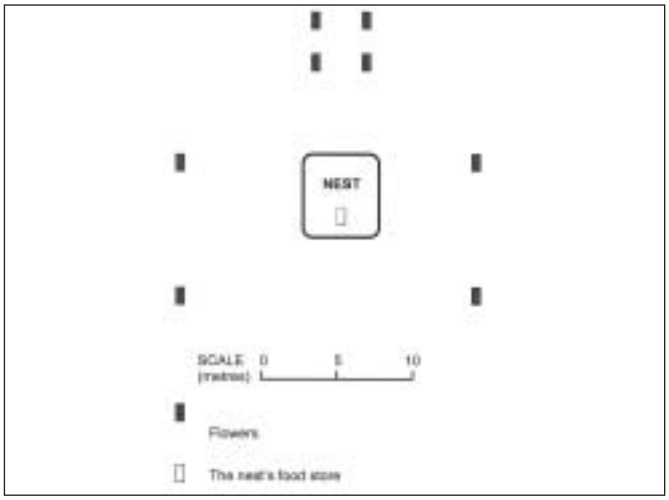

Figure 2. *The layout of the pitch*

Return the rubber bands from the food store to the flowers.

Round two

The game is played in exactly the same way, but this time one of the participants is a conopid. He or she has to tag the bumblebees while they are out foraging. Once caught a bumblebee becomes a conopid, and any food that the bumblebee may be carrying is lost to the nest. Bumblebees are safe from the conopid when inside the nest. Round two continues until all the bumblebees are caught.

Hints: Some of the bumblebees will be reluctant to leave the nest, particularly when the number of bumblebees has declined. There are several means of persuading them to run:

1. Tell them they are running out of food and will starve to death.
2. Give them a count of three, by which time they must leave the nest.
3. Tell the conopids that they must withdraw beyond the flowers, or that they can only stand still if perched on a flower, otherwise they must keep moving.

Round three

Play the game in the same way as Round 2, but as well as one person being a conopid, another becomes a crab spider (Figure 3). He or she can only live in the patch of four flowers, and moves sideways on all fours. A bumblebee caught by a crab spider becomes a crab spider. In this Round conopids cannot catch crab spiders and crab spiders cannot catch conopids.

Round four

Play the game in the same way as Round 3, but this time the crab spider can catch both bumblebees and conopids. If a bumblebee or a conopid is caught by a crab spider, it becomes a crab spider.

Round five

Play the game the same way as in Round 4, but this time introduce a cuckoo bee. The cuckoo bee could be represented by a teacher (Figure 3). If at any point there are two bumblebees or less in the nest, the cuckoo bee can take over the nest by entering it and

***Figure 3**. The game in progress. A highly predatory crab spider is in action (on hands and knees) in the clump of four flowers in the foreground and a cuckoo bee (male teacher) hovers close to the nest. Pupils from Kingsbury High School. (Photo: Dr I Kill.)*

finish the Round. If the cuckoo bee enters the nest when there are three or more bumblebees in the nest, the cuckoo bee is 'stung to death' and is out of that Round. Hint: vary the threshold number of bumblebees needed before a cuckoo bee can invade for different group sizes, and to prevent a stalemate that may result if some participants are not prepared to run from the nest.

At this point draw out the food chain and food web that the participants have been acting. It is best to draw these diagrams with the participants, asking them 'Who is eating who?' Ask them the name given to the type of diagram in Figure 4 (food chain) and then in Figure 5 (food web).

If Round Five is repeated, it may be noticed that the bumblebees start to organise themselves such that they maintain the right number of bees to protect the nest. Explain that bumblebees being social insects work together to defend their nest.

During the game show the participants pictures of the animals that they are acting, and tell them how conopid is spelt (Hint: use a picture of a conopid with the word 'CONOPID' written in large letters).

Rounds six and seven – optional

Place one of the flowers three times further from the nest than any of the other flowers. Play the game as in Round 5. The bumblebees should visit the furthest flower least frequently. At the end of this Round ask the participants: What would make them more likely to visit this flower? Would they be more likely to visit it if they were able to collect more rubber bands? How many extra rubber bands – five? Explain that bumblebees need a larger reward if they are to travel further to a flower. Play Round 7 with the increased food value of this flower.

Rounds 6 and 7 will only work if the bumblebees are being reliable and taking the correct number of rubber bands per flower visit. Up to this point it does not matter if they take more than one rubber band. If the participants are taking handfuls of rubber bands, it may be better to leave out Rounds 6 and 7 rather than trying to enforce rules.

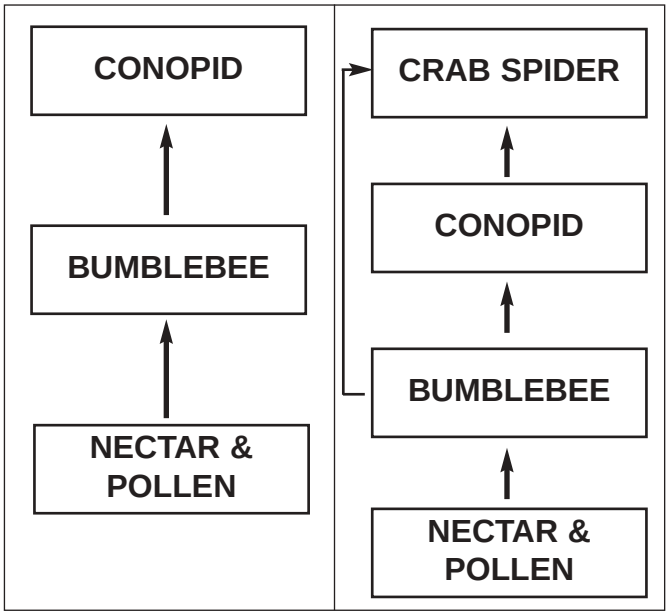

***Figure 4** (left) The food chain.* ***Figure 5** (right)1 The food web*

Conclusion

This game is fun. It introduces the biology and inter-relationships between four types of invertebrate, as well as some more general principles of ecology including food chains, food webs, parasitism and competition. The game uses simple and inexpensive apparatus.

It is hoped that this game will help people develop a fascination for the complexity of invertebrate biology. Perhaps also it will foster an interest in the conservation of invertebrate biodiversity. The game was used during a 'Science Club' visit by a secondary school to Brunel University in May 2003. At the end of the activity one child was so enthusiastic that she was heard to ask if she could come back tomorrow!

Acknowledgements

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