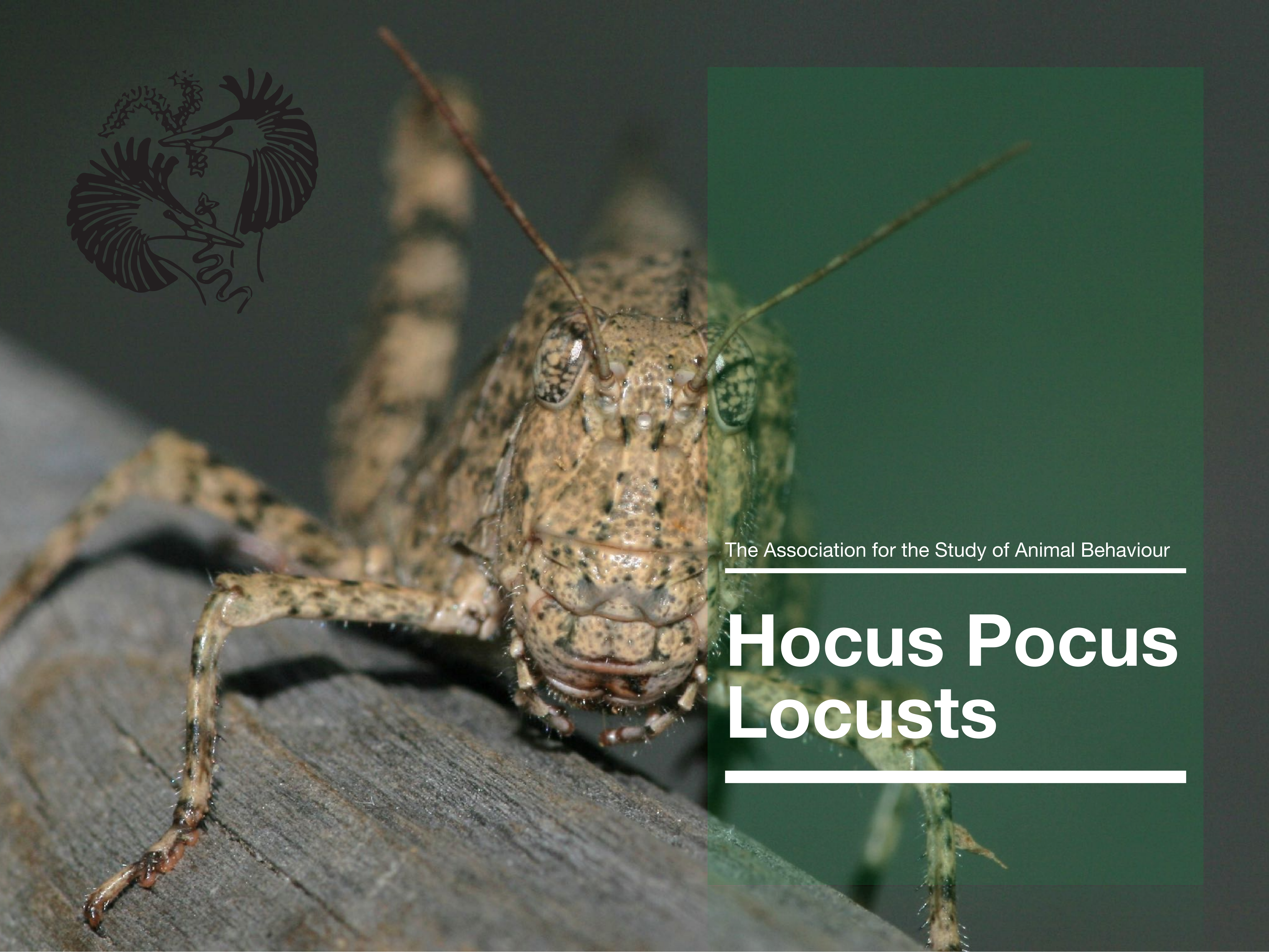
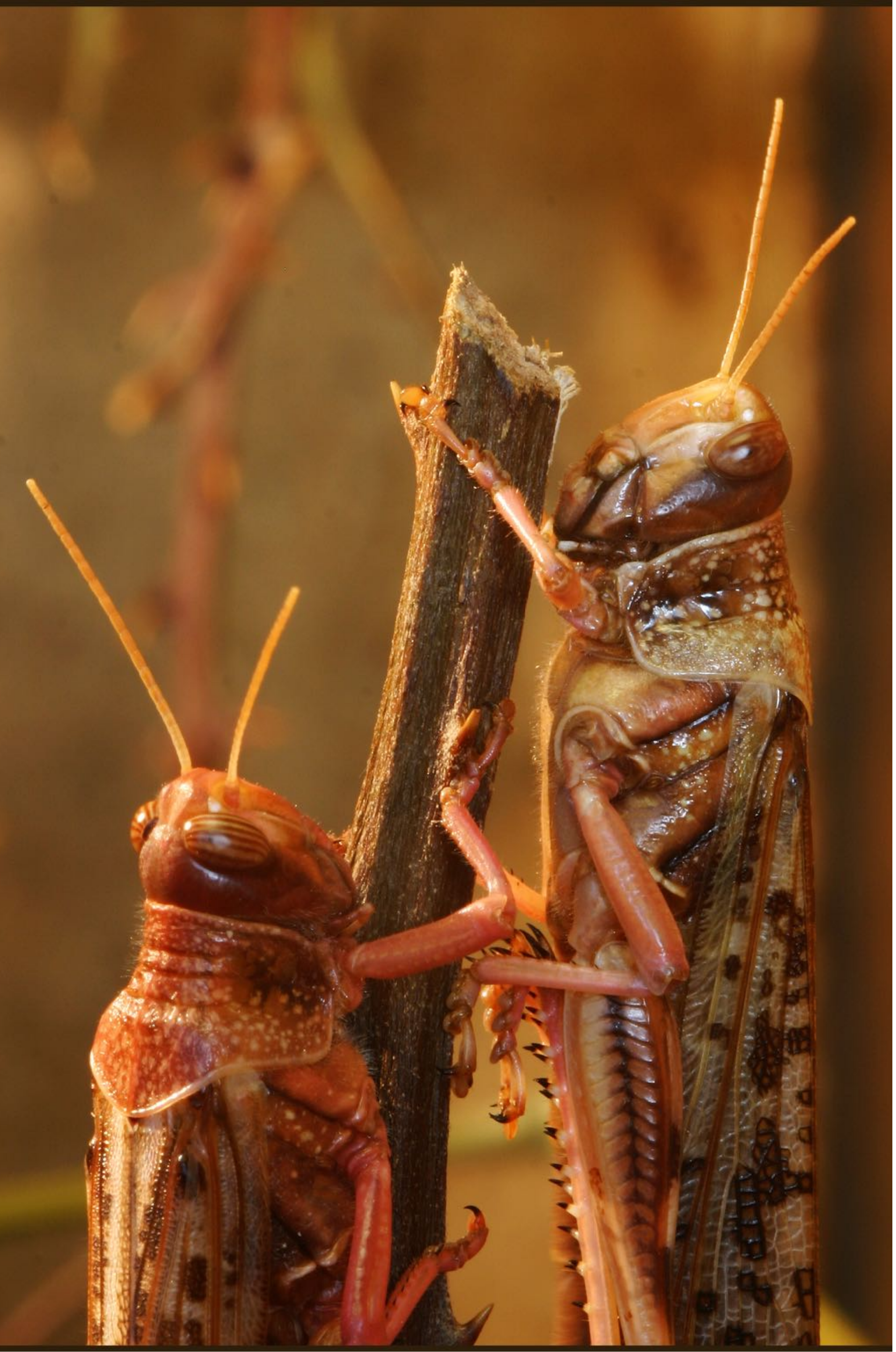


The Association for the Study of Animal Behaviour

Hocus Pocus Locusts



An activity for GCSE pupils to illustrate **the flow of energy through trophic levels** using live locusts

Written for ASAB by Paul Weeks (Oxford High School)

A practical where students follow the change in mass of animals over time, and then compare it to the mass of food they are given…

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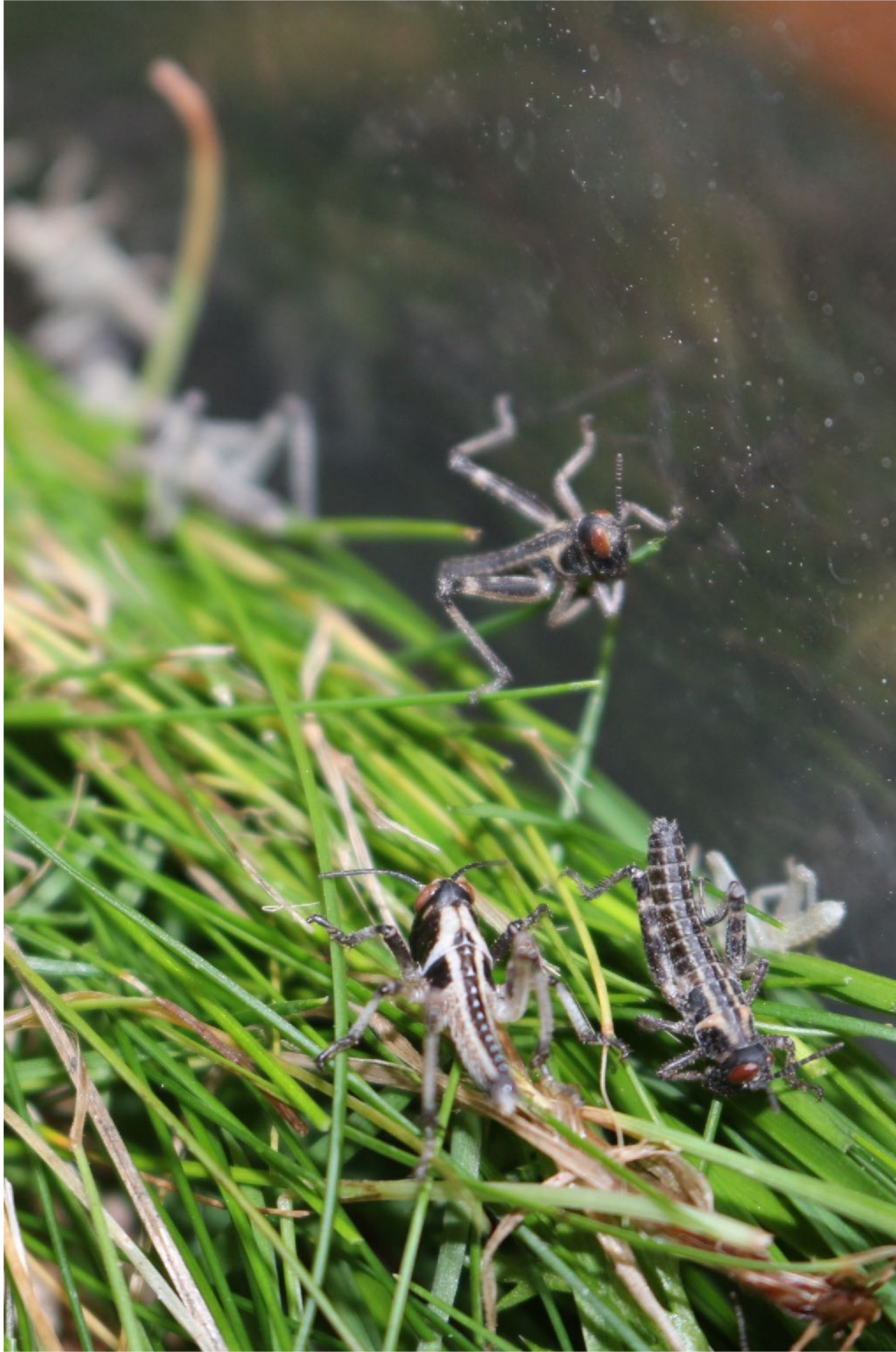
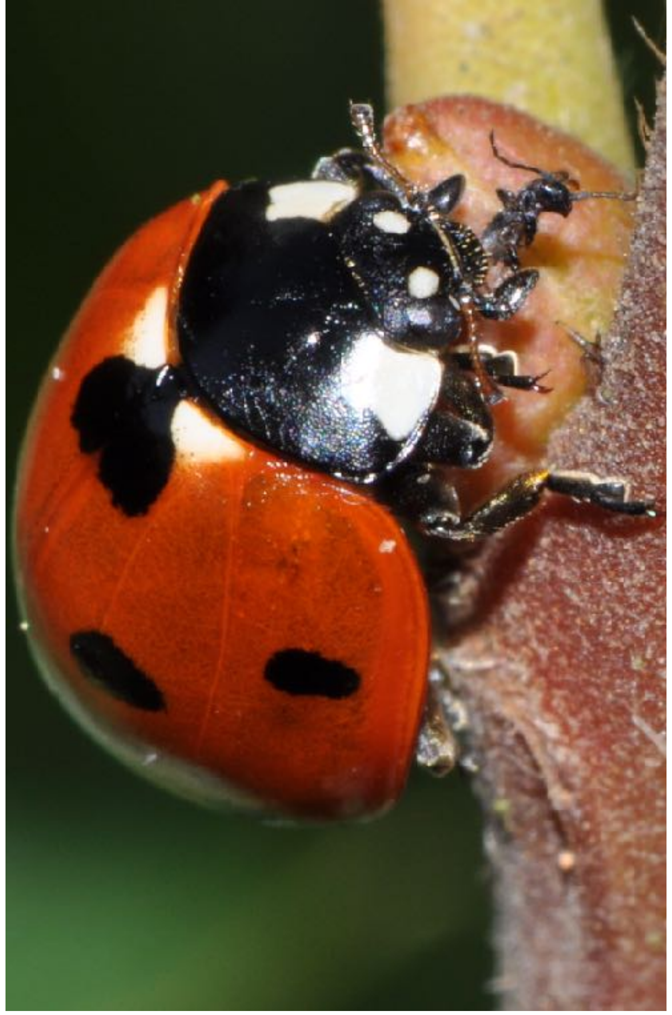
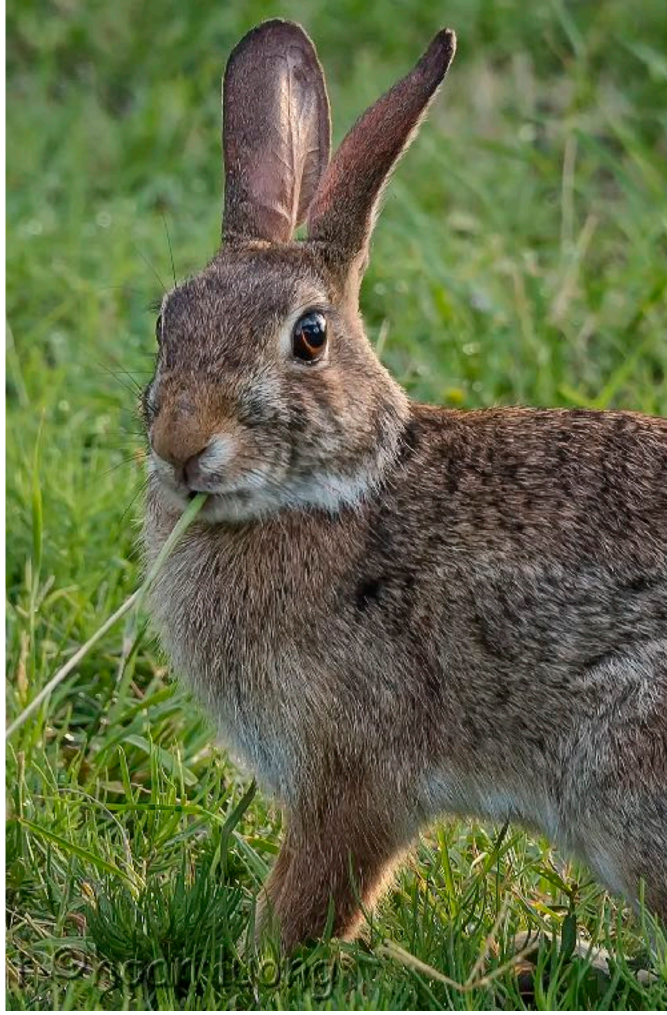


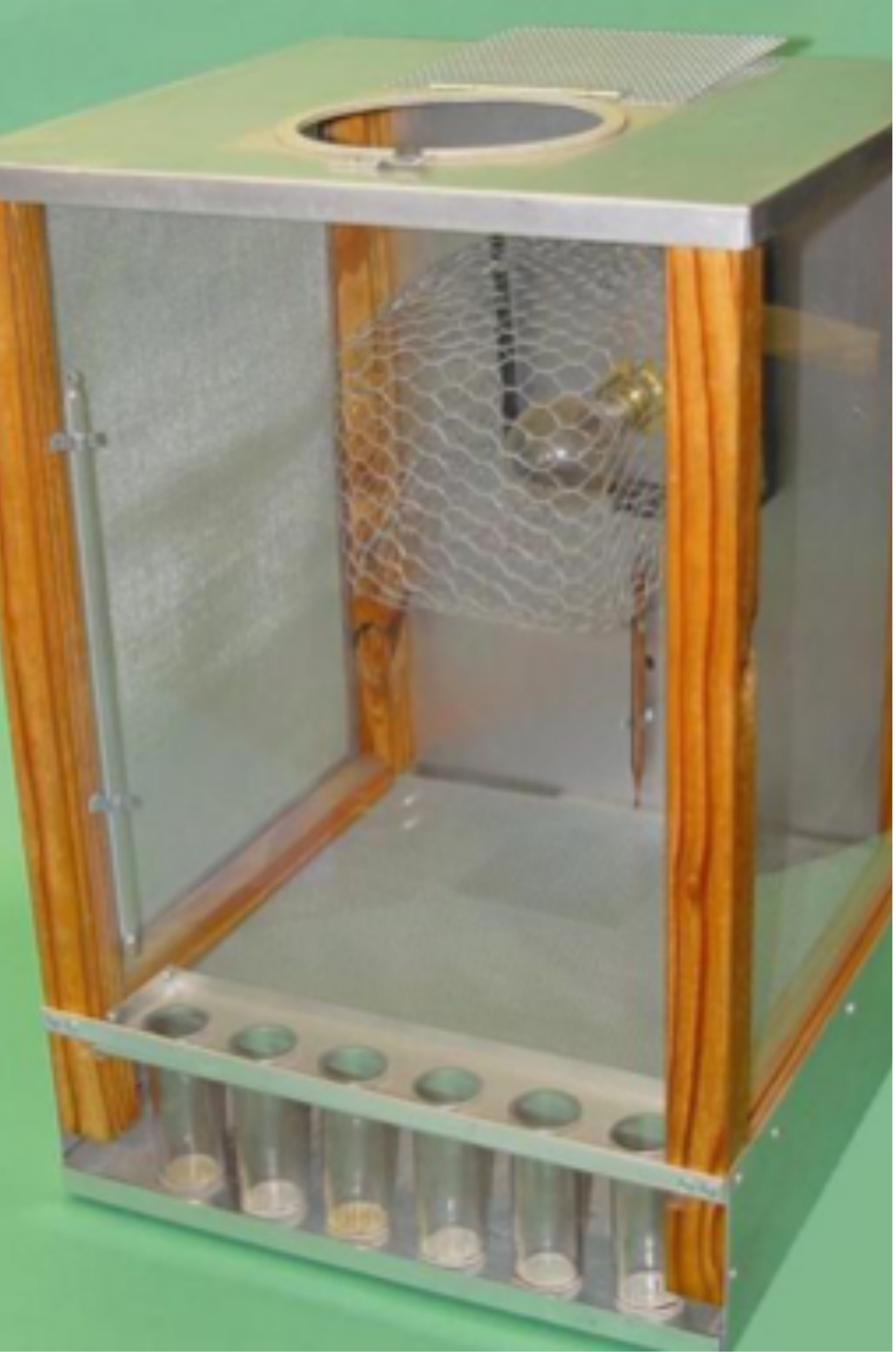
Background notes for teachers

Locusts make superb study animals for a wide range of topics at A-level. Living locusts can be used for a variety of respiration experiments whilst dissecting locusts is a fascinating way of illustrating an invertebrate gas exchange mechanism. It is less obvious, however, how locusts could be used at KS4. This resource introduces a new way of incorporating a display of live locusts into a GCSE topic: **the flow of energy through trophic levels.**

The concept of energy flow through food chains is found in every GCSE Biology specification (Edexcel Topic 9 – Ecosystems and material cycles 9.7B and 9.8B– OCR Topic B4.1 Ecosystems B4.1i and B4.1j – AQA Topic B4.7.4 Trophic levels in an ecosystem 4.7.4.3 Transfer of Biomass). There are existing and well-established practical lessons that aim to illustrate the loss of energy as it transfers through the trophic levels – **the Leaf Litter Safari** (see Appendix) being, perhaps, the best – but although this activity is great fun, and students get to work with live animals, the snapshot of data that it provides is conceptually hard for children to grasp. In particular, they struggle with the idea that the number/ mass of detritus/detritivores/carnivores is somehow linked to inefficient energy transfers between trophic levels**.**







This resource provides direct experimental and observational evidence of the inefficiency of energy transfer. Locusts are ideal animals for this protocol as they are easy to keep, grow very rapidly (hoppers become adults in only 3 weeks) and their food is either free (grass) or cheap (lettuce).

You will need:

A locust terrarium - the traditional old designs can be hard to find (we picked one up on e-bay for £X – see picture), but any glass fronted tank would do the job, provided it has a source of heat (a 60W bulb, for example). You will need to access the tank on a daily basis to add/remove food, so a suitable hatch or door is essential.

Locust hoppers (1st instar growth stage) - these can be ordered from Blades Biological https://blades-bio.co.uk/ at £11 for 10. We found that 20 to 30 is a good number, depending on the size of your tank. Blades provide a care sheet https://blades-bio.co.uk/wp-content/uploads/Caresheets/locusts.pdf

Food - fresh grass is best, served au naturel in a glass beaker, but locusts will happily munch through lettuce, apple or carrots if grass is not available. They also need a constant supply of bran.

Small beakers of silver sand - (if you want your adult females to lay eggs).

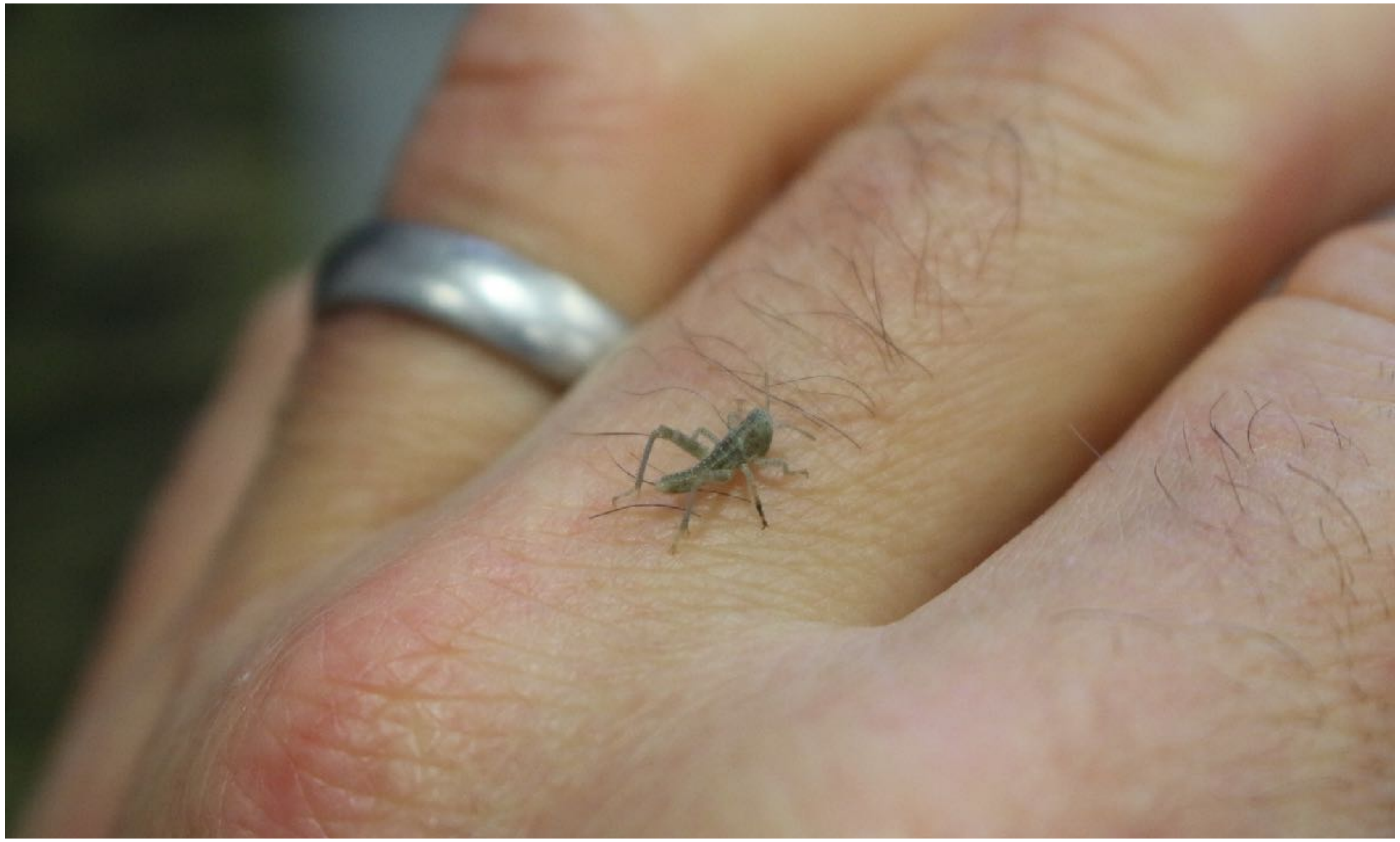
A balance

Method

The locusts will take around 3 weeks to complete their growth, so plan your teaching accordingly – it should not, for example, span a holiday or half term. Ideally, you want the final results to come in just as you are teaching the topic.

When the hoppers arrive they are very small and very hoppy. Weigh the entire package they are in, transfer them to their tank, and then weigh the empty package. Use these figures to calculate the initial mass of the locusts. We found that 30 hoppers weighed about 1g.

Every day for the next 3 weeks, we recorded the mass of all food that went into the locust tank. Any uneaten food from the previous day was removed and this mass was also recorded (see Appendix for suggested data spreadsheet).



After 3 weeks – by which time the locusts had reached their final instar - we removed the locusts from the tank and recorded their mass

This is best done by putting all the locusts into a plastic bag and weighing them together. We also removed all the general debris (locust poo etc) and weighed that. The summary of our data is as follows:

Results

The first question to ask is, why have the locusts not gained the same mass as the food they have been given?

Two answers to this are immediately apparent to all the students who have helped feed the locusts over the preceding 3 weeks.:

- First, they don't eat all the food – the chewier bits of the lettuce/grass/carrot/apple never make it into a locust in the first place.
- Second, of the food that they do eat, a significant proportion just comes out the other end – this poo is the food that they can't digest.

But the really interesting question focuses on the food that does go into the locust. The class can then be asked to suggest about the missing mass – just look: of all the food that went into the locusts and did not come out as poo, **95% of it has just disappeared!** *Where on earth has it gone?* This is a good point to introduce the concept of BioMass and the fact that it is a way of representing how much energy is present. So a better way of phrasing the question is, where is all the missing energy? The data can be used to plot a Pyramid of Biomass, and they can immediately see all the ways in which it is better than a Pyramid of Numbers.

Starting mass of locusts (g)	1.00
Final mass of locusts (g)	62.20
Change in mass of locusts (g)	**61.20**
Total mass of food provided (g)	1516.12
Total mass of uneaten food/poo (g)	268.43
Total mass of food eaten and digested (g)	**1229.69**
%age of food eaten converted into locust mass	**4.98**

The relevant Powerpoint in the Appendix uses grass, rabbits and foxes to reinforce the key points on energy transfer inefficiency (suggestions on how to use the Powerpoint can be found in the notes on each slide).

Why it works

The daily task of feeding and weighing was divided among members of the class – we kept a clipboard next to the locust tank where data could be recorded (see Appendix for spreadsheet).

Students were also encouraged to watch the locusts and make observations of anything they thought interesting or relevant. They were very struck by the following:

- The rate of locust growth – it is genuinely extraordinary how quickly they grow
- The moulting of locusts as they progressed from one instar to the next – the students really enjoyed seeing the shed exo-skeletons hanging from the sticks in the tank
- The rate at which a locust can devour a blade of grass – like watching a piece of spaghetti being slurped up by a hungry teenager – close observation reveals their formidable jaws in action
- Locust mating – when they reach adulthood, they waste no time in starting the next generation
- Locust cannibalism – adult locusts will start eating other locusts if there is not enough fresh food provided – something to watch for if your students are more sensitive and less ghoulish than mine
- Locust egg laying – females lay their eggs deep in a pot of sand

All of these behavioural observations make excellent discussion topics in their own right. One student suggested that the locust feeding behaviour could be incorporated into RS lessons to illustrate the devastating effect of a swarm of locusts descending on a field of wheat. We also discussed locusts as a possible source of protein to replace more conventional animal food like pigs and cows – after all, fried locusts are something of a delicacy in East Africa (the wings fall off, you remove the legs, and it's like eating a prawn).

Further points for discussion

We discussed as a class why the recorded energy transfer of less than 5% efficiency was around half the accepted figure of 10%. Again, the regular monitoring of the tank suggested one reason – the uneaten lettuce removed has dehydrated in the heat of the lamp – of course, 90% of a lettuce is water, which is not an energy storage molecule.

The relevance of this topic for humanity is, of course, the problem of feeding a world population predicted to reach 10.9 billion by 2100. The Powerpoint of George and the salmon (see Appendix) is one way of illustrating this, using Pyramids of Biomass to illustrate just how many more people you could feed from the same food chain if you harvested the food from increasingly lower trophic levels.

Much more fun, however, is the Desert Island Game. In this lesson, you use roleplay to shipwreck increasing numbers of students on a "tropical island" where they have to allocate land for cultivation so they have enough to eat. Details of this lesson can be found on my blog, Biological Burblings, here: https://biologicalburblings.wordpress.com/2017/07/03/decisions-decisions/

Every time I have taught this lesson, whether to boys or to girls or to mixed classes, when finally faced with the choice of giving up eating meat or killing their babies, most students will choose to kill their babies. You can decide whether to laugh or be profoundly depressed.

What to do with all those locusts?

When the experiment is over, your adult locusts can be used for the following experiments/investigations:

- How ventilation rate in locusts is affected by gas concentration OCR Practical Activity Group 11 (Investigation into the measurement of animal responses)
- Locust dissection – removal and observation of the spiracles and….? OCR Practical Activity Group 2 (Dissection)
- Investigating effect of temperature on respiration rate in locusts OCR Practical Activity Group 10 (Investigation using a data logger)
- Investigating the respiratory quotient (RQ) of locusts

Details of observing ventilation rate and locust dissection can be found on the Nuffield Foundation website https://www.nuffieldfoundation.org/practical-biology/dissection-ventilation-system-locust. We have found that a great modification to the ventilation rate activity is to change the gas composition of the tubes and challenge students to explain the changes they observe. Start by establishing ventilation rate in atmospheric air. Then repeat the measurement after the student exhales into the syringe to increase the CO2 concentration. Then repeat the measurement after flushing the tube with oxygen (requires an oxygen cylinder). It works beautifully!

Suggested protocols for investigating respiration rate and respiratory quotient can be found in the Appendix.

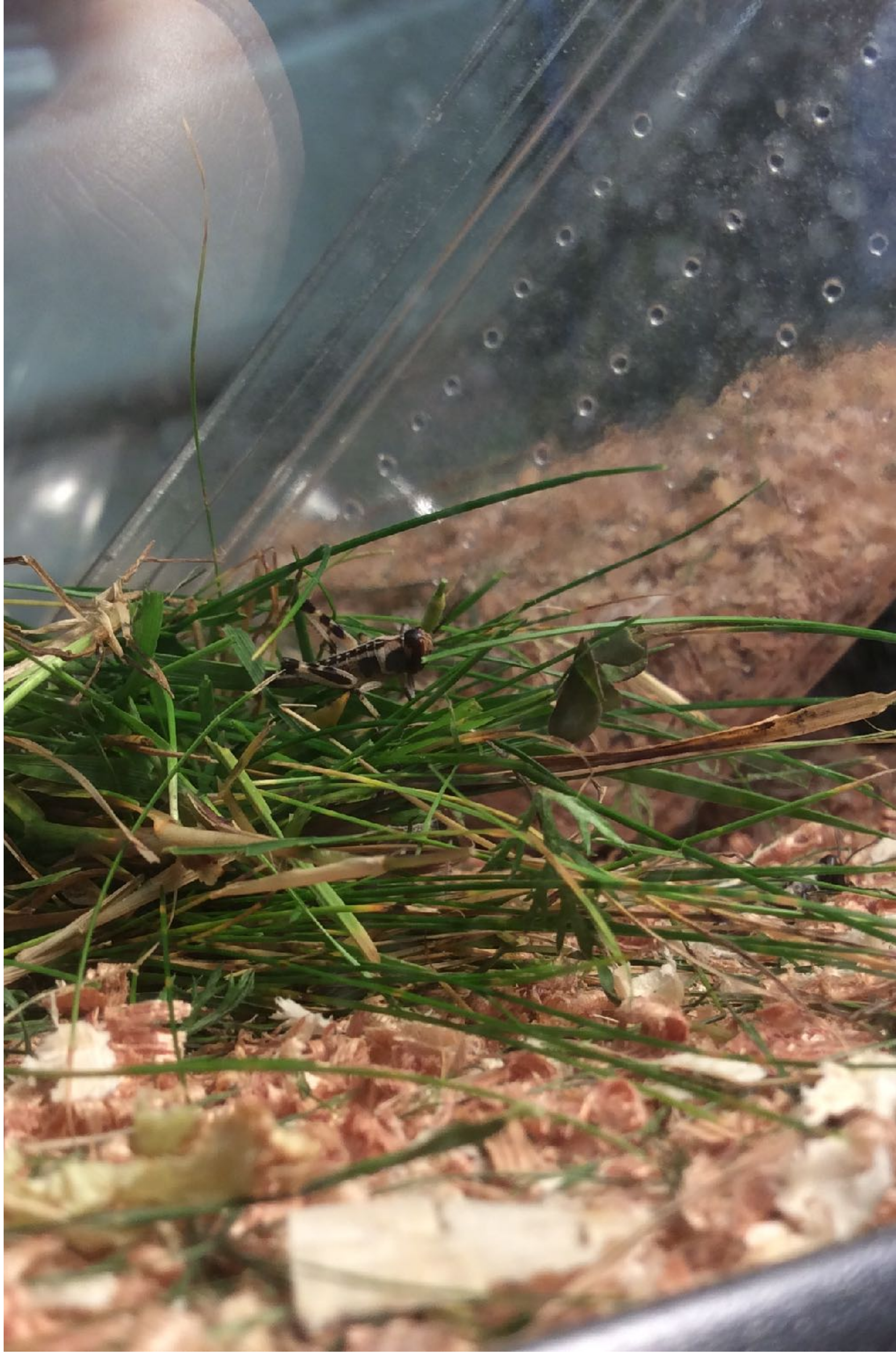
Appendix

Energy loss in food chains Power Point

Food chains and pyramids with George and salmon Power Point

Investigating respiratory rate in locusts

Determining the respiratory substrate(s) in locusts



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ASAB would like to thank Paul Weeks for his enthusiasm and brilliant ideas. The photographs were kindly given for use in this resource by the following people: John Brandauer (cover locust), Michael Brace (locusts on crops), Brian Fuller (ladybird), Hoan Luong (rabbit), Kylie Jaxxon (bird and fish) and Paul Weeks (hoppers and hand). If you have any comments or questions about this resource, or wish for support with teaching animal behaviour please email the Education Officer education@asab.org or @ASABEducation on twitter.

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