Animal Behaviour

Practical work and data response exercises for sixth form students

by
Michael Dockery &
Michael Reiss

Association for the Study of Animal Behaviour

ANIMAL BEHAVIOUR

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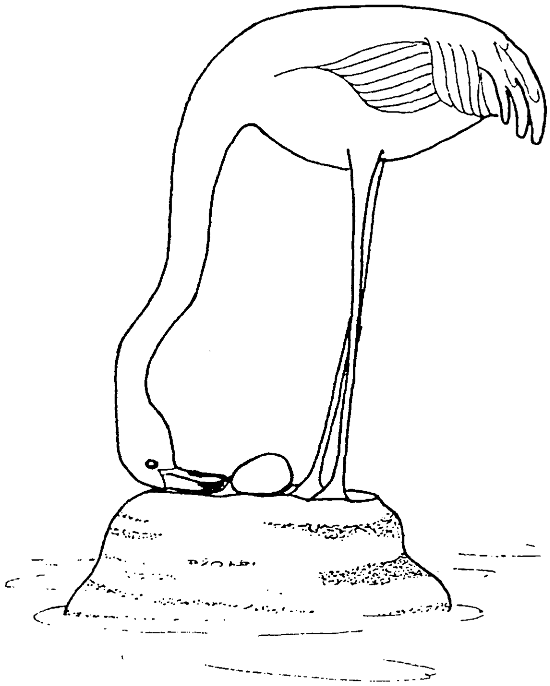
Michael Dockery

ASAB Education Officer, Manchester Metropolitan University

Michael Reiss

Senior Lecturer in Biology, Homerton College, Cambridge

1996



Association for the Study of Animal Behaviour

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INTRODUCTION

The purpose of this book is two-fold. First, to encourage the use of more practical work on animal and human behaviour in the 16-19 age range. Secondly, to enable students studying for 'A' level Biology, Psychology, Human Biology and Social Biology, or other 16-19 examinations, to develop their study skills through tackling data response exercises. Most of the book consists of suggested practical work and data response exercises. However, we have also included a section on describing and measuring behaviour and a section on using statistical tests, and have appended a list of further resources.

Practicals

The practical work is divided into two sorts. The first sort - titled 'practicals' - provides a range of practical work that can be tackled within a relatively short period of time. In most of them the observations and data collection can be completed within an hour or so. Some of these practicals are laboratory based; some involve field work outside of the classroom; some require the administration of questionnaires. As well as introducing the reader to important aspects of animal and human behaviour, the practicals encourage the development of a range of scientific skills including planning, observation, manipulation, recording, analysis and interpretation. We have tried to provide mainly new practical work, though readers may recognise one or two old favourites. Each practical is accompanied by a list of requirements.

Projects

The second sort of practical work is titled 'projects'. These are open-ended activities and require the reader to carry out a sustained piece of scientific study over a period of weeks or months. Projects should encourage students to plan their work, design their methodology, evaluate their findings and refine their investigation accordingly. Sometimes projects don't appear to 'work'. There's a fine line between showing perseverance - which is to be commended - and demonstrating inflexibility - which is not. Projects often need to be modified as one proceeds. Sometimes they need to be abandoned altogether and a new one started afresh.

We have reported the results of three selected projects in some detail, hoping that these will help give some ideas about how behaviour topics can be developed into successful projects. We have also suggested a larger number of possible projects in outline.

None of the practicals or projects should result in any harm to animals or the environment. At the time of writing none of them requires special permission to be obtained from the Home Office, a Local Education Authority, the Department for Education and Employment, or any other body. All practical work should be carried out under the supervision of a teacher, lecturer or trained animal technician. All project work should be approved by a teacher or lecturer before it is undertaken.

Safety

Experimental animals should always be obtained from reputable sources. Students should wash their hands in soap/disinfectant and water after coming into contact with animals. Field work should always be carried out in pairs at least, preferably in threes. That way if something goes wrong, one person can stay with the injured person while the third party goes for help. Field work should never be undertaken by anyone under the age of 18, or in a school, without their letting their parents / guardians and teachers / lecturers know where they are going. Teachers are advised to check that no practical work they, or their students, undertake contravenes any Local Education Authority directive.

Data response exercises

The data response exercises start with one or more pieces of stimulus material. These might be a piece of text, some numerical data, a figure or a photograph. Following the stimulus items there are questions that relate to them. Some of these questions require some factual knowledge about animal behaviour; most can be answered entirely from the stimulus material. The data response exercises have been written by us so as to help the reader develop skills of analysis, comprehension and data handling. The number of marks for each question is indicated by the number in brackets at the end of the question. Each data response exercise has a total of 20 marks. After some thought, we decided not to provide model answers, hoping instead that any uncertainty would encourage fruitful debate.

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DESCRIBING AND MEASURING BEHAVIOUR

Describing behaviour

Behaviours can be described either by their structures or by their consequences. In everyday conversation we tend to describe behaviours by their consequences. "Oh, look, it's feeding" we might say when we see a starling repeatedly inserting its beak into the ground. Often, though, it is better to describe a behaviour by its structure, because this stops one assuming what the behaviour is for. After all, the starling might simply be searching for food, rather than actually feeding. So describing the behaviour as "inserts beak into ground" is safer than describing it as "feeding".

Before choosing the categories you will use to describe the behaviour of the organism you are observing, carry out some preliminary observations. These will help you to familiarise yourself with the organism, and get an impression of the range of behaviours it exhibits.

Your categories should be non-overlapping and unambiguous. It is no good when describing the movement of sheep, for example, to have four categories "walk slowly", "walk quickly", "trot" and "run" unless you can clearly distinguish "walk slowly" from "walk quickly". Beware, too, of making assumptions. Do sheep really trot, for instance? Your categories should be clear enough for someone else to use them with a high degree of accuracy. You will probably need to provide a written description of each behaviour, or illustrate it by a drawing. (These considerations are discussed in more detail in the Practical 'Constructing an ethogram' on page 12.)

Keep in mind what effect you, the observer, have on the behaviour of the organism you are watching. Usually you will want to minimise this, unless you are intentionally mimicking, for instance, the effect of a predator.

If the organism is in an artificial environment, such as a laboratory cage or a zoo, think about how this may affect its behaviour. An animal kept on its own in a small bare enclosure, for example, will behave very differently from a similar individual in the wild. Some behaviours will occur much more than normal; others may not be seen at all.

Finally, think carefully about the focus of your study. Are you simply interested in describing and measuring the behaviours shown by the organism you are observing - as in a natural history study - or is your study an experimental one in which you will be altering a variable and seeing the effect this has on an animal's behaviour?

Types of measure

Once you have identified your behaviour categories and clarified the focus of your study, you need to think about how you will measure the behaviours you observe. Four types of measure are commonly used in behaviour studies: latency, frequency, duration and intensity.

Latency

Latency is the time interval from some specified event to the onset of the first occurrence of the behaviour. Its units are those of time, e.g. seconds or hours.

Suppose, for example, you are investigating the territorial behaviour of male blackbirds. You might make a tape recording of the songs of a territorial male blackbird, play these to other territorial male blackbirds and then record how long it took these blackbirds to reply by singing themselves.

Frequency

Frequency refers to the number of occurrences of the behaviour per unit time. Its units are those of $time^{-1}$, e.g. min^{-1}.

Suppose, for example, you are investigating the drinking behaviour of two different species of hamster. You might record how often, over the course of a 24-hour period, individuals of each species bring their mouths into contact with the tubes that lead from their water bottles (a structural description of a behaviour that is presumed to equate to drinking).

Duration

The duration of a behaviour is a measure of the length of time for which a behaviour lasts. Its units are those of time, e.g. seconds or minutes.

For example, the drinking behaviour of hamsters could be quantified by the duration of each 'drink' ('animal brings mouth into contact with the tube that leads from its water bottle') as well as by the frequency of its drinks.

Intensity

A universal definition of the intensity of a behaviour cannot be given, and intensities may be measured in various units. However, they can be a valuable way of helping to describe behaviour.

For example, one might record the height of a jump (in cm), the amplitude of a vocalisation (in decibels) or the aggressiveness of an interaction (by means of an arbitrary, but clearly defined, scale).

Sampling rules

You will need to decide how you are going to sample. Four main methods are used.

Ad libitum sampling

Here you simply sample whenever you feel like it. This approach is most appropriate during initial observations when you don't know much about the behaviour of the organism. *Ad libitum* sampling allows you to build up a picture of the sorts of ways in which the organism behaves. *Ad libitum* sampling is also helpful for recording rare behaviours - you simply make a note of them if and when they occur.

Focal sampling

In focal sampling you focus (hence the term) on just one individual and record what it is doing. Focal sampling can also be carried out on other 'units' aside from individuals. For example, you might focus on a litter of young animals or on a pair of animals (a dyad).

Scan sampling

Here you scan a whole group of individuals and, in some way, record what they are doing. For example, you might scan a flock of sheep and record how many individuals are feeding, how many are ruminating, how many are moving, etc..

Behaviour sampling

In behaviour sampling, you focus not on individuals or other units of organisms (e.g. a litter, a dyad or the whole group), but on a particular behaviour. You scan the whole group, but then focus on any individual showing the behaviour in which you are interested, for example suckling. Once the behaviour is no longer shown by this individual, you resume scanning the whole group until you see another instance of the behaviour you have chosen to concentrate on.

Recording rules

You will need to decide how often you are going to record your results. Three main approaches are used.

Continuous recording

Here, as the name suggests, you record continuously. This is really only possible if:

- you select just one individual (focal sampling)
- you have only a small number of behaviour categories which you can accurately remember without having to take your eyes off the animal
- the animal changes behaviour only infrequently

Instantaneous sampling

In instantaneous sampling, a signal goes at a regular internal (say every minute). The signal might be an electronic beep, or you might work in a pair, with one of you keeping an eye on a watch with a second-hand and telling the other one of you, who is recording, whenever it is time to record. In either case, whenever the signal is given or beep heard, you record your observation.

One-zero sampling

Here a beep goes, or a signal is given, at regular intervals. You then record whether or not a particular behaviour has occurred since the last beep. If it has, you record a '1'. If it hasn't, you record a '0' (hence the name 'one-zero sampling'). One-zero sampling is most often used with focal sampling for recording occasional behaviours which don't last long, such as a bout of grooming or play.

One-zero sampling can be combined with instantaneous sampling, so that you record whatever the animal is doing when the beep goes (or signal is given) and you record whether or not certain behaviours have occurred since the last beep or signal.

Recording medium

Finally, you need to think about how you will record your results. Several approaches are possible.

Check sheets

A check sheet is a recording medium you will need to design yourself. An example of one, used by one of the writers, is given in Figure 1. This check sheet was used for recording the behaviour of male red deer on the Isle of Rhum, Scotland. Both focal and scan sampling were used and a combination of instantaneous and one-zero sampling, with an electronic beep going off every 60 seconds.

On Figure 1, ACT stands for 'activity' (i.e. the behaviour of the focal individual when the beep went off); GRT for 'gradient' (Rhum is very hilly and I was looking at energy expenditure in the deer), RN for 'rain', WD for 'wind direction' (8 points of the compass used) and WS for 'wind speed" (Beaufort Scale). Also recorded were cloud cover, the presence/absence of flies and the area in which the focal animal was at the beginning of the 30 minutes recording. (The whole of the study area was divided into 100 m x 100 m squares.) The study was carried out during the annual mating season when dominant adult males hold harems of females. Kleptogynists are less successful male deer which occasionally try to steal females.

Tape recorder

A tape recorder can be very useful if it is raining or if you are moving around a lot. It is essential to transcribe your recording the same day, otherwise a lot of detail gets forgotten.

Film

Both video and still filming can be a valuable way of recording certain behaviours. You may be able to borrow a camera with a telephoto lens or, even more valuably, a camcorder. The great thing about videoing behaviour is that you have plenty of time subsequently to examine the tape in detail.

Automatic recording device

An automatic recording device can be a useful way of recording just one or two behaviours over a long period of time (e.g. several days). For example, a light trip attached to a data logger can be set up to enable the running of a small mammal in a cage to be recorded automatically.

DATE				TIME	ANIMAL	WD	WS	CLOUD		FLY				AREA
				Distance moved	Roars			Group Information		Nearest Harem		Kleptogynists		
Mins	ACT	GRN	RN					No.	Compos'n	No.	Dist.	No.	Dist.	
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Figure 1 An example of a check sheet.

PRACTICALS

CONSTRUCTING AN ETHOGRAM

Background

An ethogram is a careful description of all the behaviours that a species of animal exhibits. It is obtained by many, many hours of careful observation of the animals, preferably in their native habitat as well as possibly in a laboratory environment. The descriptions may be made by means of drawings or words or both.

One of the best established ethograms is that of the domestic cat (*Felis silvestris catus*). The UK Cat Behaviour Working Group has identified a total of 114 behaviours. These are divided into two overall categories: solitary behaviour patterns and social behaviour patterns. Figure 1 shows an example of a solitary behaviour pattern: *lie half side*. Figure 2 shows an example of a social behaviour pattern: *body cat rub*.

Some examples of verbal descriptions of solitary behaviours are as follows:

Sleep - Cat immobile, eyes closed and not easily disturbed.

Rest - Cat remains generally inactive with eyes closed but occasionally opens them to scan the area; ears flicking regularly.

Alert - Cat remains generally inactive with eyes fully open and flicks its ears occasionally as it scans its surroundings.

Groom self - Cat grooms itself by licking its body or by licking its paw and passing the paw over its head. (Subdivisions are possible according to region of body groomed, e.g. *Groom genitals.*) Grooming can include scratching and brief chewing of the body.

Object scratch - Cat repeatedly scrapes its extended claws against a rough surface, e.g. wood.

Method

1 Read the section on 'Describing behaviour' on page 4.

2 Obtain access to an animal or a group of animals of known species.

3 Start to construct an ethogram. After preliminary observations, provide careful written descriptions or drawings of the various behaviours.

4 Devise a way of seeing whether your outline ethogram can be used by another person or needs refining.

Reference

UK Cat Behaviour Working Group (1995). *An Ethogram for Behavioural Studies of the Domestic Cat* (Felis silvestris catus *L.)*. Universities Federation for Animal Welfare, 8 Hamilton Close, South Mimms, Potters Bar EN6 3QD. ISBN 0 900 767 90 1. £3.00 incl. p. & p. at 1995 prices.

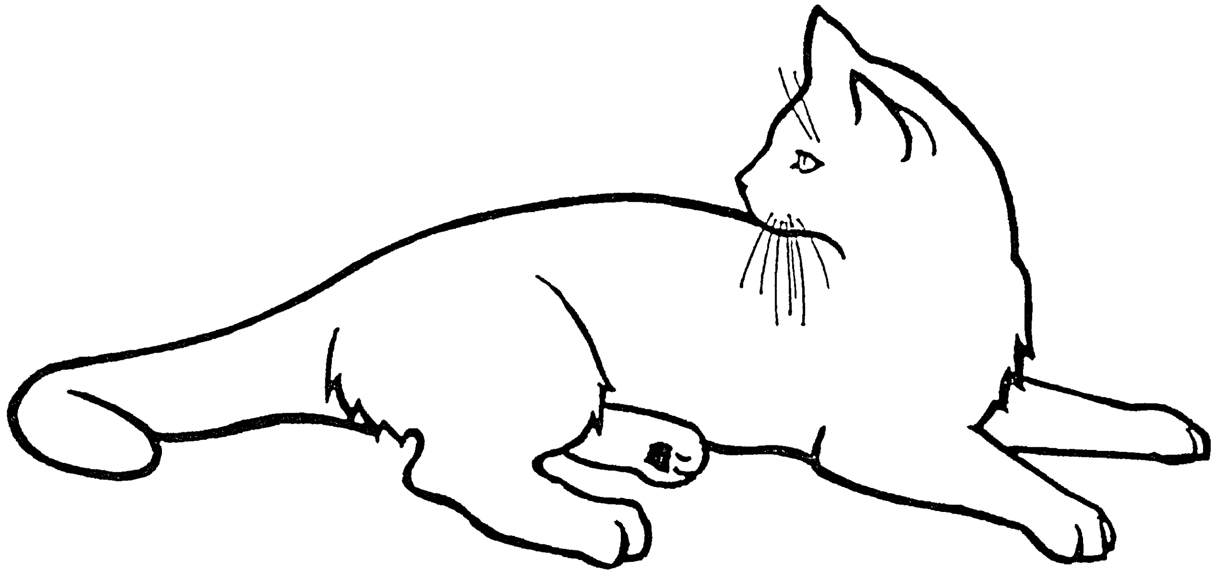


Figure 1
A solitary behaviour in cats: *lie half side*.

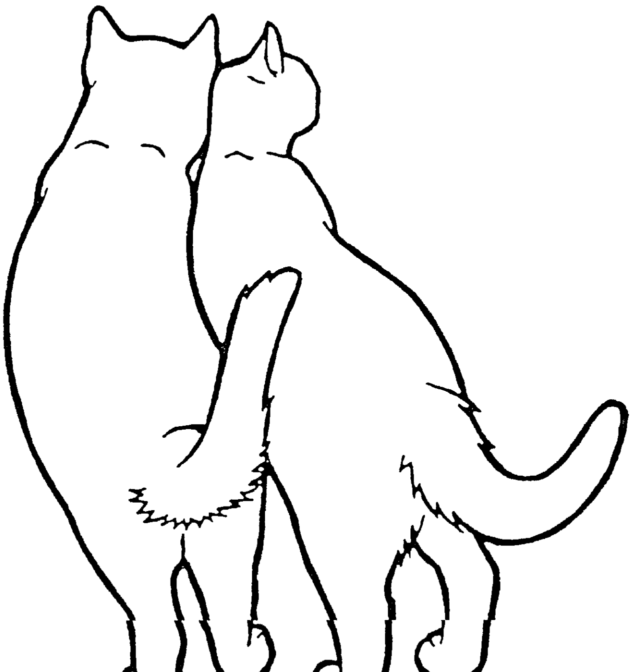


Figure 2
A social behaviour in cats: *body cat rub*.

ATTITUDES TOWARDS ANIMALS

Attitudes are relatively stable positions that an individual holds towards a person, object or idea. Attitudes are learned and can be either positive or negative. Our attitude will affect how we think, feel or behave towards something or somebody. Whatever the issue, people will evaluate it from a personal perspective and thus the depth of feelings and range of the behaviour will vary from person to person. For example, some people disapprove of the live export of animals for veal production under continental systems (i.e. under conditions not found in the United Kingdom) and are prepared to march and actively demonstrate against this trade: others who disapprove may do so by signing a petition.

Scientists are very interested in measuring attitudes. It is relatively easy to measure length, weight, time etc. but it is much more difficult to measure attitude. One widely used method of measuring attitude is a questionnaire. A questionnaire is a list of questions that will gather information about a particular topic or issue. One technique that has been used is to construct a scale to indicate how strongly the statement is held or believed. The researcher provides subjects with a list of statements and asks them to respond by ticking a box to indicate the strength of their agreement or disagreement.

For example, consider the statement 'snakes make ideal pets for young children'. We might offer the subjects two choices viz. *Yes* or *No* and allow them to indicate their preference by perhaps ticking a box or circling their choice. More frequently an odd number of choices is offered so that the middle one acts as a neutral choice e.g. you could give them five choices such as strongly agree, agree, undecided, disagree and strongly disagree. Sometimes numbers are used instead of a verbal label e.g.

1	2	3	4	5
complete agreement				complete disagreement

The subject then circles the number that reflects how strongly they feel about snakes being ideal pets for children.

In this practical you will carry out a questionnaire and will effectively be using a numerical scale. You will be trying to obtain a measure of how strongly people feel about certain common animals when they are provided with the opportunity to donate a specific sum of money to a number of animal charities. The assumption behind the allocation of money is that if people feel more positive about a particular animal they are prepared to donate more money to that charity.

The accompanying sheet, headed Donating To Animal Charities, shows a questionnaire that could be used in this study. You may wish to change the animals, add more to the list, ask subjects for more information about themselves etc.. [For the purposes of an A Level investigation, you are more likely to get a positive response from prospective subjects if you allow them to remain anonymous and also if they can put potentially sensitive information into a broad category. Thus, if you feel age may be linked to the allocation of money you could boldly ask adults their age but a greater response rate usually occurs if they can tick one of a number of boxes e.g. 21-40 years, 41-60 years and >60 years.]

BEFORE you conduct the study you need to consider and record:

i) the specific aim of the study - e.g. to determine the strength of feeling of people (or adults or sixth formers depending on which group, or groups, you are interested in) towards certain animals as revealed in the allocation of money to animal charities.

ii) the hypotheses that you may wish to test - e.g. there will be no difference in the strength of feeling toward certain animals between female and male subjects. In a similar way you could determine if age is influential, if exposure to information about the animals affects the allocation of money, etc..

iii) the number of subjects you wish to involve in the investigation - as a general rule, a large sample is preferable, but how large is large? For an A Level study, aim for at least 15; 16-30 is better but there is seldom a need to go beyond 30 subjects unless you suspect that there could be a potential bias which might affect the results.

iv) how you will obtain your sample of subjects - it may be possible for you to use a **random sample** if you can have access to the school or the college registers; it is much more likely that you will have to use a **systematic sample** in which you select people at a constant interval (e.g. you may decide that you will ask every fifth person who enters the school/college library, or approach every tenth person walking down the street) or an **opportunity sample** in which you select those subjects who just happen to be around when you are ready to collect the data.

v) the standardised instructions you will give to each subject - these can be put at the top of the questionnaire sheet but you still need to approach subjects to ask them if they will participate in your study and this information cannot sensibly be put on the sheet.

Suitable standardised instructions for this study could be: "You have £100 available to donate to animal charities. After giving the matter careful consideration you decide to allocate the money to the following charities, with at least £1 being given to each. We would be grateful if you would indicate how much money you would give to each of the charities below: please ensure that the amounts do add up to £100." These instructions could be written at the top of your questionnaire sheet.

When you approach potential subjects you might say: "Excuse me, I wonder if you could help me to carry out an A Level project concerning animals. It will not take longer than 4-5 minutes. Could you please read the couple of sentences at the top of the sheet and then put a number in the appropriate place." After they have completed the questionnaire do remember to thank them for their help with the project.

vi) which variables you might wish to try and control (i.e. keep constant throughout the investigation) - in this study you should control the instructions given to the subjects, the subjects should all receive identical sheets and you should try to carry out the investigation over as short a time period as possible: you might think you should control other variables too.

vii) the procedures that will be used to carry out the study e.g. where it will be carried out, if any apparatus will be needed, etc. - you might like to carry out your questionnaire study at your school or college but it may also be possible to conduct it in other places e.g. a public library (seek the permission of the librarian before you begin), a shopping precinct etc.. Always work in groups of two or three when carrying out research projects and ensure that your school/college and/or parents/guardians know where you are.

viii) the techniques you will use to analyse the data obtained from the questionnaires -

you could present a summary of your findings in a table

you could represent the data graphically

you could analyse the data statistically (if so you will need to decide which statistical test to use and what would be the appropriate level of significance to allow you to reject/accept your hypotheses - you should consult pages 77-78 in this book to help in this regard).

Carrying out the investigation

It is often a good idea to carry out a **pilot study** before you embark on your investigation. A pilot is a small scale study, of perhaps 5-10 people, who carry out the task you expect your real subjects to do, in this case to complete a questionnaire. The pilot study allows you to check the questions - questions may be misinterpreted, they may be ambiguous, they may embarrass people, etc.. In this particular study these problems will hopefully not occur as one of the writers has used this exercise with other A Level groups and it has worked quite successfully. However, in spite of all your efforts to produce a problem-free investigation subjects will often respond in a way you had not anticipated, e.g. by asking you "What is a salmon?" You may therefore need to have with you a prepared sheet with a short description of each animal in order to answer such questions with a standard reply. You will also need to ensure that you have one questionnaire sheet per subject.

Always approach potential respondents in a polite manner, this will increase the chance that they will agree to your request. It will probably be worthwhile having a sheet of headed school/college notepaper signed by your teacher to verify that you are conducting research for an A Level investigation. This is also useful to show any other people who might ask you what you are doing, e.g. the owner of a shop, police or security personnel, etc.. When the subjects have agreed, present them with the questionnaire on a clip-board as it is much easier to complete it if the respondents can write on a hard surface. Also have a spare pen or pencil handy: it is surprising how often a subject will walk off with your pen or pencil: leave your Mont Blanc pen at home when you are collecting the data for the project!

Do thank your respondents for their participation and be ready to explain what you are trying to investigate, how the results will be analysed, what practical value your findings may have, etc..

Research is always interesting and is a highly enjoyable academic activity. Enjoy it and good luck!

DONATING TO ANIMAL CHARITIES

You have £100 available to donate to animal charities. After giving the matter careful consideration you decide to allocate the money to the following charities, with at least £1 being given to each. We would be grateful if you would indicate how much money you would give to each of the charities below. Please ensure that the amounts do add up to £100.

		£
1.	Working Together For Bees	______
2.	Working Together For Cats	______
3.	Working Together For Dogs	______
4.	Working Together For Frogs	______
5.	Working Together For Magpies	______
6.	Working Together For Moths	______
7.	Working Together For Rats	______
8.	Working Together For Robins	______
9.	Working Together For Salmon	______
10.	Working Together For Spiders	______

It would be helpful if you would indicate, with a tick, which groups you belong to:

SEX - Female ☐

Male ☐

AGE -	< 21 ☐		41 - 50 ☐	
	21 - 30 ☐		51 - 60 ☐	
	31 - 40 ☐		> 60 ☐	

HABITUATION IN SNAILS

Background

If an animal repeatedly receives a stimulus which is associated neither with benefit nor with harm, it soon learns not to respond. This is known as habituation. In this practical you can investigate habituation in snails.

Method

1 Obtain a number of snails (at least six) of the same species and of about the same size.

2 Make sure you can recognise your snails as individuals, either by noting individual characteristics of their shells or by marking their shells with very small applications of paint or white-out fluid.

3 Carefully read through the rest of these instructions before proceeding. Ensure you understand what to do and have the necessary apparatus to hand.

4 Place one of the snails on a table top or other flat surface.

5 Ten seconds after it has started to move, tap the table smartly with your knuckles approximately 10 cm in front of the snail.

6 Observe the snail's behaviour. Does it withdraw into its shell - or at any rate stop moving? What are its tentacles doing?

7 Assuming that the snail has stopped moving, time how long it takes it to start moving again.

8 Repeats steps 5 to 7 above a total of six times, or until the snails stops moving for more than two minutes, whichever comes first.

9 Repeat steps 4 to 8 above with the rest of the snails.

10 Unless you intend to carry out further work on the snails, return them to the wild or from wherever you obtained them.

11 What do you think might be the function of habituation?

12 Write up your results. You will need to find some way to represent your results graphically. Can your data be analysed statistically?

13 There are other reasons apart from habituation that can explain why animals stop responding to repeated stimuli. One possibility is muscle fatigue. Can you devise an investigation to test whether the failure of a snail to respond to repeated stimulation is the result of habituation or muscle fatigue?

Requirements

Snails x 6 (at least), of the same species and of similar size

Stopwatch

Access to a flat surface

TURN ALTERNATION IN WOODLICE

Background

A number of research studies have shown that in some species of invertebrates turn alternation, or correcting behaviour, occurs. Turn alternation is seen when an organism tends to turn in the opposite direction to a prior forced turn. Thus if an animal is in a simple maze and is forced to turn right, it will turn left at the next choice point in the maze, or at least show a preference for turning left. In this practical you can see if woodlice show turn alternation.

Method

You will need to construct a simple H maze from balsa wood/hardboard/perspex/card. The dimensions of the maze are not too critical, the size indicated in Figure 1 has been successfully used in the past. After you have constructed the maze you will need to make a 3 cm cube of wood which should fit tightly inside the arms of the maze, see Figure 1.

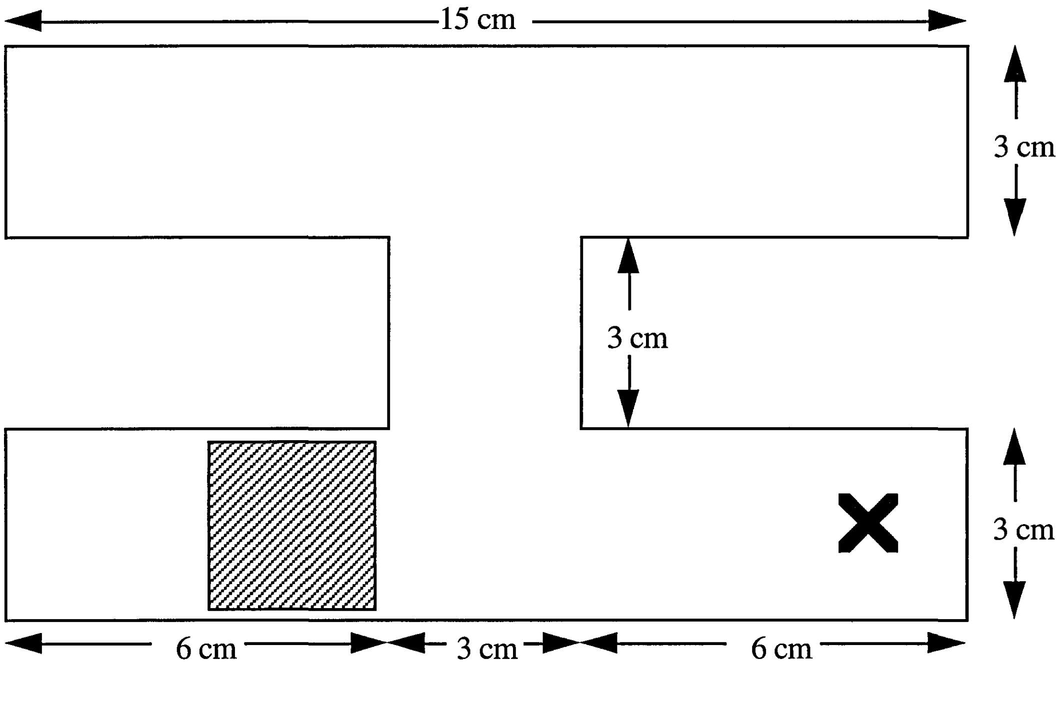
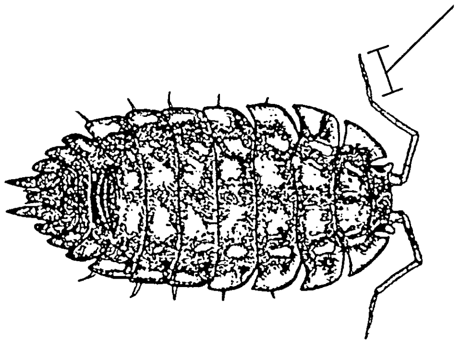


Figure 1
Dimensions of an H maze / cm.
In the diagram, X is the point at which the animal is introduced into the maze.
In this particular example the woodlouse would be forced to turn right.

Collect your experimental animals from around the school/college grounds. You are likely to find woodlice in flower beds, beneath bushes and trees, in a compost heap, under large stones, in a greenhouse, etc.. When you have found them use an artist's brush to place them inside a biscuit tin which has either damp soil or moistened paper hand towels in it. Transfer them carefully as they have delicate legs which can be damaged. Woodlice occupy damp, dark places in the wild so replace the lid when you have collected your animals (20-30 should suffice). Return to the laboratory and leave the animals to settle for a while before you begin the first trial.

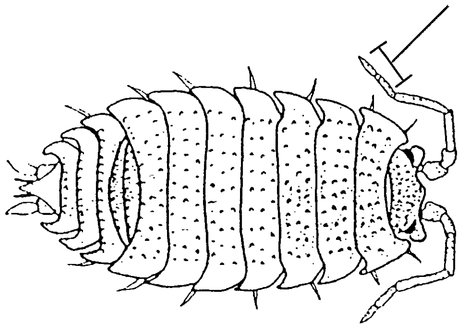
3 segments



Smooth and shiny. Brown/grey. 16mm max. length
Pale edges. Two rows of yellow patches.

Oniscus asellus Common Shiny Woodlouse

2 segments



Dull, uniform slate grey. 17mm max. length
Rough surface.

Porcellio scaber Common Rough Woodlouse

Figure 2

Two of the common species of woodlice found in Britain.

While you are giving the animals time to adjust, find a statistical text book and, using a set of random number tables, determine the order of the forced turns for the woodlice when it is time for them to be placed into the maze. Roughly half should be forced to turn right, the other half left. Alternatively, you could force woodlice numbers 1, 3, 5, etc. to the left, and woodlice 2, 4, 6 etc. to the right.

When you are ready, select one of the woodlice from the biscuit tin and place it in the maze using the artist's brush. When the animal leaves the choice point record whether it turned right or left. After each trial, put the experimental animal into another biscuit tin with soil or dampened paper to avoid using it again. Using a cotton wool swab, moistened with de-ionised water, wash the floor of the maze before the next trial in order to remove any chemical markers that may have been left by the previous animal.

After you have completed the experiment, return the animals to the site from where they were collected.

Tabulate your findings. Do they seem to suggest that turn alternation has occurred? You may be able to use a statistical test to ascertain if turn alternation has happened: suitable tests are the binomial or the chi-squared tests.

NOTE: There are a number of possible follow-up studies that you might wish to try if you want to pursue this further. You could omit the washing of the floor after each trial to investigate if a chemical influence seems to be important. You could alter the angle of the forced turn (i.e. not 90 degrees as in this case) to see if this is influential. You could detain the woodlouse after it has made the forced turn, but before it has made its chosen turn, to see if a delay affects the likelihood of turn alternation occurring. You could also try other invertebrates and see if they show correcting behaviour.

Reference

Hughes, R N. (1967). Turn alternation in woodlice (*Porcellio scaber*). *Animal Behaviour*, 15, 282-286.

EGG-LAYING BEHAVIOUR IN SEED BEETLES

Background

For egg-laying species of animals it is vital that they deposit their eggs in a safe place and that they lay them in a way that maximises the chance of the young hatching successfully. Whilst it is possible to study egg-laying in the field there are some practical problems, for example, the presence of predators, the difficulty of the observer keeping up with the laying animal, etc.. In a laboratory there are no free-roaming predators for a researcher to worry about and so it is much easier to carry out studies. A suitable animal to use in such studies is the American seed beetle, or cowpea weevil, *Callosobruchus maculatus**. Females, after mating, lay eggs on the seeds of various legumes. For laboratory studies, researchers could use both the mung bean and the black-eyed bean, though the former has the great advantage that if eggs are laid on its surface they are more easily seen. In this practical you will be able to see the egg-laying strategy used by a female seed beetle.

Method

You will need to have a reasonably large stock of beetles for this investigation. Select your sample of beetles from a batch of recently emerged adults. Put one female and one male inside an empty 55 mm petri dish and leave them in the dish for 3 - 4 hours (or overnight) to mate. Whilst they are in the dish, take an empty 90 mm petri dish and arrange 16 mung beans (or any other convenient number) in the pattern shown in Figure 1. Use a very small dab of adhesive (balsa wood cement or Araldite is suitable) to stick the bean into position. The female can then be removed from the dish in which she has mated and placed in the centre of the petri dish with the 16 mung beans. You can then record the behaviour shown by the female as she lays her eggs on the beans, i.e. record the sequence in which the eggs are laid. Use the letters on the outline beans in Figure 1 to identify each one.

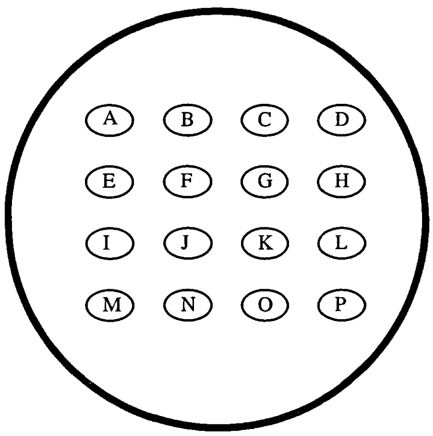


Figure 1
Arrangement of seeds in the petri dish.

You can identify if an egg has been laid since you can see a small white dot after she has moved off the bean; this dot is the egg. [You may notice that before the female lays an egg she "inspects" the bean. This is a normal part of their egg-laying behaviour.]

Egg-laying can take quite a while and if a camcorder is available this would be convenient to use; a three hour tape will suffice, however. You can probably get three or four petri dishes in the field of view, though this may depend on the particular camcorder, and you can let the apparatus run for three hours to record the behavioural details. You can then replay the tape at fast- forward speed to identify the order of egg-laying.

Tabulate your findings and determine if there is a pattern in the order of laying eggs.

NOTE: You would be able to extend this investigation into a project quite easily. You could try another geometrical arrangement of the beans, for example a circle, and again observe the laying sequence. You could try another legume seed (for example black-eyed beans) using the pattern in Figure 1 and see if the sequence is the same. You could place two recently mated females in a petri dish and observe the sequence when two individuals are effectively competing for space. You could put a second female into a dish in which a female has already laid eggs - is the strategy shown by the second female different from that used by a female laying on egg-free seeds?

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* A starter population of these seed beetles can be obtained from:

Michael Dockery (ASAB Education Officer)
Department of Biological Sciences
John Dalton Building
Manchester Metropolitan University
Chester Street
Manchester M1 5GD

Tel: 0161 247 1149
Fax: 0161 247 6365

The cost is £5 which will include the cost of postage and packing: please make cheques payable to '**ASAB**'.

The seed beetles are not native to Britain, though in the United States they are a pest of leguminous stored seed. It is, therefore, best to confine their use to a school or college laboratory and take the appropriate measures to minimise the chance of individuals escaping.

CHEMICAL COMMUNICATION IN ANTS

Background

The individuals of many social insects, including ants, can communicate with one another about food sources they have found. In this practical you can see what information, if any, ants can communicate to each other using chemical trails.

Method

1. Locate a trail of active ants, preferably on a hard surface such as a pavement.
2. Put a heaped teaspoonful of honey about 60-75 cm to the side of the trail and surround it with four pieces of overlapping cardboard or plywood as shown in Figure 1.
3. Once the ants have discovered the honey, observe and record their behaviour as carefully as you can for about ten minutes.
4. About ten minutes after they have discovered the honey either turn the piece of cardboard / plywood over which they have made a trail through 180° or swap it with one of the other four pieces of cardboard / plywood.
5. Observe and record their behaviour for a further ten minutes.
6. Repeat steps 1 to 5 above with a different ant colony, using fresh pieces of cardboard/plywood.

SAFETY: Some ants can bite or spray you with unpleasant chemicals. Take care not to come into contact with the ants and don't let any ants get to within 30 cm of your eyes.

Requirements

Ant trails, 2

Honey, 2 teaspoonfuls

Cardboard / plywood pieces as shown in Figure 1, approximately 15 x 25 cm, 8

NOTE: This practical could easily be extended into a full project.
How long does the chemical trail last?
Does it contain information only about the location of the food or also about its direction or quality?
Can the information be detected and utilised by another colony?
Are there differences between ant species?

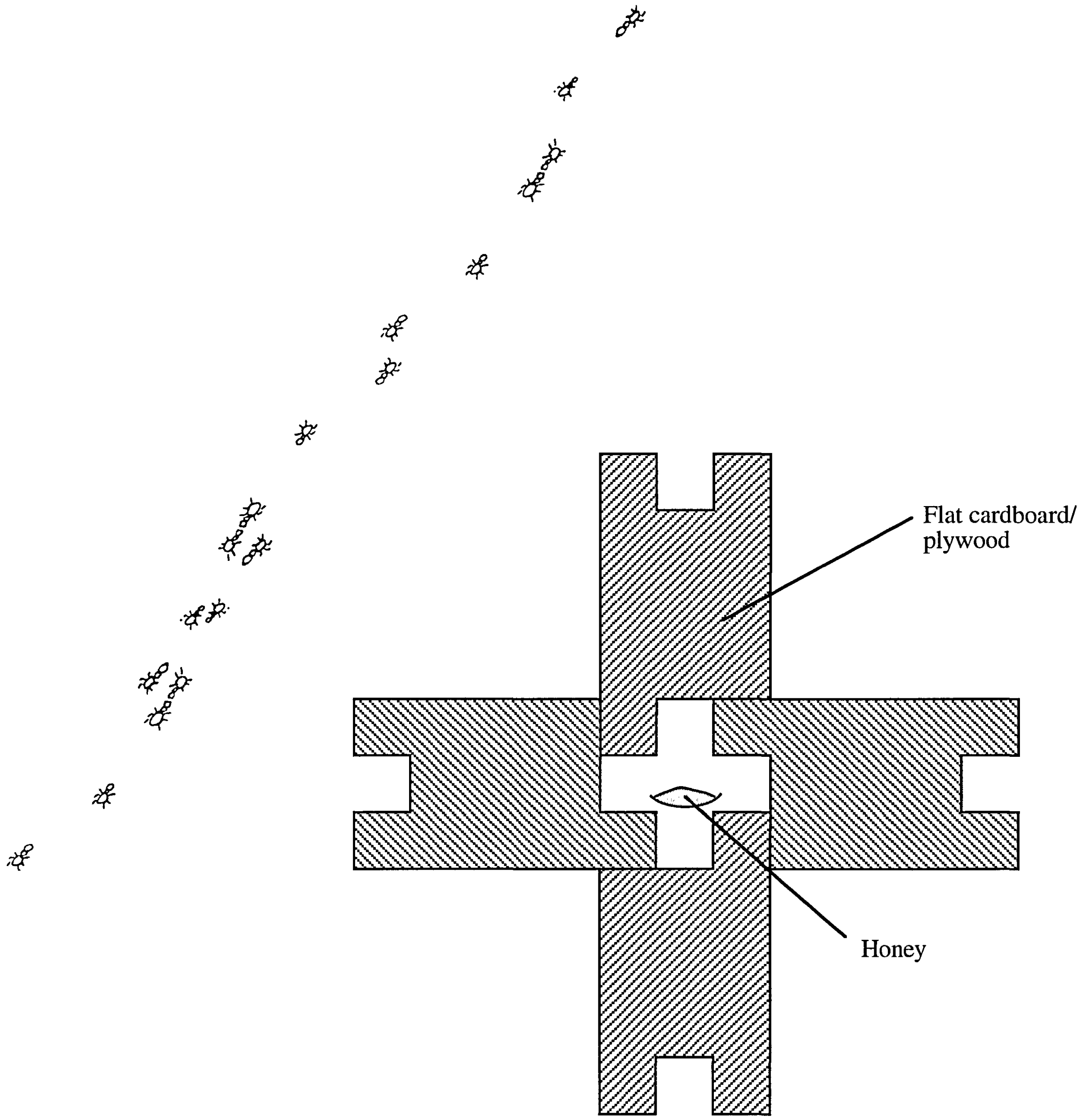

Figure 1
Ant trail.

MAZE LEARNING IN SMALL MAMMALS

Background

There are many animals, including a number of invertebrates, that can learn to find their way through mazes, especially if they are given a reward on successfully completing their journey. In this practical you can see how a small mammal learns its way through a maze.

Method

1. Obtain or construct from wood/hardboard/perspex a maze much like the one shown in Figure 1. Before using it, wash it in warm, non-soapy water and ensure that it is dry.
2. Read the rest of the instructions before proceeding, and ensure you have all the apparatus to hand and are clear about the procedure.
3. Obtain a small mammal, such as a gerbil or hamster, that has not previously been through the maze. Ensure that the animal has not eaten large amounts of food just prior to the practical. (However, you must **not** unduly deprive the animal of food for the purposes of the practical.)
4. Place the animal at the starting area without there being any food in the food area.
5. Let the animal find its way to the food area. Time how long this takes and score the number of mistakes it makes *en route*. You will need to decide what constitutes an error before carrying out the first trial.
6. When the animal arrives at the food area, give it a small item of food. Once this has been eaten, repeat steps 4 and 5 until the animal has learned to complete the maze three times in a row without making any errors or you have conducted 10 trials (whichever comes first).
7. Plot a graph of time taken to complete the maze as a function of the number of trials.
8. Plot a graph of the number of errors made on each trial as a function of the number of trials.

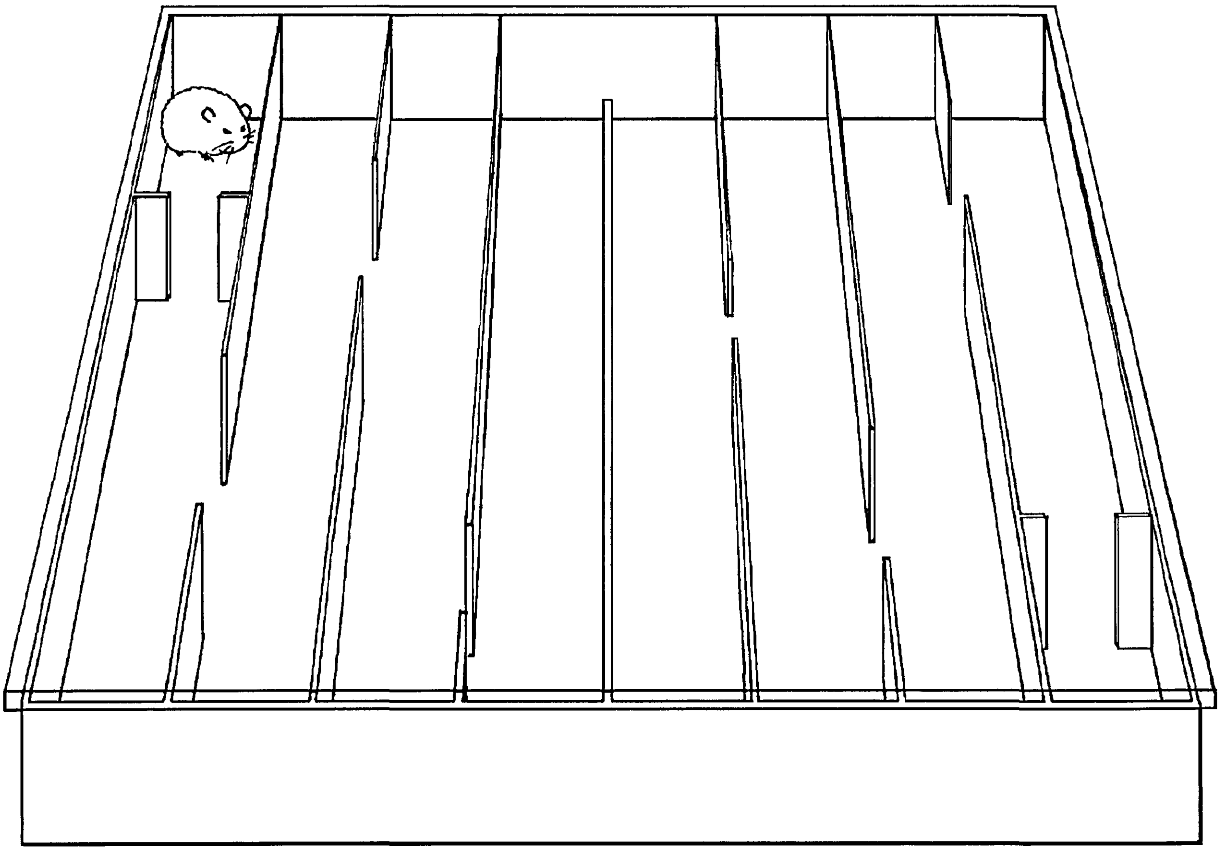

Figure 1
A suitable maze for a small animal.

Requirements

Maze like that in Figure 1 or the equipment to make one from wood/hardboard/perspex

Small mammal, not overfed and with no experience of the maze

Stopwatch

Non-smelly food (e.g. small nut or piece of solid food pellet)

NOTE: This practical could easily be extended into a project. Does a small mammal use chemical cues (try washing the maze between each trial)? Do different individuals / species learn at different rates? Do old animals learn less well than young ones? Once an animal has learned how to find its way through one maze, does it learn to negotiate another maze more quickly than an inexperienced individual? Does it make any difference if the animal is towed through the maze in a little transparent carriage prior to its first trial?

SELECTIVE PREDATION OF COLOURED PREY ITEMS

Background

Many animals are the prey of others. If an animal is likely to be eaten then it is to its advantage to reduce the chance of this happening. Some animals run or fly the moment a predator is seen; others produce distasteful chemicals or have a protective or armoured outer covering to reduce the likelihood of a predator eating them. A widely used tactic is to limit the chance of being seen by a predator by either keeping very still or blending in with their background: this is commonly seen in insects such as stick insects, moths, etc..

In this practical each subject will be a 'predator' and try to detect 'prey', which in this case are coloured pasta spirals.

Method

Obtain a pack of multi-coloured pasta spirals (*Fusili tricolori*) from a local supermarket: a pack of 500 g should be sufficient for a class activity. Cook the pasta in boiling water for the recommended time, drain and allow to cool. [If you cannot find a pack of multi-coloured spirals then buy a pack of egg pasta and two vegetable dyes, one green and another colour, such as red. Divide the pasta into three and put each third into a separate pan. During the cooking add the dye to the water (i.e. the green dye to the first third, the red dye to the second third and the last third remains undyed), then drain and allow to cool.]

When the spirals are dry, put 60- 20 of each colour- into a container and shake to mix the colours thoroughly. Mark out a 10 m x 10 m square grid on the school/college sports field and then scatter the pieces of pasta, without any conscious bias, inside the grid. The first subject can then be brought to the grid and the standardised instructions can be read to them. [These could be: "Inside the grid are 60 pasta spirals. We would like you to find as many as you can in 30 seconds. When you find one, please put it inside this container. Do you understand?".] Repeat this procedure until you have used a reasonably large sample of students, 20-30 should be sufficient.

Tabulate your findings by recording the percentage of each colour found by each student. You can graphically represent the data and also determine the mean percentage discovered for each colour. What can you conclude from your results?

NOTE: You could carry this investigation further quite easily. You could try a selection of different colours to determine which are easily detected and which are not. You could compare the performance of 15 subjects who are shown the colours they could find, with 15 subjects who are simply told there are 60 pieces of pasta somewhere inside the grid: this is in order to give the first group a "search image" for their prey. You could try and select colours that mimic the colours of flowers on the field: if daisies are abundant, try green, yellow and white.

Using the same basic idea of searching for prey, could you devise an investigation that would be suitable for a study of animals in the field?

CARRYING BEHAVIOUR

Carrying is an every day activity: people carry babies, shopping, luggage etc.. The style of carrying items can vary from culture to culture e.g. compare the styles of carrying shopping from supermarkets in UK and USA. In schools and colleges, students carry books and files and this provides the focus for this investigation. Do female and male students carry books and files in different ways?

Spottswood and Burghardt (1976) studied carrying and they found that although females and males carried in different ways there was no significant difference between the sexes with regard to their grip strength or the weight of books they carry.

Hanaway and Burghardt (1976) thought that the difference between male and female carrying styles was explained by social modelling and that males were under greater peer pressure to use only masculine methods than are girls to use feminine methods. They also believed that comfort was important: females could find some carrying methods uncomfortable, largely due to their wider hips.

Jenni (1976) found that males are more likely to be ridiculed if they carry like females, than females are if they carry like males. She also believed that females use more symmetrical body positions than males and that symmetry suggests a less relaxed body posture. Social pressure may encourage females to use symmetrical positions.

Jenni and Jenni (1976) investigated the book carrying styles of students in four countries. They identified two styles of carrying which were associated with each sex viz. Type I, usually used by females, Type II by males. The methods commonly associated with each style are illustrated in Figure 1.

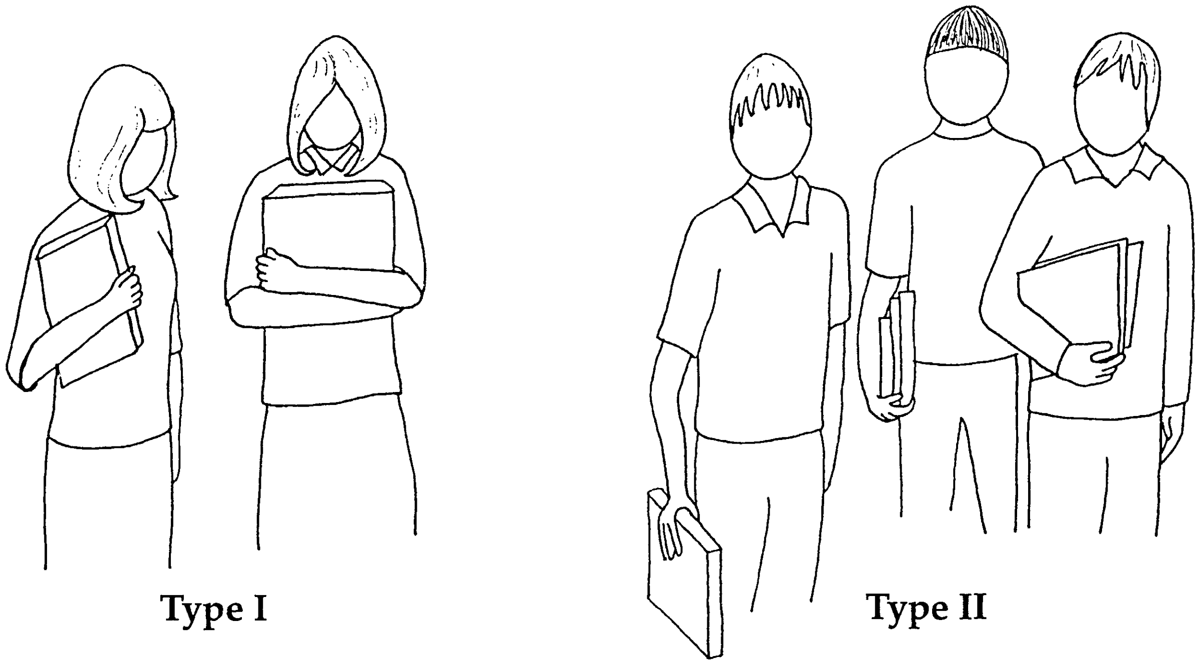

Figure 1

Type I and Type II carrying styles.

Data from one American location showed that 92% of college (university) females used the Type I style of carrying and 95% of college males used Type II. This illustrates how strong this difference is. Jenni and Jenni also measured the ratio of hip width to shoulder width. Females have a higher ratio and their arms do not hang vertically. This may affect their carrying style. Females also have a 'shelf' at the top of their hips on which an object could be rested to support its weight. One of the most fascinating of their findings was that females will regularly use Type II styles when they are younger but around the age of 8-9 years they begin to change to the Type I style and most are using this by the age of 16-18 years. They believe social modelling is important in explaining this change.

In this study you can use the Jenni and Jenni styles and investigate the forms of carrying shown by students in your school/college. [You could also investigate the forms used by your staff, to see if there are age differences in the forms that the two groups use.] This is the aim of the study viz. to determine if there are differences in the carrying styles of female and male students. An appropriate null hypothesis to test would be 'there will be no significant difference in the number of female and male students carrying books using the Type I and Type II styles'.

This will be an observational study and you will need to conduct the observations in an unobtrusive manner i.e. without the subjects knowing their carrying style is being observed. The type of sample you will use is likely to be either a systematic sample or an opportunity sample. It would be important not to record a student more than once and it would be a good idea to make your observations on occasions when students are in small discrete groups, for example, at times of registration. Obviously the ideal would be to record the carrying styles of as many students as possible, but in reality you should aim for at least 30 females and 30 males. Also, try to keep to a narrow age range, for example, sixth form students, since age may be influential. You will also need to ensure that all observers record the behaviour when the students are carrying only books or files.

The data collected in this study will be in the form of frequencies, i.e. the number of people who are carrying in the Type I style or the Type II style. Bar charts will be appropriate if you wish to represent the data graphically. For the statistical analysis of the data the chi-squared test would be suitable.

You may find that your results will be similar to those of Jenni and Jenni but you may find that your results differ. Perhaps you will find that the female students are more likely to carry in Type II styles, or at least equally likely to use both styles. This may not be the same for male students.

You will need to be aware of the limitations of the study, however. You have only observed their carrying style once, is this their typical style? You have not been able to control the weight or size of the books the students carried. If they were carrying objects in both hands, this may be influential. The environmental variables may be influential, for example, the air temperature may determine the carrying style. Were the subjects alone when they were observed? If not, then their carrying style could be influenced by their friend or acquaintance: often two people show symmetry in body positions when they are talking.

Finally, you might try to think of how you could investigate carrying behaviour experimentally, rather than relying on observation, since the conditions could be more easily controlled.

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Hanaway, T.P. & Burghardt, G.M. (1976). The development of sexually dimorphic book-carrying behaviour. *Bull. Psychon. Soc.*, 7, 267-270.

Jenni, D.A. & Jenni, M.A. (1976). Carrying behaviour in humans: analysis of sex differences. *Science*, 194, 859-861.

Jenni, M.A. (1976). Sex differences in carrying behaviour. *Perceptual Motor Skills*, 43, 323-330.

Spottswood, P.J. & Burghardt, G.M. (1976). The effects of sex, book weight and grip strength on book carrying styles. *Bull. Psychon. Soc.*, 8, 150-152.

PROJECTS

MATE PREFERENCES IN *DROSOPHILA* FRUIT FLIES

David Fawcett, Hills Road Sixth Form College, Cambridge

Abstract

To investigate the importance of mate choice in *Drosophila* fruit flies, various crosses were set up giving individuals choices of red-eyed or white-eyed mates. Both males and females seem to show mate choice, though not in the same way. However, other explanations of the results of this project are possible.

Background

In many species individuals do not mate randomly, but select mates according to certain criteria. Often, females are more choosy than males about their mates.

Aim

To investigate mate choice in *Drosophila* fruit flies.

Methods

Various *Drosophila* crosses were set up in which either males of a single phenotype were presented with a choice of females of different phenotypes with which to mate, or females of a single phenotype were presented with a choice of males of different phenotypes. The phenotypes used were white-eye and red-eye. This trait is known to be due to a single, sex-linked gene, which allows predicted ratios to be calculated on the assumption that no mate choice operates. Standard *Drosophila* breeding techniques were used and F_1 or F_2 individuals identified and counted. Each cross was replicated a total of four times and only pure-bred individuals were used in the parent crosses.

Results

A number of different crosses were carried out. In a breeding bottle containing two red-eyed males with two red-eyed females and two white-eyed females, the following ratio of offspring were produced (summed over three replicates, the other replicate having failed):

143 red-eyed females

0 white-eyed females

101 red-eyed males

25 red-eyed males.

As expected, the ratio of males to females is not significantly different from 1 : 1. However, the ratio of red-eyed males to white-eyed males in significantly different from the 1 : 1 we would expect in the absence of mate choice, being instead close to 4 : 1.

One initial explanation for these findings is that the males are four times more likely to mate with the red-eyed than with the white-eyed females. However, closer inspection of the results shows that in each of the replicates both red-eyed and white-eyed males were produced. In other words, at least one of the white-eyed females mated in each bottle. One possibility is that each male *Drosophila* mated with more than one female, but passed fewer of its sperm to white-eyed females, resulting in white-eyed females having fewer offspring. Another possibility is that the males did not show mate choice, but that white-eyed females simply produced fewer offspring than red-eyed ones. This possibility was not investigated in this project, but could have been.

In separate crosses, results were found which were consistent with the conclusion that white-eyed males were six times more likely to mate with red-eyed females than with white-eyed ones. However, white-eyed females were six times more likely to mate with white-eyed males than with red-eyed ones.

ENVIRONMENTAL FACTORS AFFECTING HONEYBEE AND BUMBLEBEE ACTIVITY

Ruth Schofield, Hills Road Sixth Form College, Cambridge

Abstract

The effect of various environmental variables on honeybee and bumblebee activity was studied over three weeks. Both honeybees and bumblebees were affected by temperature and wind speed, but in different ways.

Background

Though invertebrates, both honeybees and bumblebees are able to control their body temperature to some extent. Anecdotal evidence suggested that their activity might be affected by various physical factors such as temperature.

Aim

To investigate the way in which physical factors of the environment affect the activity of honeybees and bumblebees.

Methods

Observations were made daily at 3 p.m. for a period of 20 days and every two hours from dawn to dusk on four days. On each occasion, the observations were carried out close to a single, artificial honeybee hive situated in a large garden. The following environmental data were collected: wet and dry shade temperatures, light intensity, wind speed, presence or absence of rain, extent of cloud cover. The honeybees were then observed for five minutes and the number entering and leaving the hive counted. Finally, a 'bee-walk' was conducted round a standard 65 m trail in the garden and the number of bumblebees counted. Statistical analysis was carried out on a microcomputer using partial regressions. Graphs to relate the number of bees to variations in significant environmental variables were plotted using second order polynomial curves.

Results

The main findings were that:

- the greater the temperature, the greater the number of honeybees seen
- the number of bumblebees seen peaked at a temperature of about 16°C
- the less wind, the greater the number of honeybees seen
- the number of bumblebees seen peaked at a wind speed of about 4 on the Beaufort Scale
- thunder, lightning and heavy rain resulted in neither honeybees nor bumblebees being seen.

THE EFFECTS OF CAFFEINE ON REACTION TIME

Nicky Foster, East Norfolk Sixth Form College

Abstract

To investigate the effect of caffeine on speed of reaction, the reaction times of volunteers were measured before and after drinking coffee. Caffeine increased the speed of reaction.

Background

Caffeine is a stimulant, enhancing the electrical activity of spinal neurones. It is well known that caffeine counteracts the effects of fatigue on various kinds of performance.

Aim

To test whether caffeine speeds up the body's reaction time.

Methods

The amount of caffeine in various coffees (instant, decaffeinated, filter) was determined using a continuous flow solvent extraction apparatus with 1,2-dichloroethane as the solvent.

A computer program was written to enable a subject's reaction time to either a visual or an auditory stimulus to be determined to the nearest millisecond. In each case the subject had to tap the keyboard as soon as possible after detecting the stimulus. Each subject was given a trial run in order to familiarise them with the experimental set-up and ensure that any subsequent changes in reaction times were not due to increasing experience. They were then tested three times: (a) before; (b) ten minutes after drinking a standardised amount of coffee (with milk and sugar to taste); (c) one hour after drinking the coffee. Subjects were given one of three different strengths of coffee. Although subjects knew they were drinking coffee, they were not told how much caffeine they were consuming. All tests were fully replicated.

Results

A large amount of data were collected from both male and female subjects with a wide range of ages (16 to 44 years). Results were analysed by analysis of variance. The consistent, statistically significant finding, was that caffeine increased most subjects' speeds of reaction. The mean reaction times are shown in Figure 1.

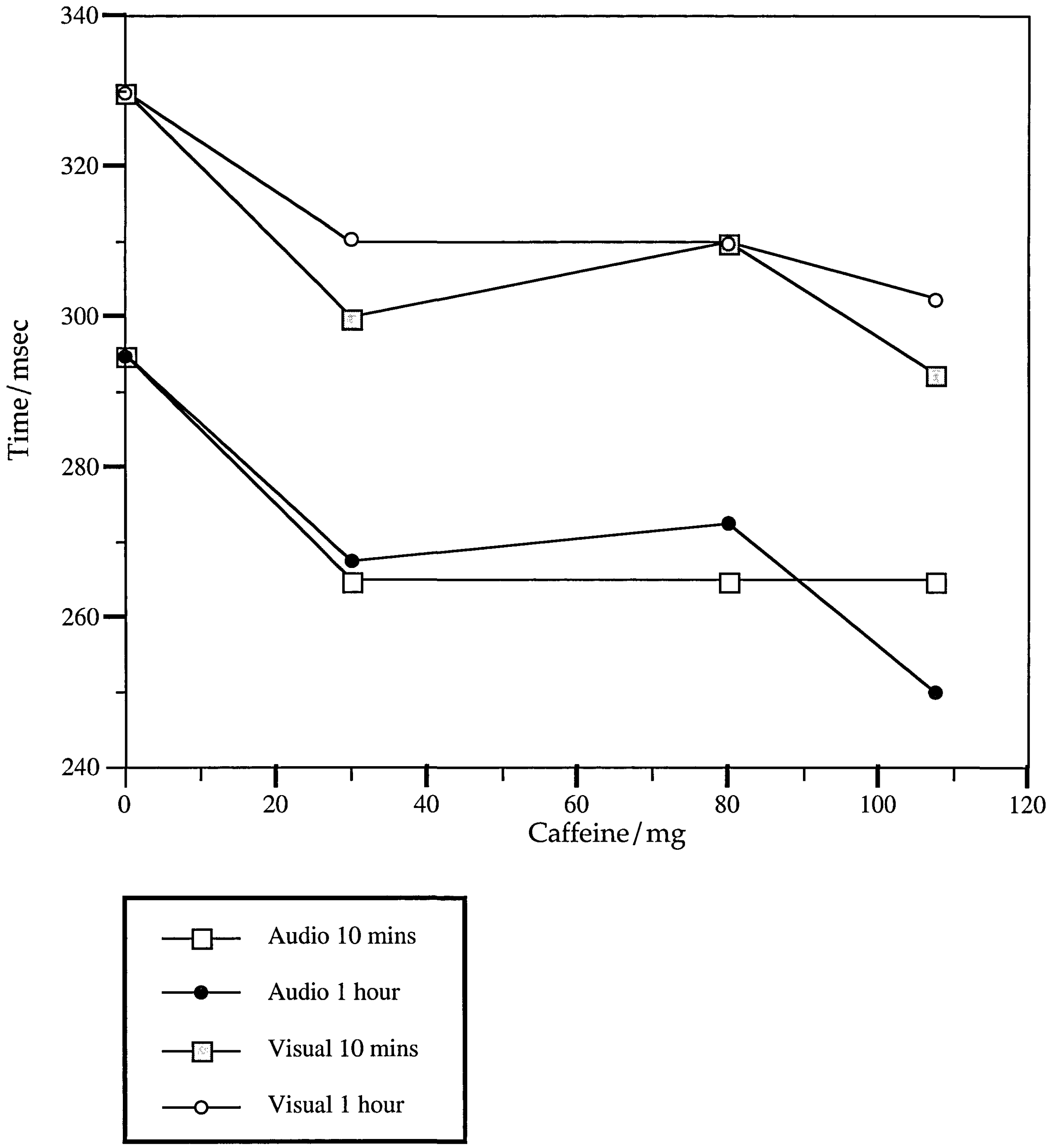


Figure 1
Mean reaction times.

OUTLINE PROJECTS

Foraging behaviour of butterflies

What factors affect the foraging behaviour of different species of butterflies? How important are temperature, cloud cover and time of year? How far do individual butterflies fly between feeding visits? For how long do they feed at each stop? What strategies do butterflies employ when they feed at a flower with a long spike, such as rosebay willowherb?

Rest-site selection of moths

The moths need to be caught in a trap or at a light and they can be released into a tank (an aquarium would be fine) with different substrates (you could try sand, soil, leaves, white paper, black paper, coloured paper, bark, etc. - of course, the moths could also alight on the glass walls of the tank). When you release them into the tank, record which substrate they select as their resting position. Does the substrate relate to their wing colour? If disturbed into flight, do they return to the same substrate? Do they adjust their position on landing? Do they change their resting site if a narrow beam of light is shone on them? Does the moth fold its wings over its body when it is at rest? Are the hind wings visible when the moth is at rest? What is their rest-site selection when you release the moths in the wild after your studies?

Reproductive behaviour in dungflies

Find a field in the summer with cattle in it. Observe the behaviour of yellow dungflies (*Scathophaga stercoraria*) on or near cowpats. The males are covered in a dense golden fur; the females are duller and greenish. How long do they mate for? Are there differences in the behaviour of males and females at cowpats? Do males mate with more than one female? Do females mate with more than one male? What happens after a pair of dungflies has finished mating? What age of cowpats are preferred? (A dab of paint on the thorax of the fly will help to identify individuals and make it easier to check if a fly has mated more than once.)

Maternal behaviour in mallards

In spring many aquatic habitats (ponds, canals, etc.) have breeding mallards. If possible, find (without disturbing them) nests before the eggs have hatched. Do both sexes brood the eggs? How many offspring hatch? How long does hatching of the clutch take? Keep a daily record of such things as number of surviving chicks, calling behaviour of mother, calling behaviour of chicks, distance of chicks from mother, etc..

Grooming behaviour in house sparrows

Which parts of its body does a house sparrow groom with its beak? Which parts of its body does it groom with its feet? Do individual birds have a preference for using their left or right foot? How do they clean their beaks? What happens when a house sparrow takes a dust bath? Do house sparrows use water baths? If possible, use a camcorder to video grooming movements (which are very rapid) and play back repeatedly for analysis.

Vigilance behaviour in starlings

Observe flocks of starlings feeding. Does group size affect the rate at which individual birds raise their heads to scan about them? What other factors affect vigilance? (For example, feeding success, time of day, presence of a nearby potential predator, time of year.) Do the starlings forage with other birds?

Behaviour of gulls

Flocks of gulls are frequently seen on school/college sports fields from July to March. They provide the opportunity for a number of different studies; three such are outlined below. Observations of behaviour can be made fairly easily provided you do not try to approach too closely: one option is to use binoculars.

a) Foraging behaviour

Are all members of the flock feeding? Does the flock break up when its members feed or does it remain a fairly cohesive unit? How long does each gull forage for before looking up to scan for danger? Do they forage into the prevailing wind, downwind or across the wind? Do they compete directly for food? How many steps do they take before they probe the grass? [A camcorder may be needed to answer this question.] How does the behaviour change when you take out any food for them? Do they exploit opportunities for food after lunch breaks?

b) Resting behaviour

What time of the day does this occur? Does it follow a foraging session? What postures do the gulls adopt when resting? [You will be able to distinguish standing, lying with head up, lying with head buried in feathers etc..] How is an individual gull aligned with respect to the prevailing wind direction? How close is a gull to its nearest neighbour? What is the time interval between an alarm call and flight? [The camcorder may help here.]

c) Arrival and departure

You will need to obtain a large scale map of the sports field, sketch it on a sheet of A4 and then make several photocopies of it to allow you to put information directly on the sketch. Try to discover the nearest known roosting sites, often lakes or reservoirs, and the nearest coastal feeding areas. From which direction do the birds fly onto the sports field? How is this related to the direction of the prevailing wind? Do they fly around the field or land straight away? Do they land in the centre of the field? Where does the first gull land? Where do subsequent gulls land? When gulls depart, do they do so singly or in groups? How close can you approach a flock before it takes off? [Ensure that this is only done **once**. If such disturbance was repeated it could affect the long term survival of the birds.] Does the flock fly to another part of the field or leave? In what direction do they leave? How is this related to the prevailing wind direction?

Diurnal rhythms in a small mammal

Small mammals, such as hamsters, gerbils and rats, exhibit diurnal rhythms. This means that their behaviour depends on whether it is light (day) or dark (night). Most small mammal cages can be modified so that an automatic monitoring device, linked to a microcomputer, records whether or not a small mammal is running in its wheel. After a few days of recording how the running behaviour varies over each 24-hour period, try putting the cage in continuous dark for a few hours. However, it must be remembered that vertebrate animals should not be exposed to conditions beyond those that they would experience under normal environmental circumstances. Most species continue to exhibit diurnal rhythms. However, the cycle length is rarely exactly 24 hours. What is it? Is it shorter or longer than 24 hours? Is it the same for different individuals? Are there differences between species? What happens when the animals are returned to natural daylight and darkness? What happens if the animals are kept in continuous light?

Foraging behaviour of domestic cats

Design a checksheet for people who have domestic cats so that they can record the predatory behaviour of their pets. Which prey species do cats catch? (You may need to confirm people's identifications.) How many prey does a domestic cat catch over a week, a month, a year? What seasonal differences are there? Are there differences between male and female cats? Is the age of the cat important? Does wearing a cat collar with a bell make a difference? How important is where the cat lives (e.g. rural, suburban, in a city)?

The sleeping substrate selected by cats

Use your family pet, or the pet(s) of a friend for this study. When you have identified the cat's usual sleeping position you can alter the conditions. Only change one condition at a time. You may have to ask your friend to record the results. What happens if you change the cat's usual substrate? [You could select a rougher texture, e.g. corrugated cardboard, a smoother texture, e.g. a silky material, a warmer texture, e.g. furry material or a colder material, e.g. a metal plate.] What happens when you move the cat's basket to a new place? [Try < 1 m away, 1-5 m away and in another room.] What happens if you move the cat's basket to a different height in the room? Put an object like a cushion in the basket just before the cat goes to sleep and observe its reaction. (This study could also be done with dogs.)

Behaviour of cats in zoos

Devise a way to record the behaviours of cats (e.g. lions, tigers, caracals) in zoos. Either compare the behaviour of two or more species, or compare the behaviour of one species in two or more zoos. Ask permission from the zoo owners before starting your project.

Sleeping behaviour of dogs

Use your family pet for this study, or else the pet of a good and close friend. Does the dog have a usual sleeping posture? Does it sleep with a toy in its basket? If so, what happens if you move it? Try playing with the dog just as it is about to go to sleep and observe its response. When does the dog usually go to sleep? How long does the dog sleep for? Does it sleep close to a radiator, fire or other source of heat? What happens to its pattern of sleep when we change the clocks in spring and summer? (This study could also be done with cats.)

Open field behaviour of animals

In an open field situation the animal is placed in a novel setting which is usually some form of arena, most coveniently circular, with walls to prevent the animal escaping. The size of the arena is not too critical but should be proportional to the size of the animal. If mammals are put into such an arena they may become stressed and so it may be advantageous to use an invertebrate like a beetle. The animal is placed in the centre of the arena which is uniformly lit, for example, from above. The observer then records how the animal behaves. How long does it remain in the centre before it moves? Does it move to the perimeter? If so, does it move in a straight line? Does it stay at the perimeter or return to the centre? [Mark out the floor of the arena so that you can describe its position - you could try two or three concentric circles.] Does the animal urinate, defecate, vocalize, etc.? Does it try to escape from the arena? When the animal is given a second trial, does it repeat the behaviour it showed before?

Vocabulary acquisition in humans

Obtain permission to get access to people of various ages, ideally from toddlers around 24 months of age through to people over sixty years of age. Devise a method to investigate how many words they understand. You might, for example, ask young children to tell you all the words they can think of that begin with the letter 'e', and then record how many they list. For older children and adults you might make a note of twenty sequential words from a dictionary (e.g. empower, empress, emprise, empty, empurple, emu, emulate, emulous, emulsify, emulsion, emunctory, en, enable, enact, enamel, enamour, enantiomorph, enantiopathy, enarthrosis, encaenia) and ask them if they can explain what each means. Or you might be able to think up a better method of your own. Try to extrapolate from your findings to calculate how large a vocabulary people have. How is this related to age, gender, education, occupation or anything else? Take great care neither to offend nor upset anyone you study.

Personal space in humans

Occupy a chair in a fairly crowded student area such as a library or common room. Vacate it and retire to a distance from which you can unobtrusively observe the chair. Measure how long an interval of time elapses before it is occupied by someone else. Now repeat the behaviour, but this time leave something on the chair, such as a scarf. How long an interval of time elapses before it is occupied by someone else? Repeat your findings. Combine them with careful recordings of how a student area fills up with people at busy times of day. Do people space out regularly or cluster? What happens in a class where everyone knows each other? What happens among strangers on a bus or train?

Altruism in humans

Altruism is behaviour that will benefit another without the donor expecting a reward. It is fairly easy to investigate altruism in the field. One technique is for one of the research team to drop a coin, as if from their pocket, as they approach a subject. Another member of the team is some distance away and carefully records the subject's behaviour. The subject might a) pick up the coin and keep it, b) pick it up and return it, c) ignore it or d) call out to the researcher that they have dropped some money. Does altruism depend on the value of the coin dropped? [Try dropping a 10 p and a 50 p coin.] Does it vary with the age or sex of the researcher? Does it vary with the sex or age of the subject? Does it vary with the location of the study? [You could compare a small town with a large city or busy rail/bus/air terminal, etc..] Does it vary with how the researcher is dressed?

Influence of music on arithmetic accuracy

Adolescents often claim that they can complete their homework more effectively if they are able to have music playing while they are working. Many adults believe that this is unlikely to be the case. You can test the claims of the two groups using a fairly simple task such as multiplication. Divide your subjects into pairs, so that each member of the pair is of roughly equal arithmetic ability. [You might wish to use a pilot study to decide this.] One member of each pair is in the group that completes the task in silence: the other member will work with music playing. [Use multiplication sums such as 4357 x 6, 2418 x 9, 3965 x 3, etc.. Have 50 such sums on a sheet of paper and give the subjects 10 minutes to complete the task.] Does the music influence arithmetic accuracy? Is the volume of the music influential? Do different styles of music influence accuracy? [Try classical, pop, folk, country and western, etc..] Does the nature of the task determine the outcome? [Try addition, subtraction, solving simple equations, etc..] This same approach could be used for a verbal task or a sensori-motor task.

Audience effects on the performance of a sensori-motor task

It has been found that if a group of subjects perform a task in front of an audience they will complete the task more quickly, or more slowly, than a group who perform without an audience. It is generally the case that if the task is complex the audience effect is negative, i.e. the subjects take longer, whereas if it is simple, the effects are positive. Draw two circles of 3.0 cm diameter, and with their centres 22 cm apart, in the centre of a sheet of A4 paper. The task is to place 40 pencilled crosses inside the circles, 20 inside one and 20 inside the other, but alternating from circle to circle. The time to complete the task is recorded. The subjects are randomly divided into two groups, one group perform in front of the audience the other group do not. If the times to complete the task differ significantly the audience has had an effect. How does the complexity of the task affect the performance? [You could make the circles much smaller to make the task more difficult.] Is the number of people who make up the audience influential? Is the status/sex/age of the audience influential? If the audience wear blindfolds does this have an effect? If the audience are in an adjacent room, but are watching the task on a video link, is the effect as strong?

DATA RESPONSE EXERCISES

CASE BUILDING IN CADDIS FLY LARVAE

Caddis flies spend the larval stage of their development in a case on the bed of a stream. Each larva spins a tube of silk and fixes to it material such as sand grains, small stones, plant stems, twigs etc. and thus the creature gains some protection.

Otto and Johansson (1995) studied the cases of one species of caddis, namely *Silo pallipes*, which adds stones to its silken case. This was a laboratory study, though the larvae that were used were collected from streams in northern Sweden. The larvae were put into a tank with either small brown trout (*Salmo trutta*) or bullhead (*Cottus gobio*) to observe the fish attacking the caddis larvae. There was only one fish in each tank, with the fish given one week in the tank before the experiments began. In each test condition, two larvae were introduced into the tank by being dropped through a vertical glass tube. On each occasion, one larva had the stones on its case intact, for the other larva the stones on the case were removed before it was put into the tank, see Figure 1.

With stones *Without stones*

Figure 1
Caddis cases with and without stones.

Otto and Johansson measured the width of each caddis case before an experiment began and the mass of the larva at the end. A graph representing some of their data can be seen in Figure 2.

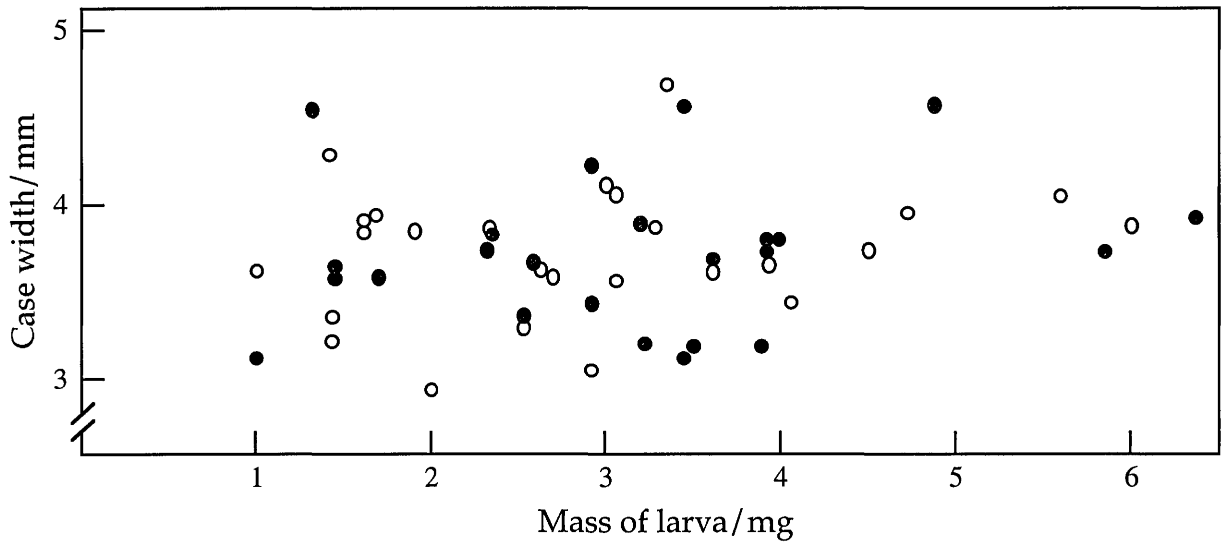


Figure 2
Case width of larvae constructing their cases
with bullfish in the tank (o) and without bullfish in the tank (•)
Mass of larva given as 60°C dry weight.

1. Suggest **two** reasons why it would be difficult to carry out this study in the field. In each case, explain your suggestion. (4)

2. Why do you think they used larvae collected from streams in their studies? (1)

3. Why do you think the two larvae used in each separate experiment were introduced into the tank through a vertical glass tube? (2)

4. From Figure 2, determine the range in width of most caddis cases. (1)

5. What does the scatter of points in Figure 2 seem to suggest regarding the mass of larvae and the width of their cases? (2)

6. Suggest **three** advantages for a caddis larva of having its silken case covered with small stones. Explain each of your reasons. (6)

7. If a caddis larva was to make a case that was two or three times the usual width, what effect might this have on their predators such as bullhead fish? (2)

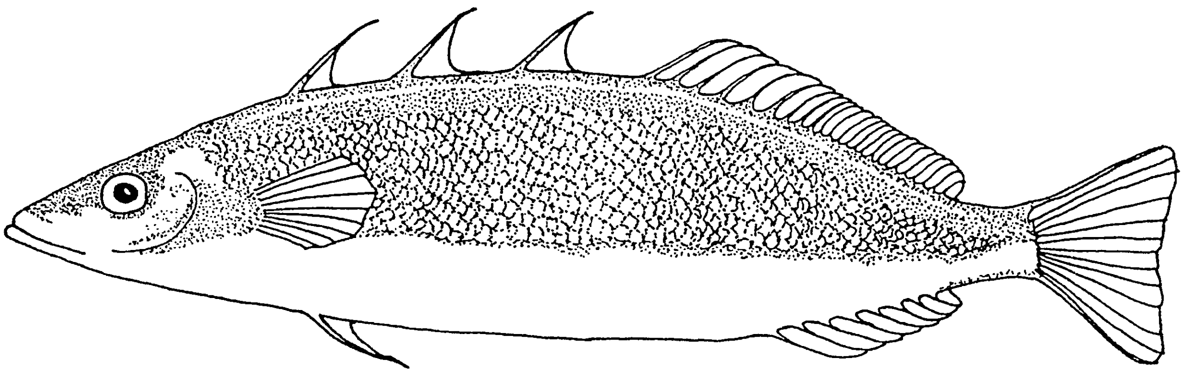
8. Why don't caddis larvae build cases that are two or three times the normal width? (2)

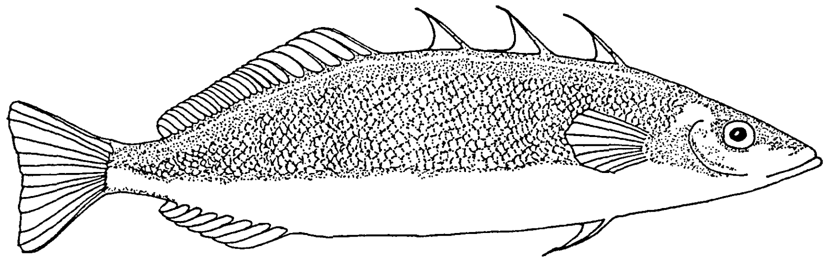
Reference

Otto, C. & Johansson, A. (1995). Why do some caddis larvae in running waters construct heavy, bulky cases? *Animal Behaviour*, 49, 473-478.

BODY SIZE AND DOMINANCE IN STICKLEBACKS

Sticklebacks (*Gasterosteus aculeatus*) are small fish that are commonly found in freshwater streams in Britain. The males are territorial and construct a nest on the bed of a stream within their territory. They then try to attract a female to lay her eggs in the nest. After eggs have been laid, the male fertilises them. He is then solely responsible for the care of the eggs and the young fish when they hatch. Without a territory a male is not able to breed and so it is vital to claim and hold one. Males will compete for a nest site if space is limited and thus aggression is shown between males in contests over territory.





In his study, Rowland (1989) set out to investigate if body size was influential in determining which of two males was dominant in territorial competition. As well as measuring the length and mass of each fish, Rowland also measured the aggressive state of each male before it was put into a tank with the other male. To assess aggression Rowland put a test fish in full breeding condition into a glass flask, placed the flask into the tank of each fish in the study and recorded the number of bites each male directed towards the test fish. The data relating to the paired contests between males are illustrated in Table 1.

Dominant male			Subordinate male			
Standard length/mm	Weight/g	Bite rate	Standard length/mm	Weight/g	Bite rate	Weight ratio
52	2.07	20	46	1.09	47	1.899
56	2.35	na	50	1.46	146	
57	2.36	31	50	1.52	119	1.553
54	1.86	59	60	2.65	41	1.425
54	2.13	127	49	1.56	66	1.365
55	2.24	138	53	1.69	197	1.325
54	2.14	63	48	1.62	35	1.321
54	1.94	56	50	1.52	44	1.276
58	2.41	na	52	1.96	na	
54	2.11	26	52	1.75	66	1.206
52	1.64	96	55	1.95	116	1.189
55	2.01	50	52	1.69	32	1.189
55	2.17	7	53	1.83	51	1.186
55	1.87	20	50	1.59	46	1.176
51	1.67	70	54	1.95	103	1.168
52	1.91	170	50	1.66	142	1.151
54	1.92	36	53	1.67	47	
53	1.87	74	52	1.63	97	1.147
55	2.08	118	52	1.82	60	1.143
52	1.89	102	53	2.14	58	1.132
52	1.66	5	49	1.47	5	1.129
54	2.02	58	53	1.84	75	1.098
53	1.82	49	54	1.98	6	1.088
54	2.13	77	53	1.96	201	1.087
55	1.88	110	54	1.76	54	1.068
53	1.83	157	54	1.94	105	1.060
54	1.77	36	51	1.67	34	1.060
55	1.92	20	52	1.82	30	1.055
55	2.10	44	55	2.16	41	1.029
53	1.81	84	52	1.77	110	1.023
53	1.83	166	54	1.87	78	1.022
57	1.96	10	55	1.92	109	1.021
55	1.95	98	55	1.99	152	1.021
54	1.99	176	57	2.01	0	1.010
52	1.71	47	51	1.71	47	

[na: data not available]

Table 1 Results of territory contests listed by descending order of weight ratio for each contest.

1. Draw a scattergraph to show, for the first ten dominant males, how their weight relates to their standard length. (3)

2. What trend is evident from the scatter of points? (1)

3. Males 4 and 8 seem to be lighter, for their length, than the others. Suggest **one** reason why this may be so. (1)

4. Calculate the mean, median and modal value of the bite rates of the subordinate males. (3)

5. Calculate the ranges in the bite rates for both groups of males. (1)

6. Calculate the weight ratios for the male pairs 2, 9, 17 and 35, which are missing from the weight ratio column in Table 1. (2)

7. Rowland selected males randomly when pairing off the males. Why is random sampling a preferred method for taking samples? (1)

8. Name **one** other type of sampling method and explain how this method would be used in an investigation. (2)

9. Rowland found that: i) dominance was positively correlated with weight ratio; ii) dominance was not correlated with bite rate. Explain what these two findings mean. (2)

10. Suggest **one** reason why Rowland's method of assessing aggression may not be a real measure of the aggressive state of a fish. (1)

11. Briefly outline **three** advantages to carrying out behavioural studies in the laboratory rather than in the field. (3)

Reference

Rowland, W.J. (1989). The effects of body size, aggression and nuptial coloration on competition for territories in male threespine sticklebacks, *Gasterosteus aculeatus. Animal Behaviour*, 37, 282-289.

FEMALE CHOICE IN AN AUSTRALIAN FROG

Robertson (1990) investigated how females choose a mate in one species of Australian frog (*Uperoleia laevigata*). As with most animals, males compete for opportunities to mate with females. To attract the females, male frogs call from the bank of a pond. The females select the male they wish to mate with on the basis of his call, since a male's call indicates its size i.e. its mass. It seems that females prefer males whose body mass is approximately 70% of their own. After selecting the male, the female allows him to mount her and then she carries him to the pond. She will support his weight on her back throughout the egg-laying phase, which is usually 4-7 hours. A female will select a reasonably large male in order to obtain sufficient sperm from him to fertilise her eggs. However, she does not want to select a male who is too big, otherwise she will find swimming and egg-laying difficult.

In this laboratory study, Robertson took gravid females (i.e. females with eggs) and put them in a circular arena (1.5 m diameter) between two loudspeakers. Each female was tested alone in the arena. One speaker played back the calls of a real male whose mass was approximately 70% of hers. The other speaker played back an artificial call which was of a frequency that was either higher or lower than the predicted frequency (the predicted frequency being equivalent to a male with a body mass that was around 70% of the female under test). The two speakers were mounted in the walls in the side of the arena. When the apparatus was set up, the female frog was placed in a cage in the centre of the arena and left for 5 minutes. After 5 minutes the cage was removed and Robertson recorded which speaker the frog hopped to.

Table 1 records the responses of 25 gravid females and Figure 1 is a graph of female weight plotted against male weight.

Preference totals	**Totals**
Higher frequency (lighter male)	1
Predicted frequency (male 70% of female mass)	22
Lower frequency (heavier male)	2

Table 1 The responses of 25 gravid females to two calls, one equivalent to a male weighing 70% of the female under test (the predicted frequency) and the other, a randomly selected call, which was higher or lower in frequency.

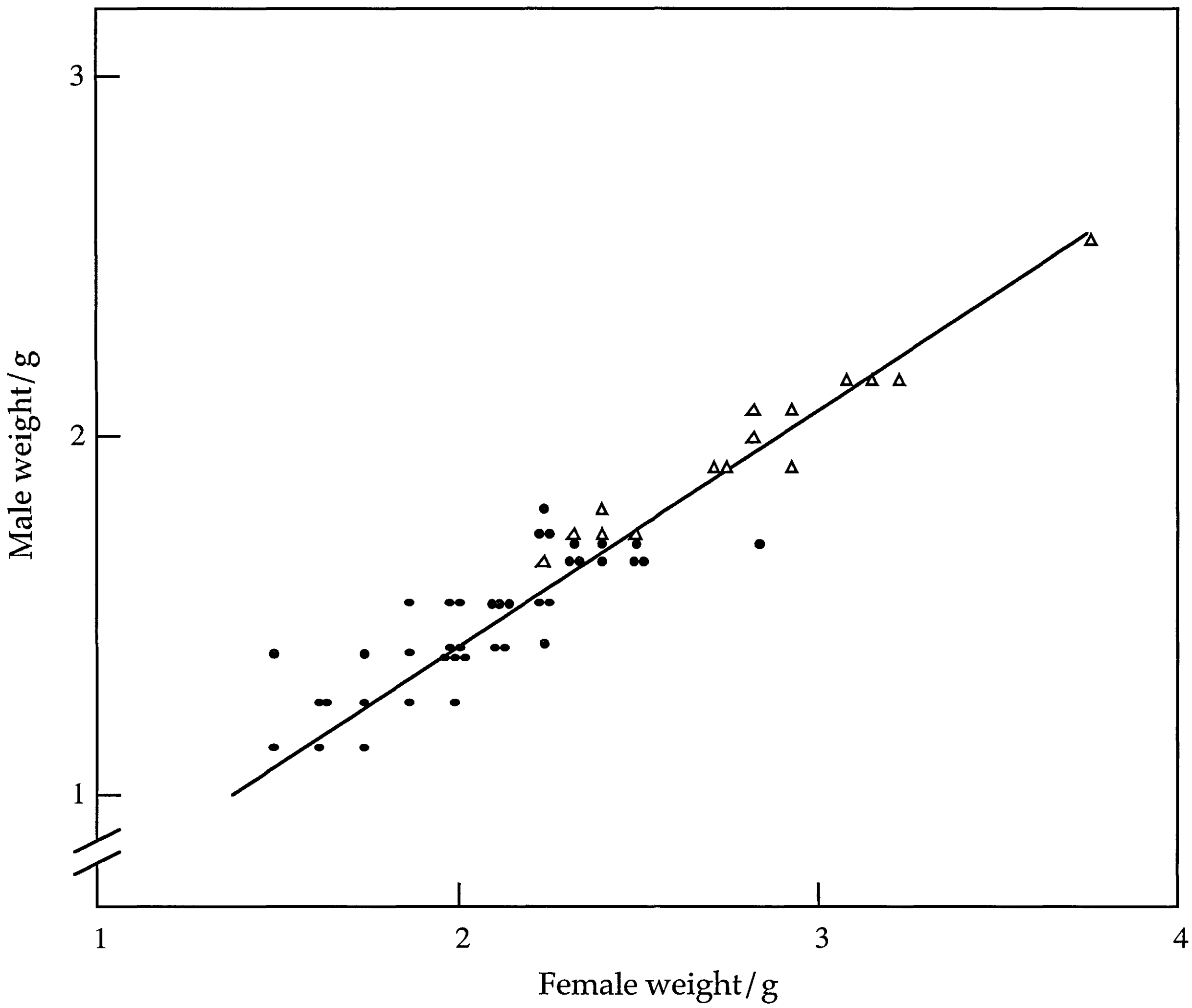


Figure 1

The weights of mating pairs in 1979-1981 (Δ) and 1985-1986 (•). The line is fitted along points at which male weight is equivalent to 70% of the female weight.

1. Why do you think Robertson used a circular arena in this study and where do you suppose the two speakers were mounted in the walls of the arena? (2)

2. Why was the female placed in the centre of the arena and why did Robertson wait five minutes before releasing her from the cage? (2)

3. If a female frog had a mass of 3.20 g, what is likely to be the mass of the male frog she would select for her mate? (1)

4. Describe the trend that is evident in Figure 1. (2)

5. Using the same axes as those in Figure 1, draw a sketch of a graph that would indicate no correlation between female weight and male weight. (1)

6. Draw a bar 10 cm x 1 cm. Using the data in Table 1, divide the bar into three sections to represent the percentage of females who preferred a male of higher, predicted or lower frequency. (1)

7. What percentage of females did not respond to the predicted frequency? (1)

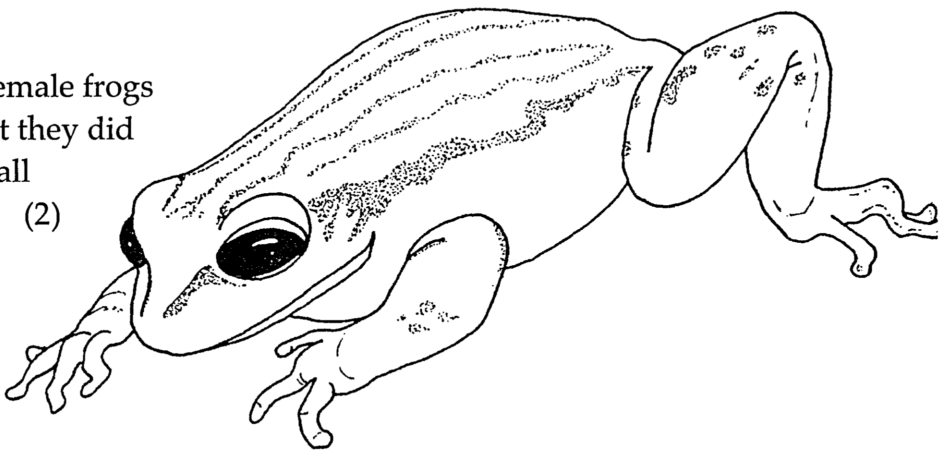
8. What might explain the fact that not all females selected males whose body mass was 70% of their own? (2)

9. Why do you think that the female frog responds to the call of a male rather than simply hopping up to a number of males and making a visual assessment of their quality? (2)

10. What might be another potential problem for a female frog, other than impaired swimming or egg-laying, of selecting a male whose mass is equal to, or larger than her own? (2)

11. Suggest what a small, or underweight, male frog might do to increase his chance of being selected by a female as a mate. (2)

12. What tactic could female frogs adopt to ensure that they did not mate with a small male? (2)

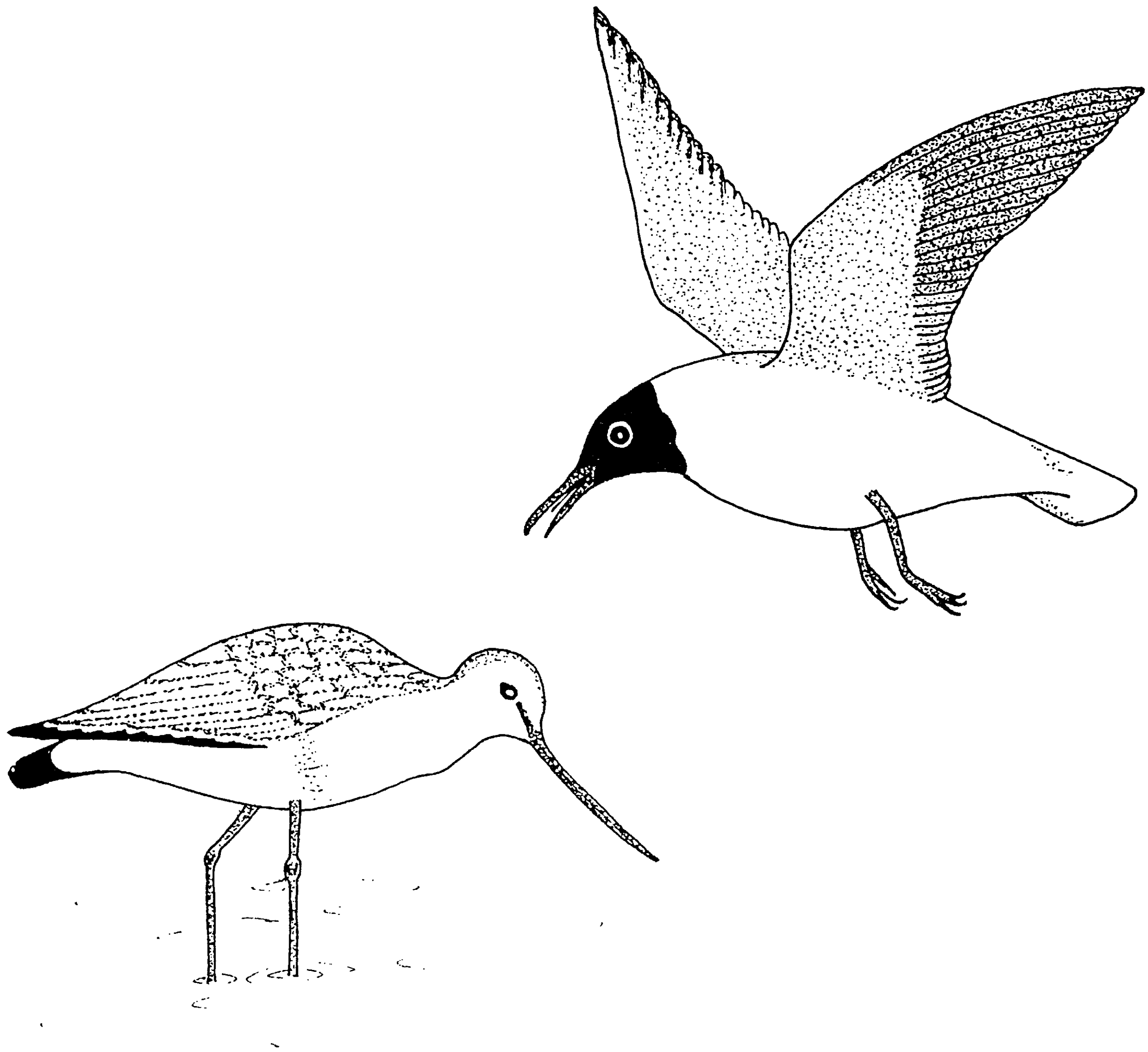


Reference

Robertson, J.G.M. (1990). Female choice increases fertilisation success in the Australian frog, *Uperoleia laevigata*. *Animal Behaviour*, 39, 639-645.

TACTICS OF ROBBING GULLS

Black-headed gulls (*Larus ridibundus*) have been observed to kleptoparasitise a number of other bird species. Kleptoparasitism occurs when one bird steals the prey / food found by another bird: kleptoparasitism can also be referred to as piracy.



A study of kleptoparasitism involving black-headed gulls was carried out by Amat and Aguilera (1990) in South West Spain in the Donana National Park. They noted attacks by black-headed gulls on several species of water birds, namely little egrets (*Egretta garzetta*), black-winged stilts (*Himantopus himantopus*) and black-tailed godwits (*Limosa limosa*). For each attack they recorded the species finding the food, the number and age of the gulls involved (i.e. 'young' gulls < two years old and adult gulls > two years old) and the outcome of the attack (i.e. if the attack was successful or not). Some of their data are illustrated in Tables 1 and 2.

Species	Mean number present *	Number of attacks observed	% successful
Little egret	148 ± 73	172	46
Black-winged stilt	143 ± 249	100	17
Black-tailed godwit	78 ± 121	709	57

Table 1 Number of water birds, number of attacks and the success of robbing attempts by gulls.

**Mean (± standard deviation) of six censuses conducted in the winters 1983-1984 and 1984-1985.*

		Outcome	
Host species	**Age of gull**	**Successful**	**Unsuccessful**
Little egret	Young	1	10
	Adult	51	67
Black-winged stilt	Young	7	26
	Adult	6	23
Black-tailed godwit	Young	31	39
	Adult	280	206

Table 2 Outcome of attacks by young and adult gulls on water birds.

1. How many of the attacks observed on (a) little egrets, (b) black-winged stilts and (c) black-tailed godwits were unsuccessful? (3)

2. Of the total number of attacks observed, what percentage were made on little egrets and black-tailed godwits? (2)

3. Table 1 shows that the mean numbers of little egrets and black-winged stilts present are very similar but the standard deviations are not. What does this tell us about the sizes of the groups of each species of bird? (1)

4. What is the standard deviation a measure of? (1)

5. For the data relating to each of the three species, draw a fully labelled bar chart to represent the number of attacks made on each species. Then divide each bar into two, to illustrate the number of attacks that were successful and the number that were unsuccessful: use an appropriate shading technique to identify each of the two outcomes. (4)

6. Table 2 shows the outcome of attacks by black-headed gulls on wading birds and the age of the gull. For young gulls only, rank the species in terms of the success rate. (1)

7. Adult gulls seem to be very successful when attacking black-tailed godwits, quite successful when attacking little egrets and not very successful when attacking black-winged stilts. Suggest **one** tactic that gulls might use to increase their success rate against black-winged stilts and **one** tactic the black-tailed godwits might use to reduce the success rate of the gulls. In both cases, explain your reasoning. (4)

8. How do you think the size of the prey found by these wading birds might be related to the success of the gulls in robbing them? (2)

9. Identify **two** factors, apart from the age of the gull and the species of the bird chased, that might determine the outcome of an attack by gulls. (2)

Reference

Amat, J.A. & Aguilera, E. (1990). Tactics of black-headed gulls robbing egrets and waders. *Animal Behaviour*, 39, 70-77.

PARENTAL CARE IN BLACKBIRDS

Most bird species build nests in which eggs are laid and the young reared. Often both parents feed the young once they have hatched. Figure 1 shows a female blackbird returning to the nest with insects which she will feed to the offspring. When a parent bird returns to a nest with food, the young birds generally gape as wide as they can (as seen in Figure 1) and make loud cheeping noises.

Figure 1
Female blackbird returning to the nest.

1. How many offspring are visible in Figure 1? (1)

2. Many birds species build new nests each year; some use the same nests year after year. Suggest **two** advantages and **two** disadvantages to a pair of birds in using the same nest in successive years. (4)

3. From the point of view of an individual young bird, explain the advantage of gaping widely and making loud cheeping noises. (2)

4. From the point of view of a parent bird, suggest **one** advantage and **one** disadvantage of loud cheeping by the young. (2)

5. From the point of view of the parent bird, suggest **one** advantage and **one** disadvantage of wide gaping by the young. (2)

6. Adult male and female blackbirds can easily be distinguished by their plumage. Describe an investigation to study how the relative contributions of adult male and adult female blackbirds varies over the breeding season. (9)

PREY CAPTURE BY LITTLE EGRETS

Little egrets (*Egretta garzetta*) are fish-eating birds that can be found in Europe, Africa and Asia. Their prey can be found in streams, lakes, marshes and coastal waters. Since they are fishing from the land they need to estimate the position of their prey very carefully, having to take light reflection, light refraction and the movement of the water surface into account when lunging at a fish.

Lotem *et al.* (1991) carried out an observational study of these birds in the field at a series of ponds in a nature reserve in Israel. They made their observations between 0600-1100 and 1500-2000 hours using 9x25 binoculars. The distance of the observer from the birds varied from 10-60 m and they recorded their observations on a portable tape machine whilst in the field. Whenever an egret made a strike at a fish the observer recorded:

a) "**strike angle**" - i.e. the angle between the water surface and the line along the bill as it entered the water; they divided the angles into three groups viz. **steep**, if 70-90 degrees, **intermediate**, if 45-69 degrees and **acute**, if <45 degrees.

b) "**strike depth**" - how deeply the bill penetrated the water: they divided the depth into two classes:

shallow - not more than half the bill submerged
deep - at least half the bill submerged but below eye level.

c) "**success**" - **success** - if the prey item was seen in the egret's bill
failure - if the prey item was not seen in the egret's bill.

Some of their data are illustrated in Figure 1 on the next page.

1) Outline why it is advantageous to carry out observational studies in the field, rather than in the laboratory. (2)

2) Why is it important for researchers to provide details of how they carried out their studies - for example, in this case the time of day they made their observations, what equipment was used, how far from the birds the observers were, etc.? (2)

3) All the observations were carried out by one of the three researchers. Why might this be advantageous? (1)

4) Identify **one** problem with the measurements the researchers may have had in this study and outline how this could affect their findings. (2)

5) Rank the capture success (% of strikes) for the different combinations of angle and depth from the highest percentage to the lowest. (1)

6) What was the total number of strikes recorded and what percentage of the number of strikes were made in deep water? (2)

7) Suggest **three** factors, other than depth of water and angle of strike, that might influence how successful an egret might be. For each factor you identify, suggest how it could be influential. (6)

8) The researchers recorded their observations into a tape recorder. Suggest **two** advantages of using this piece of equipment in the field? (2)

9) What survival strategy could fish adopt to reduce the possibility of being eaten by little egrets? (2)

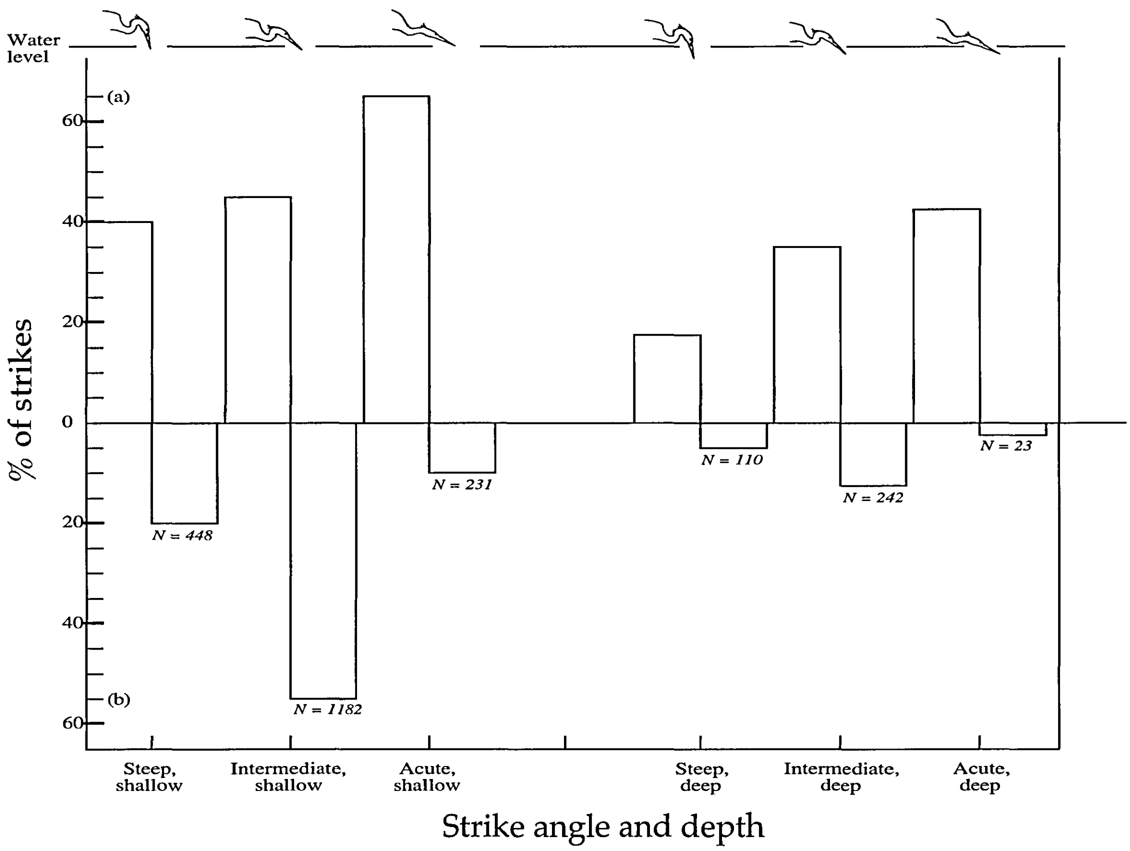


Figure 1

Prey capture by little egrets.

(a) Capture success (% of the number of strikes of the given combination of strike angle and strike depth).
(b) Frequency of use of different strikes (% of the total observed). N = number of strikes observed.

Reference

Lotem, A., Schechtman, E. & Katzir, G. (1991). Capture of submerged prey by little egrets, *Egretta garzetta garzetta*: strike depth, strike angle and the problem of light refraction. *Animal Behaviour*, 42, 341-346.

PARASITISM BY CUCKOOS

The European cuckoo (*Cuculus canorus*) is an obligate parasite. A female cuckoo never builds her own nest. Instead she lays her eggs in the nests of other birds. She waits until neither parent is present at the nest and then flies down to the nest, lays a single egg and departs. Egg laying takes only about 10 seconds, compared with the 20 minutes typical of other bird species. After laying her egg, the female cuckoo often removes one or two of the host's eggs, and then departs.

In Britain, five main host species are parasitised: dunnocks, meadow pipits, robins, pied wagtails and reed warblers (Figure 1). These hosts are all smaller than cuckoos. Cuckoo eggs are much smaller than would be expected from the size of the adult female. They usually hatch before the host's eggs, despite being laid after them. The young cuckoo waits until the host birds are absent from the nest and then pushes the other eggs (or young chicks) out of the nest. Thereafter it is fed by the host until it leaves the nest and becomes independent.

Figure 1
A reed warbler with a juvenile cuckoo.

1. Explain the meaning of the term 'obligate parasite'. (2)

2. Suggest why cuckoos lay their eggs so quickly. (2)

3. Why do you think an egg-laying cuckoo often removes one or two of the host's eggs before departing? (2)

4. Suggest **two** reasons why an egg-laying cuckoo does not remove all the host eggs. (2)

5. Suggest **two** reasons why it is advantageous for cuckoo eggs to be smaller than expected for the size of the adult bird. Briefly explain your suggestions. (4)

6. Would you expect cuckoo females to lay fewer or more eggs than other birds of their size? Explain your answer. (3)

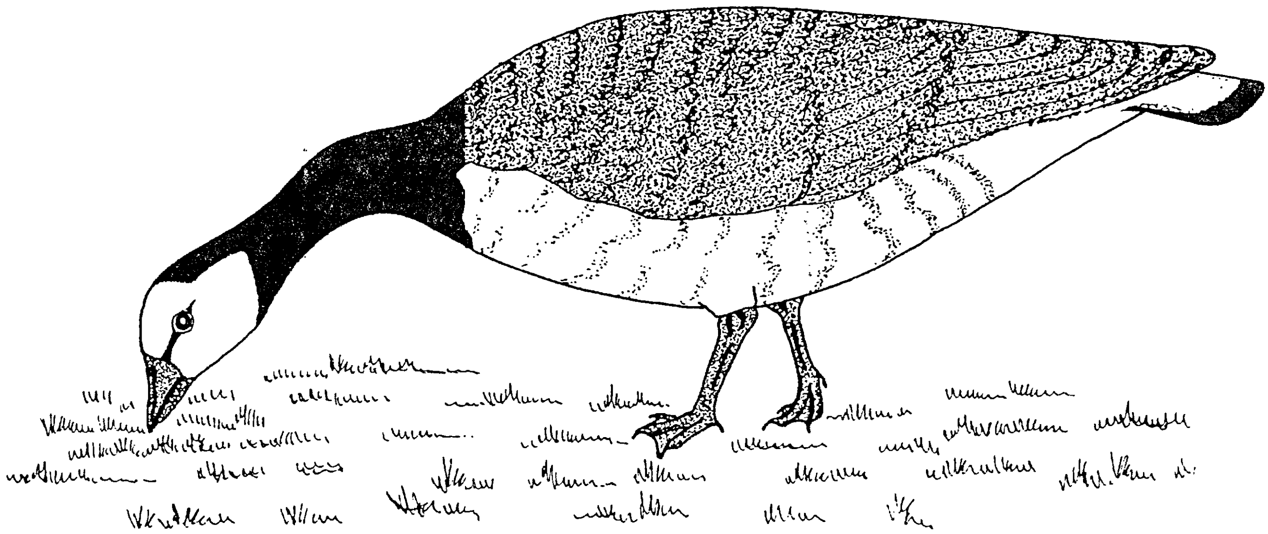
7. Explain the evolutionary advantage to young cuckoos of evicting the eggs (or young) of their hosts from the nest. (2)

8. Suggest **three** strategies that might evolve over time to enable a host, such as the reed warbler in Figure 1, to reduce the effect of parasitism by cuckoos. (3)

AGONISTIC BEHAVIOUR IN BARNACLE GOOSE FLOCKS

Barnacle geese (*Branta leucopsis*) are large birds (58-70 cm in length) with a white, black and grey plumage that is barred in appearance. They spend the winter in the UK, especially the Western Isles of Scotland and the estuary of the Solway Firth. They graze in flocks in areas of short turf since grass is the chief component of their diet. In spring they leave and migrate to their breeding grounds in Greenland and Spitsbergen.

Black and Owen (1989) investigated how the pair bonds between adults and the size of the family unit affected the social rank order in flocks of barnacle geese. Social rank is important because the higher the rank of a family, the better is the quality of the grass they get to eat. This is because social rank is linked to group size and families are more likely to be at the leading edge of a flock of feeding geese than are couples or singles. Thus there is more food available to an individual in a large flock than to one in a small flock. Large flocks show more aggression and thus protect the area in which they can forage.



This was an observational study with the recordings made from hides on a Wildfowl Reserve in Scotland. The researchers focused on agonistic encounters between geese and specifically recorded:

1) which goose won an encounter
2) how many were in each group of conflicting geese, the sexes of the individuals and their class, namely adult or juvenile.

Agonistic behaviour includes aggressive acts such as threats and fighting, together with fleeing and submission. Table 1 records the percentage of successful (winning) encounters for groups of different size. Black and Owen also recorded the intensity of the agonistic encounters: they identified four classes, namely:

a) low threat (an extension of the head and neck)

b) mid-threat (extension plus advancement of one or two steps)

c) contact (a bite or a bump)

d) chase (run after opponent).

Table 2 records the frequency of agonistic behaviour shown by parents and the type of victim which was the focus of the agonistic behaviour.

Class	Number of encounters	Number of wins	Percentage success
Single juvenile	351	37	11
Single adult	251	25	10
Pairs	714	132	
Family of three	476	304	64
Family of four	600	443	
Family of five	531	439	83
Family of six	213	188	88

Table 1 The percentage of successful (winning) encounters.

	Threat Intensity			
Victims defeated by parents	**Low**	**Mid**	**Contact**	**Chase**
Single juveniles	37	14	14	10
Single adults	20	12	3	25
Paired adults	63	48	27	32
Family offspring	14	11	6	3
Parents	25	20	15	20
Parents & offspring	2	11	1	6
Total	161	116	66	96

Table 2 Relationship between frequency of agonistic behaviour shown by parents and the status of the victim.

1. Why do researchers often use hides when making observations of the behaviour of birds? (1)

2. Researchers can also make use of video cameras in similar circumstances. State **one** advantage and **one** disadvantage of using this equipment. (2)

3. Using Table 1, calculate the percentage success of pairs and a family of four. (2)

4. What trend is evident in the success rates in Table 1? (1)

5. Why do you suppose that families of six are involved in the fewest encounters between groups of geese? (1)

6. Using the data in Table 2 and a circle with a radius of 5 cm, draw a divided circle (pie chart) to represent the proportion of chases involving each of the six groups defeated by parents. (3)

7. Why, do you suppose, do parents so rarely chase their own offspring but most frequently chase paired adults? (2)

8. What percentage of threats are (a) low, (b) mid, (c) contact and (d) chase? (2)

9. Why, do you suppose, are most threats of low intensity? (2)

10. These data show that larger groups of barnacle geese beat smaller groups in agonistic encounters. Suggest **one** factor, other than group size, that might influence how successful a group of geese may be in an encounter with another group. (2)

11. Black and Owen noticed that when barnacle geese fly into a field to graze, they tend to land in the centre and then graze towards the perimeter of the field. This is despite the fact that the edges of the field are rarely grazed and thus have a greater amount of grass available. Suggest why the geese prefer to land in the centre of the field. (2)

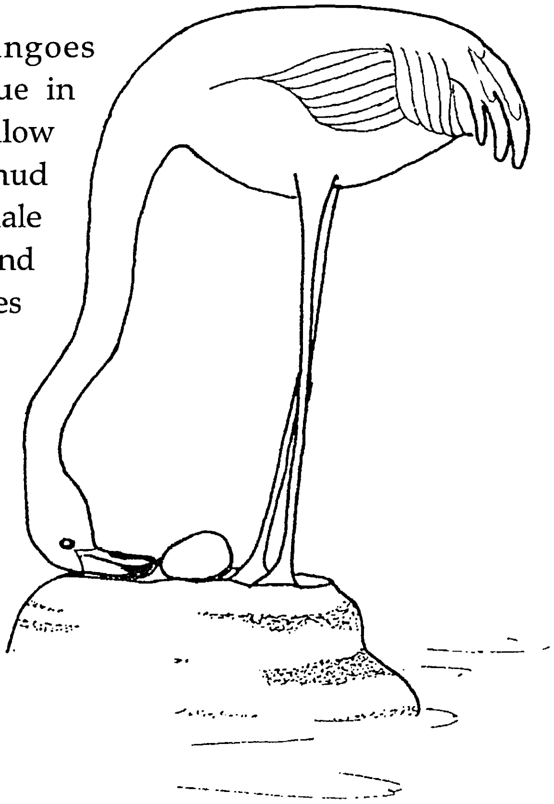
Reference

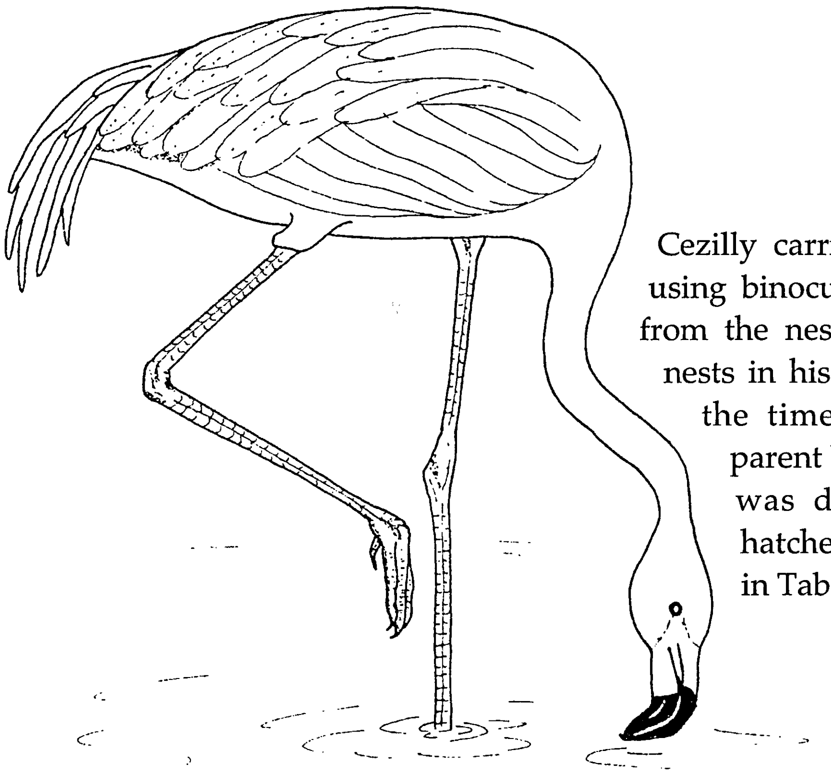
Black, J.M. & Owen, M. (1989). Agonistic behaviour in barnacle goose flocks: assessment, investment and reproductive success. *Animal Behaviour*, 37, 199-209.

NEST DESERTION IN THE GREATER FLAMINGO

In many species of birds both male and female incubate the eggs and also feed and protect the chicks. While one parent is away feeding, the other remains at the nest. It is important, however, that the two birds co-ordinate the time they spend feeding and incubating. If they do not, the sitting bird deserts the nest due to hunger and this means the eggs do not hatch or the chicks starve.

Cezilly (1993) studied greater flamingoes (*Phoenicopterus ruber roseus*) in the Camargue in Southern France. Greater flamingoes nest in shallow lakes in the area, building a conical nest from mud in which one egg is laid. Both male and female birds incubate the egg and each bird may spend several days on the nest at a time. The flamingoes feed in areas that are often a considerable distance from the nesting colony; one study recorded birds feeding 65 km from the nesting area. Flamingoes feed in water, using their bills to sieve insect larvae, small crustaceans and other small organisms from the mud and water.





Cezilly carried out his observations, using binoculars, from a tower 70 m from the nesting colony. He had 19 nests in his sample and he recorded the time of incubation of each parent bird and whether the nest was deserted or if the chick hatched. The data are presented in Table 1.

	Incubation time		
Pair	% Male	% Female	Fate
A	58	42	D
B	64	36	D
C	59	41	D
D	48	52	D
E	45	55	D
F	49	51	D
G	60	40	D
H	56	44	D
I	57	43	D
J	50	50	H
K	52	48	H
L	42	58	H
M	45	55	H
N	43	57	H
O	50	50	H
P	54	46	H
Q	47	53	H
R	49	51	H
S	44	56	H

D = Nest deserted
H = Chick hatched

Table 1 Percentage of incubation time of males and females in 19 flamingo nests.

1. In how many pairs did the female do more of the incubation? (1)

2. Calculate the difference in the percentage incubation time for each pair and then determine the median value of this set of differences in incubation time. (3)

3. Using the median value you determined in question 2, complete the table below, Table 2, which summarises how many nests that were either deserted or had chicks hatch, had differences below the median value or above or equal to the median value. The row and column totals have already been inserted into the table. (2)

Nests	**< Median**	**≥ Median**	**Total**
Deserted			9
Eggs hatched			10
Total	8	11	19

Table 2 Frequency of nests with differences in % incubation time below and above / or equal to the median value.

4. Comment on the findings in Table 2. (2)

5. Calculate the mean incubation time for males and females in the nests that were deserted and for the nests in which the chick hatched. (2)

6. Suggest **one** reason why females from nests where chicks hatched, spent more time incubating, and thus less time feeding, than females from nests which were deserted. Briefly explain your reason. (2)

7. Cezilly found that at the 9 nests that were deserted it was the female who left the nest. Suggest **two** options that such a female would have, regarding other breeding opportunities. (2)

8. Greater flamingoes nest in colonies i.e. large numbers of the same species nest in the same area close to each other. Suggest **two** advantages of this behaviour and, for each one, explain why it is advantageous. (4)

9. Identify **one** practical problem that might occur when observations are carried out from a tower 70 m from the nesting colony and suggest how the problem could be overcome or lessened. (2)

Reference

Cezilly, F. (1993). Nest desertion in the greater flamingo, *Phoenicopterus ruber roseus. Animal Behaviour*, 45, 1038-1040.

CO-OPERATION BETWEEN AN IMPALA AND AN OXPECKER

This photograph (see Figure 1), from an advertising campaign run by Schott (manufacturers of glass), shows an impala (*Aepyceros melampus*) being groomed by an oxpecker (*Buphagus erythrorhynchus*). Impala and oxpeckers are found in the savanna grassland of Southern and Eastern Africa and both animals are usually found together in groups. Impala are infested by parasites such as ticks (one estimate was that a typical impala may be carrying about 7000 ticks) and they groom themselves and each other to reduce the number of parasites. The oxpeckers also perform this service and adopt a different strategy depending on the location of the ticks. When grooming the coat of the impala they use their bill in a scissoring fashion to get the ticks; when grooming the ears they use their beak to probe the ear in a series of individual strikes. Although an oxpecker does help an impala by removing some of its parasites, the bird also takes blood from the impala if it has any open sores; the bird can obviously exploit the impala as well as help it.

Figure 1
An oxpecker grooming an impala.

1. Why are oxpeckers so called? (1)

2. The bird helps the impala by removing some of its parasites. Can you suggest **one** other advantage to the impala of the bird's behaviour and **two** advantages to the oxpecker? In each case explain the nature of the advantage. (6)

3. Why might parasites be likely to be found in the ear of an impala? (2)

4. What is the advantage of using a scissoring action when an oxpecker is searching for ticks in the coat of the impala? (2)

5. Which part of its head would an impala probably not allow an oxpecker to groom and suggest why this might be so? (2)

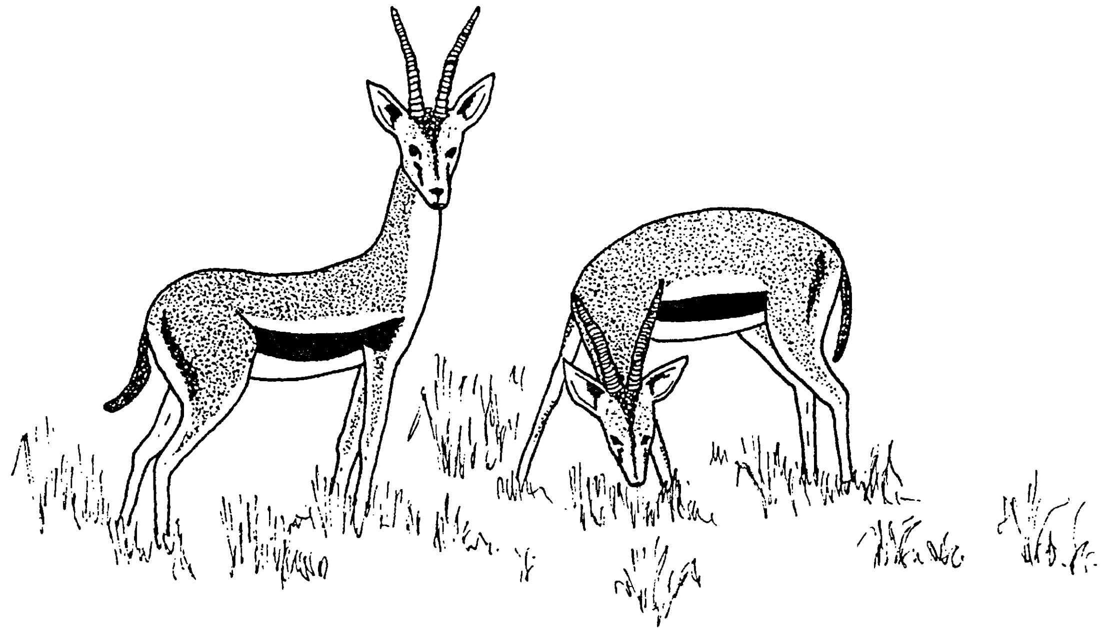
6. Suggest how the grooming of impala by oxpeckers might have evolved originally. (2)

7. Why do you think that an impala allows a bird to reduce its parasite load rather than, say, an insect or another mammal? (3)

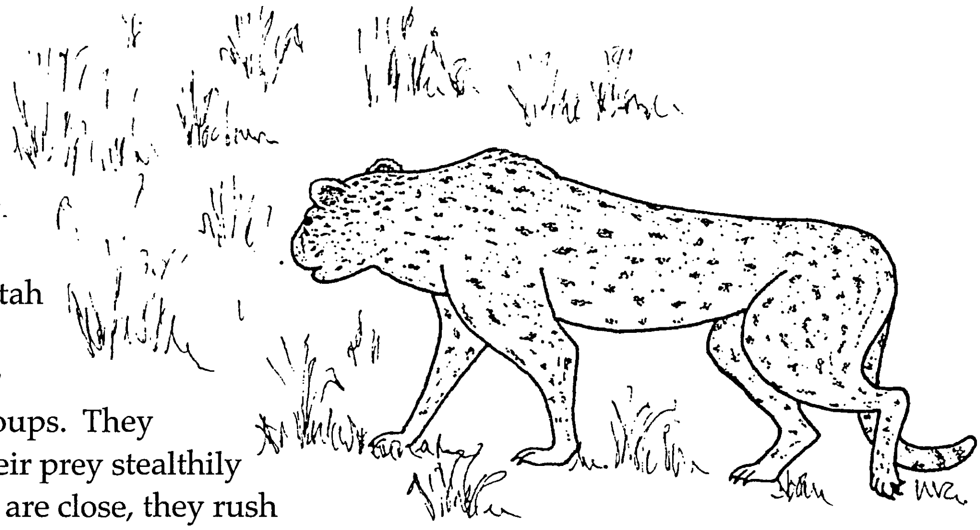
8. Can you think of another example of a bird gaining a food source from the actions of another animal? (2)

[You might like to have a group/class competition to see who can think of the most amusing caption for the photograph of the two animals.]

VIGILANCE IN THOMSON'S GAZELLES



Thomson's gazelles (*Gazella thomsoni*) are one of the principal grazers of the grasslands in East Africa. They live in groups which can vary from 5-60 animals. Their feeding is punctuated by scanning, when the gazelles look up to assess whether there are predators nearby. One of their main predators is the cheetah (*Acinonyx jubatus*). Cheetahs hunt either singly or in small groups. They initially approach their prey stealthily and then, when they are close, they rush at the victim with tremendous speed. They then either pounce on it or strike it with their paw, so bringing the animal crashing to the ground where it can be subdued and killed.



For an individual gazelle there is an important trade-off between feeding and remaining vigilant for predators. A gazelle that concentrates too much on feeding may not see a predator approaching and could be caught; one that spends too much time scanning will, no doubt, see a predator approaching and take the necessary avoidance action, but it may end up undernourished if its excessive vigilance continues for a long time.

In a study in the Serengeti National Park in Tanzania, Fitzgibbon (1989) compared the vigilance behaviour of gazelles when in a group. She concentrated on the two animals that were nearest to the cheetah when it began to stalk. She restricted her observations to two animals that were the same sex and also within 5 m of each other at the start of the hunt. Fitzgibbon recorded the amount of time the gazelles spent scanning from the moment the stalk began (when the cheetah bends its legs and keeps its head low) until the time when the cheetah began the chase. The time spent scanning was defined as the time when the gazelle lifted its head above its shoulder until it started feeding again. The data for 16 such chases are illustrated in Table 1.

Gazelle chased		Gazelle ignored	
Vigilance	**Sex**	**Vigilance**	**Sex**
8.0	M	17.5	M
31.4	M	63.0	M
40.0	M	70.2	M
15.7	M	38.8	M
40.0	M	45.0	M
35.3	M	39.1	M
31.7	M	65.2	M
68.5	M	72.5	M
81.0	M	96.3	M
49.7	M	90.1	M
62.0	M	88.3	M
72.6	M	89.9	M
10.0	F	65.0	F
78.7	F	84.2	F
52.0	F	50.0	F
23.9	F	20.5	F

Table 1 The vigilance level (percentage of time spent scanning) and sex of 16 adult gazelles which were chosen by cheetahs compared with their nearest neighbour in the group.

1. Calculate the mean vigilance level (i.e. the % of time spent scanning) for the gazelles that were chased and for those that were ignored. (2)

2. On how many occasions did the cheetah chase the more vigilant member of the pair of gazelles? (1)

3. Suggest **two** reasons why the less vigilant member of the pair is usually chased. For each reason, explain why this should be so. (4)

4. When it is stalking, what would you expect the cheetah to do when the gazelle looks up? Suggest **two** reasons why the cheetah might behave like this. (3)

5. When gazelles do detect a stalking cheetah, they usually show one of two pieces of behaviour, viz. they snort or they flee. Suggest why, on the appropriate occasion, they show each of these pieces of behaviour. (4)

6. When a gazelle does lift up its head during feeding it scans to see what other members of the feeding group are doing, as well as scanning for predators. Why would a gazelle look to see what other gazelles are doing? (2)

7. The median vigilance levels for male and female gazelles that were chased are 37.95% and 40.00% respectively. Determine the median levels for the male and female gazelles that were ignored and suggest why there is a much greater difference between these two values than between the values for the male and female animals that were chased. (3)

8. The gazelles that Fitzgibbon observed were in groups of 2-30 when they were feeding. Suggest **one** reason why it would be advantageous for a gazelle to feed in a large group, rather than a small group. (1)

Reference

Fitzgibbon, C.D. (1989). A cost to individuals with reduced vigilance in groups of Thomson's gazelles hunted by cheetahs. *Animal Behaviour*, 37, 508-510.

SOCIAL BEHAVIOUR IN LIONS

Lions (*Panthera leo*) have been studied in the Serengeti and Ngorongoro Crater, Tanzania for 30 years. Lions live in stable social groups, called prides, which usually have three to eight adult females (lionesses), their dependent offspring and a coalition of usually two to six adult males. Figure 1 shows two adult females with some of the lion cubs in a pride. Daughters born into a pride remain there for life but sons leave before they reach reproductive maturity.

The adult males in a pride may be driven away by other males. Large coalitions of males are able to remain with a pride for longer before they are driven away. If a pride is taken over by a new coalition, the incoming males try to kill as many as possible of the young cubs. As many as 25% of all lion cubs die as a result of such infanticide.

Figure 1
Female lions with cubs.

1. Given that daughters born into a pride remain there for life, explain why the adult females in a pride are often related to each other. (2)

2. Lions are one of the few species of mammals in which mothers may suckle offspring other than their own. Explain how the social structure of a pride may have led to this. (4)

3. Suggest **four** possible advantages to lionesses of living in a pride, rather than on their own. (4)

4. Suggest **two** possible disadvantages to lionesses of living in a group. (2)

5. Explain why it may be advantageous for a new coalition of adult males to kill any existing young cubs in a pride. (2)

6. Data collected over the years show that in a coalition of males some of them may be brothers but some may be unrelated. Suggest why it may be advantageous for unrelated males to co-operate in a coalition. (2)

7. Why do you think young males leave the pride, rather than remaining in it as their sisters do? (2)

8. Adult male lions are bigger than adult females and have large manes. Suggest **one** reason why males are bigger than females and **one** reason why they have large manes. (2)

USING STATISTICAL TESTS: BIOLOGY

A key question in biology is deciding which statistical test should be used to analyse any data that have been collected. There are hundreds of different statistical tests, and each makes certain assumptions. We shall concentrate on three different tests. These tests are widely used in biology and the assumptions they make are valid for many sorts of biological data.

To decide which test you want, answer the following questions.

1. **Are you interested in seeing whether there are significant differences between the means of two sets of data?**

   For example, do male and female hamsters differ in the distance they move each day, or does changing the amount of food on a bird table affect the time that birds spend at the table?

   If you are interested in seeing whether there are significant differences between the means of two sets of data, you may be able to use a t-test. Note, though, that the t-test cannot be used on percentages. You won't, for example, be able to use a t-test to see if male rats differ from female rats in the percentage of the day they spend grooming. You would, though, be able to use the t-test to see if male and female rats differ in the average amount of time (measured in minutes) they spend grooming each day.

If, however, the answer to question 1 is 'no', go to question 2.

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2. **Are you interested in seeing whether there are significant differences between ratios or proportions?**

   For example, in a flock of gulls is the proportion of immature birds near the edge of the flock, as opposed to near the centre, different from the proportion of birds in mature plumage that are near the edge of the flock?

   If you are interested in seeing whether there are significant differences between ratios or proportions you should be able to use a chi-squared test. Note, though, that the chi-squared test, like the t-test, cannot be used on percentages.

If, however, the answers to both questions 1 and 2 are 'no', go to question 3.

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3. **Are you interested in seeing whether two sets of data are correlated?**

   For example, do older people have longer reaction times, or do butterflies carry on flying later in the day the warmer it is?

If you are interested in seeing whether two sets of data are correlated, you should be able to use a correlation test.

The most sensitive test to find out if a significant correlation exists requires you to work out the Pearson product-moment correlation coefficient, abbreviated to r. Unfortunately it is extremely long-winded to calculate r, which means that you really need a calculator (or a statistical package) that works it out for you.

A less sensitive test to find out if a significant correlation exists requires you to work out the Spearman rank correlation coefficient, abbreviated to r_s. Although calculating the Spearman rank correlation coefficient is slightly less likely to reveal the existence of a correlation, it makes fewer mathematical assumptions than the test based on the Pearson product-moment correlation coefficient. So although you are less likely to conclude that a correlation exists, if you *do* conclude that one exists, your conclusion is more likely to be valid.

The test based on the Spearman rank correlation coefficient has one other advantage. This is that, as its name suggests, it can be used on ranked data. For example, you could use it to see if people are less fit if they smoke heavily, even if you can't quantify their fitness or the amount they smoke , provided you can rank their fitness and the amount they smoke.

If, however, the answer to question 3, as to questions 1 and 2, is 'no', then unfortunately we can't help you. You might like to consult a mathematics teacher or one of the books on statistics listed on pages 79 and 80. As we said earlier, there are hundreds of different statistical tests and we've only chosen three.

USING STATISTICAL TESTS: PSYCHOLOGY

One of the most difficult problems for an A Level Psychology student is to decide which statistical test should be used to analyse the data they have collected when carrying out their research projects, whether it is an experiment, an observational investigation or a correlational study. The decision is relatively easy if you consider the following four points.

1) **Are you looking for a test of difference** (e.g. have the control group and the experimental group performed differently?) **or a test of correlation** (e.g. are the two variables you have measured associated?)?

   Of course there is always some difference between the scores of the two groups, and a correlation between two variables, but the key question is, is the difference, or correlation coefficient, statistically significant? The correct test will allow you to determine if statistical significance exists.

2) **Which scale, or level, of measurement have you used in collecting the data?**

   You will need to be able to ascertain whether the nominal, ordinal, interval or ratio scale has been used. You must also realise that it is possible to change the scale. Thus data collected using either the interval or ratio scale could be converted to the ordinal or nominal scale. You should also realise that it would not be possible to convert nominal to ordinal or interval or ratio, nor can you convert ordinal to interval or ratio.

3) **Have the conditions for a parametric test been met?**

   You must be aware that there are three such conditions viz.

   a) the data should have been collected using either the interval or the ratio scale
   b) the variances of the two sets of scores should be the same/similar (this should be checked using the F test - it should be noted, however, that parametric tests are fairly robust to violations of this assumption)
   c) the two sets of scores should be normally distributed (this can be checked by drawing two histograms, one for each set of scores).

4) **Which type of experimental design has been used?**

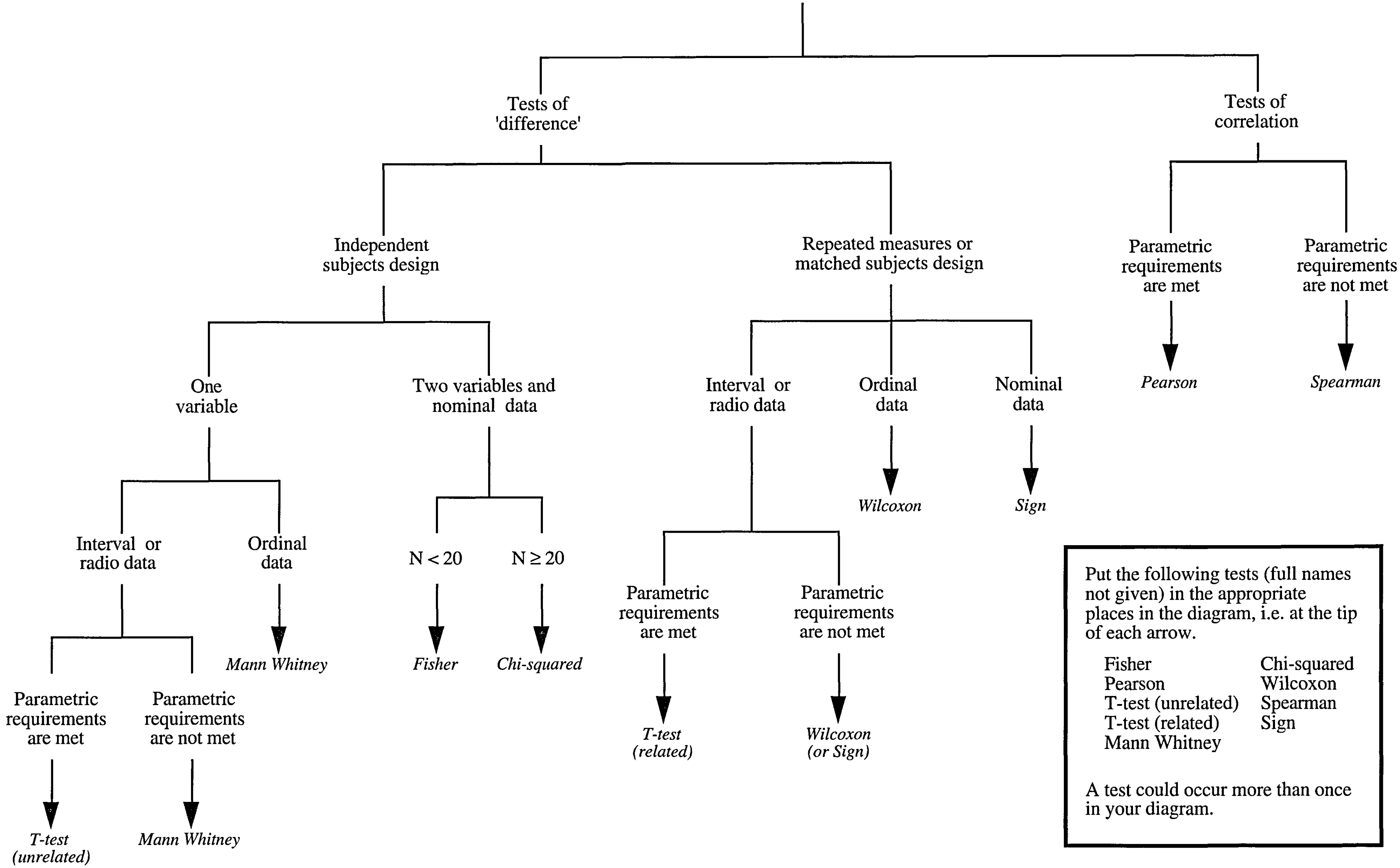
   You must know that there are three types of design viz.

   a) independent subjects design - different subjects are in the control and the experimental group
   b) matched subjects design - on the basis of a pre-test the subjects are divided into pairs of equal ability; one is then placed in the control group, the other in the experimental group
   c) repeated measures design - each subject performs under both the control and the experimental conditions.

If these questions can be answered successfully you should be able to determine which is the correct test to use to analyse the data: of course, on occasions it may be possible to use more than one test.

Hopefully, the exercise on page 78 will consolidate your understanding.

WHICH STATISTICAL TEST TO USE?



Put the following tests (full names not given) in the appropriate places in the diagram, i.e. at the tip of each arrow.

Fisher	Chi-squared
Pearson	Wilcoxon
T-test (unrelated)	Spearman
T-test (related)	Sign
Mann Whitney	

A test could occur more than once in your diagram.

FURTHER RESOURCES

Organisations

Association for the Study of Animal Behaviour, ASAB Membership Office, 141 Newmarket Road, Cambridge CB5 8HA.

British Psychological Society, St Andrew's House, 48 Princess Road East, Leicester LE1 7DR.

The Entomological Livestock Group, c/o John Green (Secretary), 11 Rock Gardens, Aldershot GU11 3AD.

Journals

Animal Behaviour - journal of the Association for the Study of Animal Behaviour, 12 issues a year. £25 a year by cheque, £20 by standing order, £10 for students (1995 prices). Available from ASAB Membership Office, 141 Newmarket Road, Cambridge CB5 8HA.

Feedback - education newsletter of the Association for the Study of Animal Behaviour, 3 issues a year. Free. Available from Michael Dockery, ASAB Education Officer, Department of Biological Sciences, John Dalton Building, Manchester Metropolitan University, Chester Street, Manchester, M1 5GD.

Books

Alcock, J. (1993). *Animal Behavior, 5th edn.* Sunderland, Massachusetts: Sinauer.

Barnard, C., Gilbert, F. & McGregor, P. (1993). *Asking Questions in Biology: Design, Analysis and Presentation in Practical Work.* Harlow: Longman Scientific & Technical.

Coolican, H. (1994). *Research Methods and Statistics in Psychology, 2nd edn.* London: Hodder & Stoughton.

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Hayes, N. (1993). *Psychology: An Introduction, 2nd edn.* London: Hodder.

Gross, R. D. (1993). *Psychology: The Science of Mind and Behaviour, 2nd edn.* London: Hodder.

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Reiss, M. (1994). *Advanced Questions on Everyday Biology (with answers)*. Walton-on-Thames: Nelson.

Roberts, M., King, T. & Reiss, M. (1994). *Practical Biology for Advanced Level*. Walton-on-Thames: Nelson.

Webb, N. & Blackmore, R. (1985). *Statistics for Biologists*. Cambridge: Cambridge University Press.

Suppliers of Equipment and Livestock

Blades Biological [supplier of zoological and botanical specimens, equipment and books], Cowden, Edenbridge TN8 7DX. Tel: 01342 850242; Fax: 01342 850924.

Griffin & George, Bishop Meadow Road, Loughborough LE11 0RG. Tel: 01509 233344; Fax: 01509 231893.

Nature of the World [suppliers of natural history specimens and equipment], Alvaston House, Dancing Green, Ross-on-Wye HR9 5TE. Tel: 01989 750840.

Paul W. Batty [butterfly & moth livestock and wild flower seed], 4 Byron Road, Dinnington, Sheffield S31 7LP. Tel: 01909 550272.

Philip Harris, Lynn Lane, Shenstone, Lichfield WS14 0EE. Tel: 01543 480077; Fax: 01543 480068.

Sciento Educational Services [suppliers of biological materials], 61 Bury Old Road, Whitefield, Manchester M25 5TB. Tel: 0161 773 6338.

The Budding Naturalist [suppliers of equipment, livestock, books and educational packs], Unit 23a, Grays Farm Production Village, Grays Farm Road, Orpington BR5 3BD. Tel: 0181 309 1813.

The Mealworm Co. Ltd., Unit 1, Universal Crescent, North Anston Trading Estate, Sheffield S31 7JJ. Tel: 01909 568953; Fax: 01909 568666.

Worldwide Butterflies, Sherborne DT9 4QN. Tel: 01935 74608; Fax: 01935 29937.

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Front cover photographs:

Top – Beautiful Golden Y moth

Middle – Lioness and cubs

Bottom – Male stickleback

ANIMAL BEHAVIOUR: Practical work and data response exercises for sixth form students has two aims. First, to encourage the use of more practical work (including project work) on animal and human behaviour in schools and colleges. Secondly, to enable students studying for 'A' level Biology, Psychology, Human Biology and Social Biology, or other 16-19 examinations, to develop their study skills through tackling data response exercises. Most of the book consists of suggested practical work and data response exercises. In addition there are sections on describing and measuring behaviour, and on using statistical tests.

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Michael Dockery is the ASAB Education Officer. Michael Reiss is Senior Lecturer in Biology at Homerton College, Cambridge.

This book is available from Michael Dockery, Department of Biological Sciences, John Dalton Building, Manchester Metropolitan University, Chester Street, Manchester, M1 5GD (Tel: 0161-247-1149, Fax: 0161-247-6365).