Chapter 2 Starting with a well-defined hypothesis

Answers to additional self-test questions

Q2.1 Salmon parr eat less per day in winter than summer. Suggest at least three hypotheses that could explain this.

(i) The fish are primarily eating invertebrates drifting downstream and in the benthos; there may simply be a lower density of such prey available in winter than summer. Hence the fish may eat less each day because less food is available.

(ii) The fish are probably visual feeders and shorter day lengths, lower light levels, and heavier sediment loads in the water in winter all reduce their ability to find prey (regardless of its abundance).

(iii) Flow rates are probably higher in winter and so drifting invertebrate prey may be harder to catch because they are moving faster.

(iv) The fish may be less able to move at the speeds required to catch many prey at the lower water (and so body) temperatures experienced in winter.

(v) Fish in winter may be concerned only with over-winter survival, rather than with growth and reproduction, and so their reduced feeding rate may simply represent reduced motivation to feed.

Q2.2 How would you critically test between these hypotheses?

(i) This can be addressed in a field study. We simply need to sample the amount of food drifting down streams with salmon parr in them at a range of times throughout the year. Exploring availability of benthic prey will be more challenging in the field, but not impossible.

(ii) This probably needs investigation with fish in a flume in a laboratory, where we can change light levels, day length, and sediment load in a controlled way without introducing confounding factors such as temperature changes. These confounders would be a problem in a field study.

(iii) Same arguments as (ii).

(iv) Again, you'd need a laboratory study to separate this hypothesis from (ii) and (iii).

(v) Now this one would be difficult to test directly, because motivation is a little difficult to measure. It is hard for us to know whether a fish does not respond to passing prey because it fails to detect it or because it detects it and decides not to attack. However, perhaps we can do this in the laboratory. If we keep temperature, light levels, sediment load, and prey availability the same and find lower attack rates (rather than capture rates) in winter than in summer, then this would suggest reduced motivation to feed in winter. The problem with this is the artificiality that we impose. We need to keep temperature constant to eliminate (iv) but it could be that the fish uses temperature as a cue to switch to its winter-time motivational state. In the end, it may be that support for (v) can only be gained by elimination of alternative hypotheses.

Q2.3 The research task you've been assigned is to go to a certain pedestrian walkway over a motorway and count the number of cars passing underneath you, so as to test the hypothesis that more cars travel from east to west than west to east on this stretch of motorway between 8 am and 9 am on weekdays. What aspects of this study would you seek to evaluate in a pilot study before you begin?

Firstly, can you find the specific pedestrian walkway and gain access to it? Can you see all the cars that are passing beneath you? Can you count all the cars in all the lanes that go in a particular direction simultaneously, or should you restrict yourself to one lane at a time? Can you count accurately using paper and pencil or should you use a tally counter? Can you count cars for one hour without a break without making mistakes, even in the wind and rain? Will you be distracted by other people crossing the bridge? Will you inconvenience other bridge users? Can you decide on an appropriate definition for a car? For example: is a Range Rover a car? Is a hearse a car? Do you count cars on a car transporter?

Q2.4 Discuss how we might test whether a university experimental design module has been successful. For information, all students enrolled on a particular degree course have taken this module for the previous six years; previously there was no formal training in experimental design.

First, we must define successful. By successful we might say that students have increased confidence and ability to design effective data collection exercises themselves and critique those designed by others. How can we measure this? The problem is that we do not have a concurrent control group. We could use a historical control and see if students have improved their scores in those parts of the course where experimental design is an integral part compared to these parts of the course where it is not. This is OK, but you fear that exam makers' criteria may have shifted according to their expectation of the students' ability in experimental design. We could try and find a course like our focal course at another university that does not feature an experimental design module and look for a difference in scores in, say, the final year research project, but we face the problems that students do not pick universities at random (e.g. they have different entrance requirements) and that there are differences between institutions in marking criteria. Returning to previous students on the focal course, we could try to correlate attendance at experimental design with exam performance, but this has the drawback that decisions not to participate in experimental design are non-random. We might be able to improve this analysis if we measured general attendance as a co-variate. This would seem the best way forward: to explore whether attendance at experimental design improves scores in those parts of the course where designing experiments is important, once general attendance has been taken into account. Alternatively, we could track down and survey students who've finished, or ask the current final year students. However, people's opinion of the value of something compared to its actual value might be questionable (cf. traffic wardens). Alternatively, in the future we could randomize students into a group that gets experimental design and a group that gets extra time off (but would it be ethical to deprive students of teaching that we believe is beneficial?).

Q2.5 It is often suggested that chilli powder can be added to nuts and seeds put out for garden birds as a way of making the food unattractive to squirrels without reducing the attractiveness to birds. Discuss how you might explore this idea using volunteer members of the public, with particular emphasis on including an appropriate control.

The first thing to consider is sample size. This depends on the quality of the volunteers; if you feel that they are highly motivated and can be relied upon to take good data then we would have thought 8–12 in each of two groups would be fine. If either of these is not true, then 20 might be a more reasonable number.

Now a historical control, where you simply ask the people whether they feel that there are fewer squirrels in their garden this winter (with the chilli) than last, is hopelessly subjective. We need records of bird and squirrel observations on nut feeders both with and without chilli. We could go for a within-subject design but we'd be concerned about carry-over effects. We think we'd want to go for a simple fully randomized design with a garden being assigned to 'chilli' or 'no chilli'. Now, we are concerned about volunteers being unconsciously biased according to what group they are in. We think this is a case where we need a placebo. Our suggestion is that we supply all volunteers with a sack of 'powder to be added'. In some cases this will be chilli, in some cases it will be something that looks and smells neutral to birds (perhaps something like sawdust). We want something with no nutritional content, but that should not be aversive if eaten, or visually attractive. If it looks like chilli powder (e.g. hardwood sawdust) then this would be a bonus. We'd want to do a little pilot study to check that the placebo seems to have a neutral effect on birds and squirrels and to identify appropriate concentrations of chilli powder to apply. An alternative to using a placebo would be to have the householder apply chilli or no chilli (determined by some third party) and have some other third party (perhaps yourself) observe the birds without them knowing which gardens had chilli and which not until the observations where completed. This has real scientific attractions of removing between-observer variation and removing the hassles of designing a good placebo. However, it would be a lot of observations for one person, but not impossible if the gardens where close together (but not so close that they share birds or squirrels; say five minutes' drive apart). You could look at paired designs with two feeders in each garden (one with chilli and one without), but we think this design is likely to be a bit too confusing for volunteers and may cause problems if squirrels 'assume' that if one feeder is aversive then the other identical looking one is likely to be also.

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