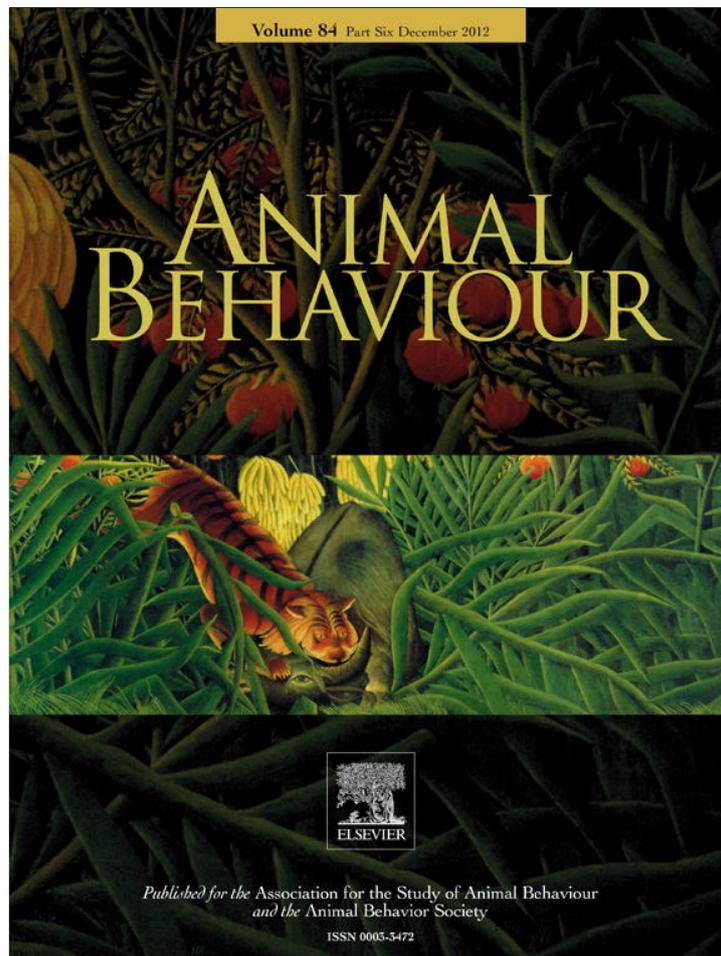


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responses and their consequences. Chapter 2 looks into how environmental changes affect communication, acoustic, visual and chemical, and how changes in signalling may affect populations. Chapter 3 gives an overview of how endocrine systems may change in response to changes in the environment. The first part of the book concludes with an examination of how animals may use learning to adjust to environmental change and its role in the development of behaviour.

The second section on behavioural responses describes how behaviours are affected by anthropogenic changes. Each of chapters 5–10 gives a nice overview of how specific behaviours such as dispersal, migration, foraging, reproduction and social behaviour, as well as species interactions, are affected by environmental changes. The final part of the book focuses on the implications and the potential consequences of behavioural changes for populations, ecosystems and biodiversity. Chapter 11 discusses how behavioural plasticity might help to mitigate the detrimental effects of environmental change on both individuals and populations. This leads nicely to Chapter 12 discussing the interplay between behavioural and population dynamics, pointing out that we need more information on how changes in behaviour affect population dynamics. Chapter 13 looks at the potential consequences of behavioural changes at the ecosystem level. Chapter 14 looks at biological invasions, another form of global change, by illustrating the importance of behaviour in the spread and impact of invasive species. Chapter 15 explains how environmental change may influence sexual selection by affecting sexually selected behaviours, and discusses the consequences for the individual, population and species. Chapter 16 focuses on potential evolutionary responses and potential constraints to environmental change. The last chapter reviews the recent wildlife disturbance literature and calls for animal behaviourists to initiate collaboration between behavioural ecologists, wildlife biologists and policy-makers.

Most of us interested in animal behaviour would probably prefer that such a book would not have been necessary. The reality is that we face one of the biggest biodiversity crises our planet has known. Looking on the bright side, I found reading the book very interesting and stimulating, because anthropogenic-induced environmental changes allow us to study many different aspects of behaviour in action. The answers of this research are unlikely to be simple and probably will not please us. However, we need them as soon as possible to mitigate the effect of global change.

In conclusion, this book is the first to provide an overview of how the behaviour of animals is affected by human-induced environmental changes. The wide range of topics covered is impressive and certainly of interest to people involved in the fields of animal behaviour, behavioural ecology and conservation. The clarity of the text will also enable students to find their way in this fascinating area of research. Moreover, the book will also appeal to a more general audience interested in aspects of environmental change and its consequences. The editors Candolin and Wong have done a marvellous job in summarizing all these different aspects in one book. I can highly recommend it.

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Getting Started with R: An Introduction for Biologists, A.P. Beckerman, O.L. Petchey. Oxford: Oxford University Press (2012). Pp. x+113. Price £19.99 paperback

Data Analysis with R Statistical Software. A Guidebook for Scientists, R. Thomas, I. Vaughn, J. Lello. Cardiff: Eco-explore (2012). Pp. 80. Price £10.00 paperback

Discovering Statistics Using R, A. Field, J. Miles, Z. Field. London: Sage (2012). Pp. xxxiv+958. Price £46.99 paperback

R is taking over the statistical world. This includes the statistical analysis of studies of animal behaviour, as any flick through this journal will now tell you. As such, those not on the R gravy train (and I myself don't yet have a season ticket) need to decide whether to be part of the R revolution or instead continue to use proprietary statistical software packages such as SPSS, SAS, Minitab or S-Plus. And this decision is two-fold. First, there is the decision about one's own research (and the analyses done in one's research group). Second, there is the decision about what we use to teach our students statistics, both at undergraduate and postgraduate level. For instance, if R becomes ever more common, are we doing our students a disservice not teaching them R, even if it does prove to be a passing fashion (and my guess is that it will not, at least not for a while)? So why not just decide to learn and teach R?

The reason why the decision is tricky is simple: as acknowledged by all three of these new books, R has a very steep and slippery learning curve. Thomas et al. sum this up very nicely with two quotes (both on page 4). The first is from Mick Crawley, doyen of statistical analysis for evolutionary ecologists: 'Learning R is not easy, but you will not regret investing the effort to master the basics'. The second is from an anonymous student: 'Learning R is an absolute nightmare, but apparently it is in some way good for me'.

And the reason that R has such a steep learning curve, that is easy to slip back down, is that R is not a stats package. Rather, it is a programming language in which statistical programmes have been developed and collected together to form a de facto statistical computing environment. Being a programming language, its programs are run using commands delivered using a command line, rather than via the user-friendly graphical user interfaces (GUIs) and drop-down menus now typical of many other stats software. While R does have a GUI that appears when you install and run the program on your computer, what you can do with the few available menus is limited to a bit of housekeeping (opening and saving files, directing R where to find and save data, and such like). The command line is where the action is.

This harsh learning curve, typified by the back-to-the-future nature of the command line, has two consequences. First, it is deeply challenging for our students, especially undergraduates who probably do not consider mathematics or computer programming as remotely relevant to their interest in animal behaviour (although hopefully everyone would read Maynard Smith 1982). Second, it may be rather challenging for the rest of us. I suspect I am not the only academic who knows of colleagues who own computers that have a 20th century date setting just so that their favourite but woefully out-of-licence SAS or Genstat or what-not still runs. And this may not be due to laziness or statistical illiteracy: skills learned are not easy to give up, especially when many of us do not manage to get the time to analyse data every week (or every month). Also, if the old package does the right analysis, then why change? Time-limited, of course we use what we know and

love, and the prospect of a steep learning curve is not attractive for anyone. Moreover, when faced with a drop-down menu in SPSS or Minitab, most academics reasonably conversant with statistics can usually bluff their way through the standard stats tests to help a stressed undergraduate analyse their data or to run a stats lab (data coding issues notwithstanding: all packages have some learning curve). But R is a different kettle of fish.

So what justification is there for using R, above and beyond a growing 'critical mass' of users? First, the R platform clearly appeals to that most fundamental of academic principles: thrift. R is free. Second, it can run on any operating system, anywhere. These are excellent reasons for adopting any package. Third, the programming language aspect of R does have the benefit that it offers students a way into programming, within the context of learning something that they need to learn (i.e. statistics). The need to help develop the next generation of computer programmers is clear, and widespread adoption of R will help prepare graduates that are not just consumers of code, but some (even if only a few) that are also makers of code. This, too, is an excellent reason for moving to R.

There are three further arguments for adopting R, and between them the three books use them to try to make the case for R. However, I think these next three arguments, while not necessarily completely fallacious, require more thought. Fourth then, the argument is often made that command line functionality demands that the user (e.g. an undergraduate) knows what is going on in terms of their analysis. One can't just trawl drop-down menus looking for the name of a test one has heard of and fire-away on the off-chance. This argument has some merit (but see below). Fifth, it is also argued that the command line actually makes analyses easier, faster and more efficient. This is because once the very steep learning curve has been negotiated, the cut-and-paste of 'scripts' (i.e. commands), and the fun of the up- and down-keys on your keyboard, mean that repetitive analyses (e.g. simplification of complex models) can be handled with far less mouse-induced repetitive strain injury. The possibility of making errors when choosing options from drop-down menus is also likely to be reduced. There is a potential contradiction though. In effect, we are being told that R is both easy and hard, and both are virtues that should encourage us to switch to R. Well, it might be argued that there is no contradiction at all, as by the time students (or faculty for that matter) know how to use R efficiently they will also know how to do the stats, so the chance of getting things wrong is diminished. However, I am not so sure this will always be true. Let's think about how we are going to teach R. At best, we will use books that teach us statistics in R, such as Thomas et al. or Field et al. We will learn what commands to write and when to write them. We will save our scripts and reuse them for new (unsupervised) analyses. It is not clear to me though why this is a priori more robust than is supervised learning of statistics via drop-down menus. At the end of an (unsuccessful) learning process, we might have a bunch of half-understood scripts we can throw willy-nilly at data, which is not really that different to a bunch of half-understood drop-down menus. Worse, students may be given sets of pre-prepared scripts that can be cut and pasted as part of their course (basically the same as drop-down menus right?). Worse still, thanks to the freeware nature of R, and the frankly amazing community of R developers, bloggers and advice groups, it is trivially easy to access scripts to statistical tests on the internet and run them without any clear idea of what is going on. Slightly harder work than shilly-shallying through drop-down menus perhaps, but I hope the point is made that R, in and of itself, does not preclude incorrect use or demand a greater understanding of what is going on just because it is a command-line language. The onus is just as much on the teaching and supervision of its use as it

ever was in the drop-down menu days, and this argument for R should probably be abandoned.

Indeed this leads on to the next argument for using R: R is now central to ongoing statistical research and new developments and approaches for analysis are increasingly appearing first in R. This means that knowing R speeds up your access to the latest techniques, adding tremendously to one's ability to wrestle with novel or difficult data (e.g. a poorly designed linear mixed models (GLMMs) have really changed animal behaviour research, they certainly sound cool. This access to cutting-edge statistical apparatus is a mixed-blessing though. First, as discussed above, the ease of access allows all of us to have a try at all sorts of tests we may not really understand: we just need to cut and paste the script from the internet. Second, this lack of understanding may mean that we do not realize that the developments are themselves in murky statistical territory (this is true for GLMMs for example, although you might not know it from the behaviour and ecology literature: see Bolker et al. 2009 for discussion). Third, since basically anyone can write an R package, let's just say that some packages are better than others, which is certainly true for their accompanying documentation. Raising these concerns is not to denigrate the heroic efforts of R developers, or the R community more generally; rather it is to remind us that open access demands greater not lesser vigilance than in the days when all a student could do was proscribed by Minitab or SPSS. In stats parlance, we may have more degrees of freedom, but that freedom can be used wisely or poorly.

Such a critique as that given above is a long way from the upbeat and positive message of Beckerman & Petchey's *Getting Started in R*. The authors love R and they want us to love it too. In a short, crisp book, Beckerman & Petchey take us through the first steps of using R, providing many valuable hints and tips along the way. The style is witty and forthright, sweeping the reader along with its unbridled enthusiasm. Crucially, the authors stress the benefits of the script-based approach, with sets of commands saved and annotated in a script editor, before being sent to the 'R console' to do the business of the analysis. Script editors can be anything from a basic text editor such as Notepad, to more designed script editor environments (see below for my current favourite, which probably is going to change my life). These scripts then become part-and-parcel of the whole process, forming records of the analysis as important as the data and final output, and I admit to being wholly won over as to the merit and importance of well-curated scripts. Used properly, this could mean goodbye to wondering just what analysis your errant postdoc actually did. Admittedly, the cynic may wonder whether researchers too lazy to write down what they did in a lab book would actually bother to annotate a script properly, but on the whole I agree with Beckerman & Petchey that scripts are a major plus-point for R.

Alongside the advocacy for scripts, *Getting Started in R* does a terrific job in explaining the nuts and bolts of doing just that: getting started. Importing, saving, manipulating and visualizing data are all covered exceptionally well, and the tricks provided for checking that your data really are what you think they are will be very useful. It was also great to see a version of my own mantra (draw as many pictures as you can before you reach for that *t* test) repeated vigorously and often. Statistics are the endpoint, when you pretty much should know the answer from all the pretty pictures you have created.

While I am delighted to have this book on my shelf, it does have self-imposed limitations. By design, the book contains virtually no statistical tests, and so is not a book on which to base a whole stats course. It would serve admirably for the first lesson or two of a stats course in R, when students (or faculty) need to get to grips with the

R computing environment, but beyond that other resources would be needed. I also wonder if students would go for a book with such a limited scope (and relatively high price). An alternative might be to use this book alongside an early introduction to R, when obtaining and visualizing data was the aim, rather than formal analysis (for instance, as part of first-year undergraduate lab practicals). Given the slippery learning curve, repeated and frequent use of R probably is the key to success, and so embedding it in practicals throughout a university course (well beyond solely animal behaviour practicals) may be the best way to teach it. However, the overall tone of the book, engaging and fun as it is, felt more appropriate to a postgraduate or faculty audience. This is not just in the introduction where the authors state that they are assuming a working knowledge of statistics, but more generally. As such, I think this is probably the perfect book for postgrads, postdocs or faculty coming to R with a solid statistics background. Short and sweet, it will help the transition to R in one, easy-to-swallow lump. Buy a copy.

Rob Thomas and colleagues have a different aim and have taken a very different approach in their *Data Analysis with R Statistical Software: A Guidebook for Scientists*. Equally witty and amusing, it is equally short and sweet. However, this book is very much about the statistics, providing a brief introduction to getting started in R, before launching into a whistle-stop tour of the wide variety of statistical tests available in R (from all the old *t* test/ANOVA/correlation favourites to GLMs and GLMMs). For someone who used to use S-Plus (the pay-per-view version of R) and up until now has used R only when I had to, this book is going to be extremely useful. With very little flannel, this provides an easy-to-use guide to the syntax of most of the stats tests I need. I can see myself using this book a lot. However, this breadth of scope in such a short book again imposes limitations. First, virtually no output is provided, so unless you know what to expect (or the book is used within a stats course where output is explained in detail) the book will be hard to use. It is not a stand-alone book for a novice in that respect. Second, there is no room for discussion of any finer points. To take one example, the rationale for model simplification is not very clearly presented. This is important because model selection/simplification in a hypothesis-testing framework is problematic. Model simplification to test effects evokes the problem of multiple testing, inflating type 1 error rates, among other problems (e.g. Whittingham et al. 2006; Mundry & Nunn 2009). Building predictive models is perhaps a different story, but care is still needed (Whittingham et al. 2006). Moreover, there is a growing trend for the model simplification approach to lead to the reporting of only the significant effects that make up a 'minimum adequate model'. Given the importance of meta-analysis though, we need to keep reporting all our results, significant or not. For many of us, the use and complete reporting of full models is probably going to be the best strategy (albeit using appropriate sums of squares, avoiding unnecessary overparameterization and so on). All told then, this is very much a guidebook, albeit a really excellent one. For faculty moving to R, this will be a very useful addition. As the basis for a stats course (at all levels), it will also be excellent, although contextualization in terms of output, some of the twiddles needed for data, and discussion of statistical techniques would need to be provided. Buy two copies.

Finally, what of Andy Field and colleagues, with their *Discovering Statistics Using R*? Probably the wittiest and most amusing of the lot (no, really), this book takes yet another approach: it is 958 pages of R-based stats wisdom (plus online accoutrements). However, within those pages is one real gem. Field et al. describe an R package called 'R Commander' (Fox 2005). R Commander is what I have been waiting for (and not just for its name): it is a drop-down menu-based GUI, allowing R scripts to be run using a menu-based system (in fact, there are a number of useful GUIs

for R out there, including Deducer; A. Field, personal communication). While this may revolt some, R Commander perhaps provides a useful solution for the problems of the R learning curve, for both students and lecturers. R Commander has a script editor (and can be used solely as a command line script editor if you want, to do whatever analyses you like), and commands can be sent to the R console or run within R Commander to be outputted in an output field. Moreover, when data manipulations, visualizations or analyses are run via the drop-down menus, the scripts for those commands are presented in the script editor, so that we can all see how to do it in words. We can also repeat analyses quickly and easily in the command line style, by highlighting text and clicking 'Ctrl + R', getting the best of both worlds. Finally, the menus are fairly simple, and do not offer a whole galaxy of options (although pretty much everything *Animal Behaviour* readers would need, including generalized linear models, model simplification and so forth, are available). This means that students are not offered that daunting multiplicity of tests in the menus (most of which they are warned off using) that the current version of SPSS provides, for example. As such, R Commander and similar GUIs provide an ideal environment to learn and use R, and should allow academics once more to bluff their way through a stats lab if they still want to stick with their tried-and-tested time-travelling computer.

In terms of the book itself, those familiar with Andy Field's SPSS books will know the score: a thoroughly engaging, expansive, thoughtful and complete guide to modern statistics. Self-deprecating stories lighten the tone, and the undergrad-orientated 'stupid faces' (Brian Haemorrhage, Jane Superbrain, Oliver Twisted, etc.) soon stop feeling like a gimmick, and help to break up the text with useful snippets of stats wisdom. It is very much a student textbook but it is brilliant. Even the glossary is fun. And although it is a shame that the current version lacks the full colour of the last SPSS edition, this probably is a must-have, and is certainly more under- and postgraduate friendly than either of Crawley's R books for example (Crawley 2005, 2007; although that feels ungrateful, as his S-Plus book was a trusted friend for many years). The size (and price) of Field et al. probably means it will be an investment for life for most of our undergraduates but it could certainly be the basis for (multiple) stats courses in R. And although I cannot claim to have read it cover to cover, I have already uncovered useful R functions I had no idea existed. Buy as many copies as you can.

In summary, R looks like the way forward. It is where the statistics action is right now. Fortunately, packages such as R Commander or Deducer mean that the command line can be introduced gently (or obviated entirely). From my perspective, if using a command line is so great, it won't take long for users to stop bothering with drop-down menus, and instead just use R Commander or similar as a script editor, so it is a win-win situation. Each of these books will be a useful addition to an R novice's library. Beckerman & Petchey is probably the place to start for reluctant academics, with Thomas et al. a source for much useful day-to-day stats syntax. Field et al. is the complete package. Well, at least up until those pesky GLMMs. And then you should probably head to MCMCglmm (Hadfield 2010).

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