Ecology

Hunting and fox numbers in the United Kingdom

The potential impact of fox-hunting ban in Britain is a contentious issue[1] that has been explored by Baker *et al.*[2]. They conclude that a suspension of lowland fox-hunting for nine months during 2001 made no difference to fox density in certain areas. We are not confident, however, that their analysis supports their conclusions — their study does not consider statistical power or account sufficiently for regional variation, and also uses an inappropriate statistic.

An analysis of statistical power is necessary to demonstrate the probability of detecting an increase in fox density of 10%, 20%, 30%, and so on, given the sample sizes and variability of the data. It seems likely that the power of Baker and colleagues' study to detect plausible effect sizes was low, whether by the analysis published or by any other test: the proper conclusion should be 'no evidence', rather than 'evidence of no effect'.

Moreover, a constant of 1.0 used (twice) in calculating the relative change in faecal abundance, R', is large by comparison with average scat density, with the result that R' is higher where faecal density before the hunting ban (imposed during the outbreak of foot-and-mouth disease (FMD)) is higher. For the same proportional increase in faecal density, R' takes lower values for a low pre-FMD density than for a high pre-FMD density. For example, a 50% increase from a pre-FMD density of 5 faeces per km^2 gives $R' = 0.008$, whereas the same 50% increase from a pre-FMD density of 100 per km^2 gives $R' = 0.085$ (we have used $\log_{10}$; average faecal density was 50 faeces per km^2 (ref. 3) and the average transect length was 6.9 km (ref. 2)).

If, as hypothesized by Baker *et al.*, pre-FMD fox density had been suppressed in hunted squares, initial faecal density would be low in those squares, but would be predicted to increase during the suspension of hunting. Because of the low initial density, R' would take low values in those squares. In an analysis of all squares, this would tend to mask differences between squares that show an effect and those that show no effect (for no change, $R' = 0$). The consequences of this could influence the conclusions of Baker *et al.*

Finally, an earlier study contrasting three large regions of England and Wales concluded that hunting with dogs was the major part of an effective cull in one region, but not in the other two[4]. It is therefore appropriate to test for regional variation in the impact of hunting pressure, requiring that an interaction term be explicitly modelled. The upland regions where hunting with dogs is more likely to suppress fox densities were not represented in Baker and colleagues' study.

Only when these concerns are addressed can we concur that Baker *et al.* have clarified the effect of a hunting ban on fox populations.

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Baker et al. *reply* — Although there is a tendency for our transformation to result in low R' values for those squares where initial faecal density was low, this does not affect our results. First, this 'bias' is equivalent to a 1.2-fold difference in R' for a 20-fold difference in initial faecal density[1]. Second, there was no difference between 'hunted' and 'non-hunted' squares with respect to initial faecal density, direction or magnitude of change in faecal density[1]. The starting conditions and pattern of change were therefore the same for hunted and non-hunted squares, and the reservations of Aebischer *et al.* about the transformation are unwarranted.

Our key hypothesis was that hunting with hounds (hereafter termed 'hunting') is additive to other culling practices[2]. Consequently, the absence of hunting during FMD would be expected to result in increased fox abundance in areas that were previously hunted. The most parsimonious way to test this hypothesis, and to remove any possibility of a transformation effect, is by using a signs test[3] — this compares the number of squares in which scat density increased with the number in which it decreased, assuming a 50% chance of either event. This negates the need for a regional approach — if hunting is additive, a change of any magnitude in any region would be detected using our paired samples[2].

To determine the power of this approach, we need the α-error rate ($\alpha = 0.05$), the sample size ($n = 157$; squares with no change are excluded) and the size of the likely effect[3]. In previous studies[4–6], the impact of hunting in Britain (total area, 230,367 km^2) has been estimated by extrapolating kill rates per unit area to the total area covered by packs of foxhounds (145,000 km^2). The proportion of land in Britain that is hunted is therefore 0.63.

Statistical power is the probability of correctly rejecting a false null hypothesis. For a two-tailed test, the minimum effect size (g) is given by: $0.63 - 0.50 = 0.13$; the statistical power that corresponds to $\alpha = 0.05$, $n = 157$ and $g = 0.13$ is about 0.950 (ref. 3). We therefore had a 95% chance of correctly rejecting a false null hypothesis, for a roughly 13% deviation from a probability that faecal density would increase (or decrease) in 50% of squares. The actual results showed no change ($P = 0.474$). The observed pattern of variation in faecal density is therefore not consistent with hunting mortality being additive. Furthermore, the small absolute changes in faecal density[2] indicate minor changes in fox density. We reiterate that these results support the Committee of Inquiry into Hunting with Dogs[6], which concluded that a permanent ban on hunting is unlikely to result in a dramatic increase in fox numbers.

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correction

Deepwater variability in the Holocene epoch

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In Fig. 1, the arrow marking the onset and intensification of the 5-kyr event was positioned incorrectly. The correct version of the figure is shown here.