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Accounting for false positive detection error induced by transient individuals

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Appendix S1

Water vole latrine counts as an indication of transience

In 2011, in addition to detection/non-detection data collected from multiple visits to water vole patches, the number of individual latrines (dung piles) was also counted. We hypothesised that if transient individuals were present in the system, sites subject to visitation by transients would be more likely to be observed as 'occupied' on only a single occasion (out of up to four visits), i.e. they are false positives. Moreover, given that transience is short lived, the number of latrines at sites more likely to be false positives would be less than observed at sites with more than a single positive site visit. In Fig. S1 we show the distribution of the number of latrines at sites with only a single visit, e.g. `'100'`, `'010'` or `'001'` (n=26) with latrine counts (mean across all positive visits) from sites with two or more positive site visits, e.g `'111'`, `'110'`, `'011'` or `'101'` (n=71).

This data is consistent with that of Woodroffe & Lawton (1990) who readily found latrines at sites occupied by breeding water vole colonies but at peripheral sites in which no breeding occurred, infrequent latrines at low frequencies were found. We suggest therefore that, while not direct evidence of transience, this is indicative of the potential for transient induced false positives.

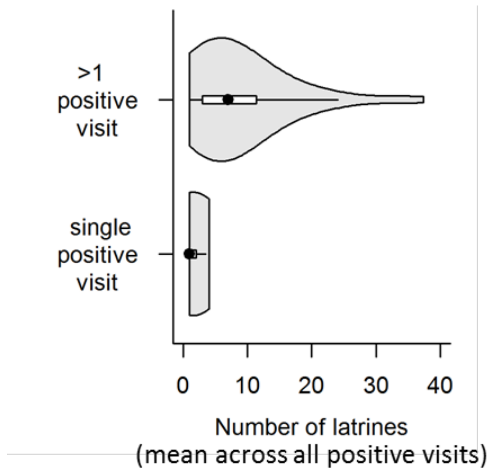

Figure S1. Violin plot showing the maximum number of latrines found at sites with more than one positive observer visit (top) compared to sites with only a single positive observer visit (below). Violin plots are a graphical description of the distribution of the 'latrine data' and show a traditional box plot (white) overlaid with the kernel density estimation (grey).

Model selection using maximum likelihood and AIC

In the main text we note that there are known issues with using DIC as a tool for model selection for models with latent variables such as patch occupancy models accounting for detection errors, i.e. that treat patch occupancy state as partially observed random effects, (Celeux *et al.* 2006). We therefore calculate and compare AIC values that are derived from the maximum likelihood method employed by Royle and Link (2006). Their model is a single season occupancy model and therefore we compare year specific AIC values which further add to the evidence for the support of the model that corrects for false positive errors over that which imposes the restriction that $fp = 0$; in all years, the false positive model is better supported by the data than the standard occupancy model.

Table S1. Comparisons of AIC values calculated using the approach described in Royle and Link (2006) using maximum likelihood. Model comparisons are year specific single season comparisons of the standard occupancy model that imposes the *fp*=0 restriction with the false positive model that relaxes this restriction, i.e. $fp \neq 0$. Table shows calculated AIC values and ΔAICm the differences between models (lowest AIC is better).

Year	AIC		ΔAIC
	$fp = 0$	$fp \neq 0$	
2009	295.83	**269.59**	26.24
2010	290.53	**269.94**	20.59
2011	288.99	**275.63**	13.35

```
################################################################################
##
## Occupancy model accounting for both false positive and negative errors
## (M16 - Table 1)
##
## Data:
##      'nyear'     - number of primary periods (years)
##      'nsite'     - number of sites (habitat patches)
##      'Y'         - number of positive visits/detections per site per year
##                    [nsite x nyear matrix]
##      'n.visits'  - number of visits per site per year
##                    [nsite x nyear matrix]
##
## * for any questions/queries, please email me @ chrissuthy@gmail.com
##
################################################################################

model {
#PRIORS

 for(i in 1:(nyear-1)){
  gamma[i] ~ dunif(0,1)
  phi[i]   ~ dunif(0,1)
  p[i]     ~ dunif(0.5,1)
  fp[i]    ~ dunif(0,0.49)
 }

 psi       ~ dunif(0,1)
 p[nyear]  ~ dunif(0.5,1)
 fp[nyear] ~ dunif(0,0.49)

#ECOLOGICAL MODEL (occupancy dynamics)

 for(i in 1:nsite){
    z[i,1] ~ dbern(psi)
  for(t in 2:nyear){
     muZ[i,t] <- z[i,t-1]*phi[t-1] + (1-z[i,t-1])*gamma[t-1]
     z[i,t]   ~  dbern(muZ[i,t])
  }
 }

#OBSERVATION MODEL

 for (t in 1:nyear){
  for(i in 1:nsite){
    Py[i,t] <- z[i,t] * p[i] + (1-z[i,t]) * fp[i]
    Y[i,t]  ~  dbin(Py[i,t],n.visits[i,t])
  }
 }

#DERIVED OCUPANCY
 psivec[1]<-psi
 for(t in 2:nyear){
   psivec[t] <- psivec[t-1]*phi[t-1] + (1-psivec[t-1])*gamma[t-1]
 }
} #END
```

References

Celeux, G., Forbes, F., Robert, C.P. and Titterington, D.M. (2006) Deviance information criteria for missing data models. *Bayesian Analysis*, **1**, 651–673.

Royle, J.A. and Link, W.A. (2006) Generalized site occupancy models allowing for false positive and false negative errors. *Ecology*, **87**, 835–841.

Woodroffe, G.L. and Lawton, J.H. (1990) Patterns in the Production of Latrines by Water Voles (Arvicola-Terrestris) and Their Use as Indexes of Abundance in Population Surveys. *Journal of Zoology*, **220**, 439–445.