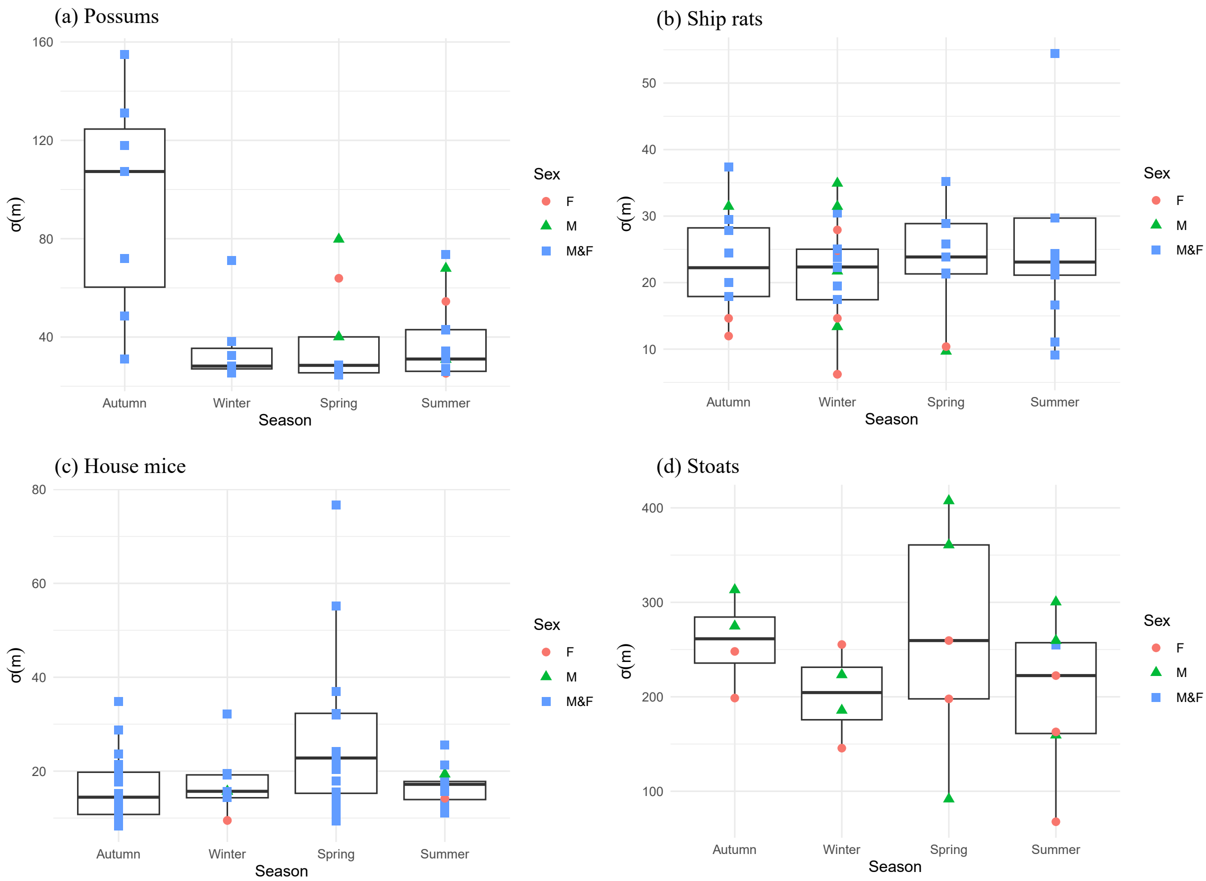
## Supplementary Material

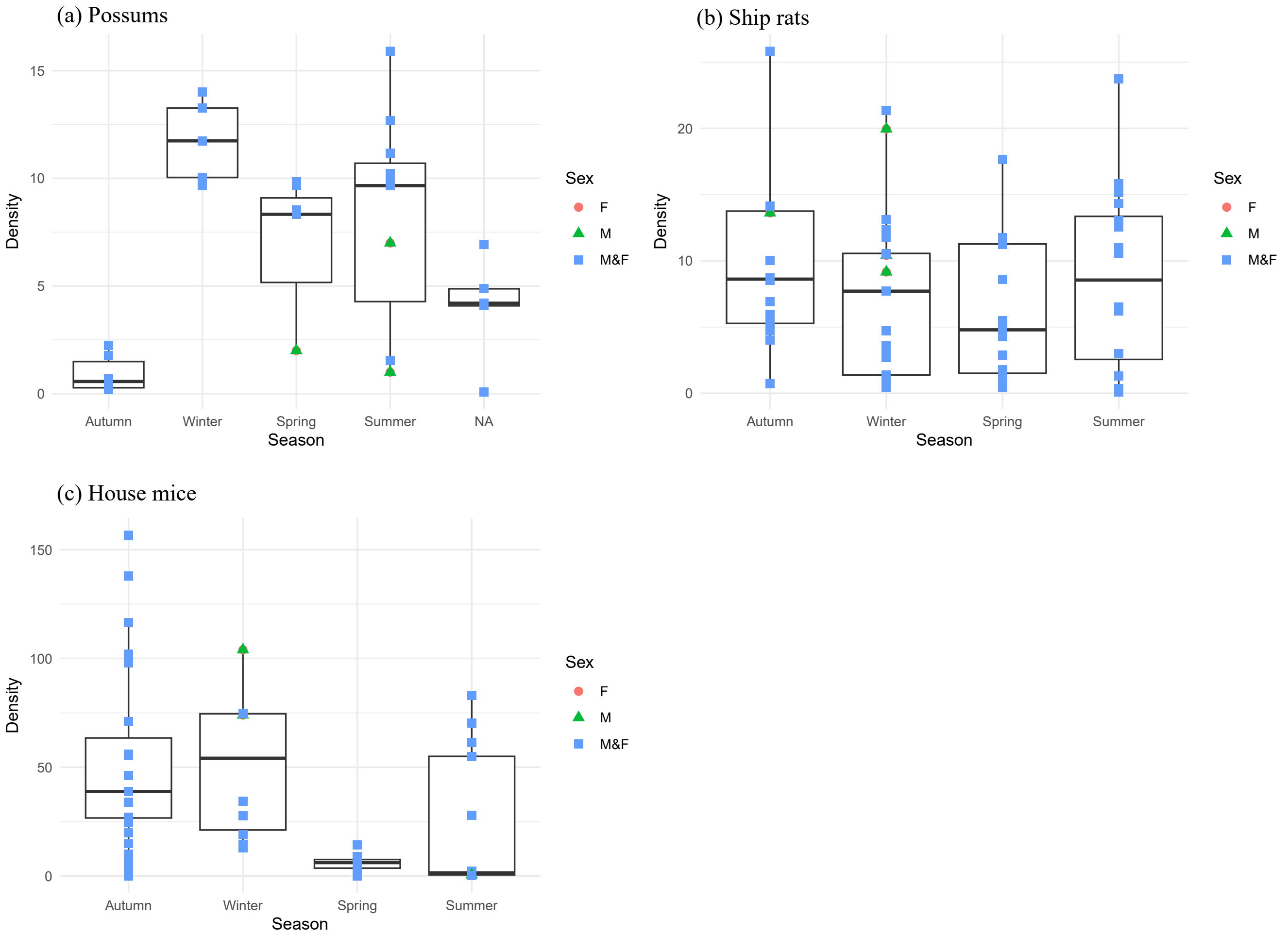
**Appendix S1.** Mean estimates of $\sigma$ (metres), with associated standard deviations and number of estimates for possums, ship rats, house mice, stoats, ferrets, feral cats, and hedgehogs, pooled over sex and season separately. Estimates from studies with less than four measurements taken over a single season were excluded from this table.

| σSpecies | | Males | Females | Winter | Spring | Summer | Autumn |
|---|---|---|---|---|---|---|---|
| *σPossum* | mean | 65.9 | 50.4 | 35.6 | 38.2 | 39.1 | 94.7 |
| | s.d. | 48.4 | 36.1 | 16.2 | 20.0 | 16.6 | 45.4 |
| | n | 20 | 20 | 7 | 9 | 13 | 7 |
| *σShipRat* | mean | 28.3 | 14.6 | 21.5 | 24.0 | 28.8 | 26.8 |
| | s.d. | 19.6 | 8.0 | 7.4 | 7.7 | 16.2 | 15.0 |
| | n | 8 | 8 | 30 | 17 | 18 | 18 |
| *σHouseMouse* | mean | 16.0 | 12.4 | 16.8 | 27.5 | 19.1 | 16.6 |
| | s.d. | 3.0 | 3.2 | 6.8 | 18.2 | 7.6 | 7.2 |
| | n | 6 | 6 | 13 | 29 | 18 | 47 |
| *σStoat* | mean | 261.0 | 201.0 | 202.0 | 263.0 | 204.0 | 259.0 |
| | s.d. | 79.0 | 50.2 | 47.4 | 126.0 | 79.1 | 48.1 |
| | n | 16 | 14 | 4 | 5 | 7 | 4 |
| *σFerret* | mean | 227.0 | 303.0 | - | - | - | - |
| | s.d. | 60.6 | 123.0 | - | - | - | - |
| | n | 11 | 11 | - | - | - | - |
| *σFeralCat* | mean | 529.0 | 381.0 | - | - | - | - |
| | s.d. | 235.0 | 188.0 | - | - | - | - |
| | n | 20 | 21 | - | - | - | - |
| *σHedgehog* | mean | 86.3 | 61.2 | - | - | - | - |
| | s.d. | 70.3 | 42.7 | - | - | - | - |
| | n | 8 | 7 | - | - | - | - |

**Appendix S2.** Estimates of $\sigma$ (metres) versus season for (a) possums, (b) ship rats, (c) house mice, and (d) stoats labelled for sex and for studies carried out over a single season. Extreme outliers (values above Q3 + 3xIQR or below Q1 − 3xIQR, with Q1, Q3, and IQR being the first quartile, third quartile, and interquartile range respectively) were excluded from this plot.



**Appendix S3.** Estimates of density versus season for (a) possums, (b) ship rats, and (c) house mice labelled for sex and for studies carried out over a single season. Extreme outliers (values above Q3 + 3xIQR or below Q1 − 3xIQR, with Q1, Q3, and IQR being the first quartile, third quartile, and interquartile range respectively) were excluded from this plot.




**Appendix S4.** Spatially-explicit capture-recapture (SECR) analysis of unpublished dataset (Byrom 2008). We analysed a dataset of ship rat capture-recapture using single-catch live traps at three sites located in the Orongorongo Valley (Wootton Stream, Orongorongo, and Peak Stream). Device spacing was 76 m at Orongorongo and 18 m at the other two sites. Trapping was conducted in Spring, Summer, or Autumn between December 2006 and October 2008 The dominant habitat is beech forest at Peak Stream, podocarp-broadleaved forest at Wootton Stream, and mixed beech-podocarp-broadleaved forest (78% podocarp-broadleaved, and remainder beech forest) at Orongorongo. We used the *secr* package, fitting the spatial detection model using maximum likelihood, to estimate detection parameters and density from the capture-recapture data at each site. A negative exponential detection function, rather than half-normal, was the most parsimonious model for all three sites, based on AIC.

Study attributes and estimates of g0, $\sigma$ and density for each site and season are detailed in Appendix S1. Note, the estimates of $g_0$ and $\sigma$ from this analysis can not be compared with $g_0$ and $\sigma$ estimates derived from SECR analyses that apply a half-normal detection function because these parameters have different definitions for different functional forms. Trap saturation at the Orongorongo site for all five trapping occasions was above 20%, therefore $g_0$ estimates may be biased because maximum likelihood SECR modelling was used rather than inverse prediction and simulation (Efford et al. 2009). Over the two years of surveys (spring, summer, autumn) at Orongorongo, mean $g_0$ estimates ranged from 0.20 to 0.40, $\sigma$ from 13 to 23 m, and density from 4.1 to 10.5 ship rats ha$^{-1}$. At Peak Stream (spring and autumn), detectability and density were generally lower, with mean $g_0$ estimates ranging from 0.09 to 0.18, $\sigma$ from 12 to 25 m, and density from 2.3 to 5.7 ship rats ha$^{-1}$. At Wootton Stream (spring, summer, autumn) mean $g_0$ estimates ranged from 0.05 to 0.25, $\sigma$ from 11 to 18 m, and density from 2 to 11 ship rats ha$^{-1}$.

**Appendix S5.** Analysis of detectability parameter estimation noise. The SECR estimation process can introduce a negative correlation between estimated values of $\sigma$ and population density. This could affect the results of a regression analysis aiming to quantify the relationship between these parameters, such as the one we present in this paper. In this section, we test the null hypothesis that the true values of density and $\sigma$ are uncorrelated, and that any relationship found between them is solely introduced by the estimation process.

To test this hypothesis, for each species, we generated 100 000 datasets of log-transformed density and $\sigma$, with true values drawn from an uncorrelated bivariate normal distribution with the same mean and variance as the original dataset, and observed values, calculated as true values plus some random noise drawn from a correlated bivariate normal distribution. We fitted a linear model to each set of observed values as we described in the main text of this paper, and we compared the resulting distribution of $R^2$ values to the value of $R^2$ found in the original regression analyses presented in Table 2. Note that only datapoints where standard errors were reported for both density and $\sigma$ were included in this analysis.

For each dataset, we first drew N true values of density and $\sigma$ from independent normal distributions $\mathcal{N}(\widehat{D}_{est}, s_D^2)$ and $\mathcal{N}(\hat{\sigma}_{est}, s_\sigma^2)$ , with N being the number of datapoints used in the original analysis for that species, $\widehat{D}_{est}$ and $\hat{\sigma}_{est}$ being the mean values of the density and $\sigma$ mean estimates from our original dataset, and $s_D$ and $s_\sigma$ being the standard deviations of the "true" density and $\sigma$, before any noise is introduced by the estimation process. The values of $s_D$ and $s_\sigma$ are unknown, but we approximated them using the standard deviations of the original data together with available standard errors associated with the density and σ estimates, as described further below. Next, we generated N "observed" values of density and $\sigma$ by adding some correlated bivariate estimation noise to the "true" values. The noise for datapoint $i = 1, \ldots, N$ was drawn from a bivariate normal distribution $N(0, C_i)$, with $C_i$ being the covariance matrix defined as

$$C_i = \begin{bmatrix} k_{i,D}^2 & \rho k_{i,D} k_{i,\sigma} \\ \rho k_{i,D} k_{i,\sigma} & k_{i,\sigma}^2 \end{bmatrix} \quad \text{(S1)}$$

where $k_{i,D}$ and $k_{i,\sigma}$ are the standard deviation in the log-transformed estimates for density and $\sigma$ respectively for the ith datapoint, and $\rho = -0.4$ is the assumed SECR estimation correlation coefficient between density and $\sigma$ (value chosen as a representative value in the range of correlation estimates in the *secr* package examples (Efford 2023); stronger correlation coefficients were also tested and gave similar results). In order to obtain values of $k_D$ and $k_\sigma$ from reported standard errors, we chose $k_{i,D}$ such that the interval $[D_i e^{-k_{i,D}}, D_i e^{k_{i,D}}]$ had the same length as the interval $[D_i - SE_{i,D}, D_i + SE_{i,D}]$, where $SE_{i,D}$ is the reported standard error in density for datapoint $i$ s(and similarly for $k_{i,\sigma}$).

To estimate the true standard deviations, $s_D$ and $s_\sigma$, we chose values such that the expected overall standard deviation of the simulated observed data was the same as the standard deviation of the original data. This was achieved by setting

$$s_D = \sqrt{SD_D^2 - \frac{1}{N}\sum_{i=1}^{N}\left(k_{i,D}\right)^2} \quad \text{(S2)}$$

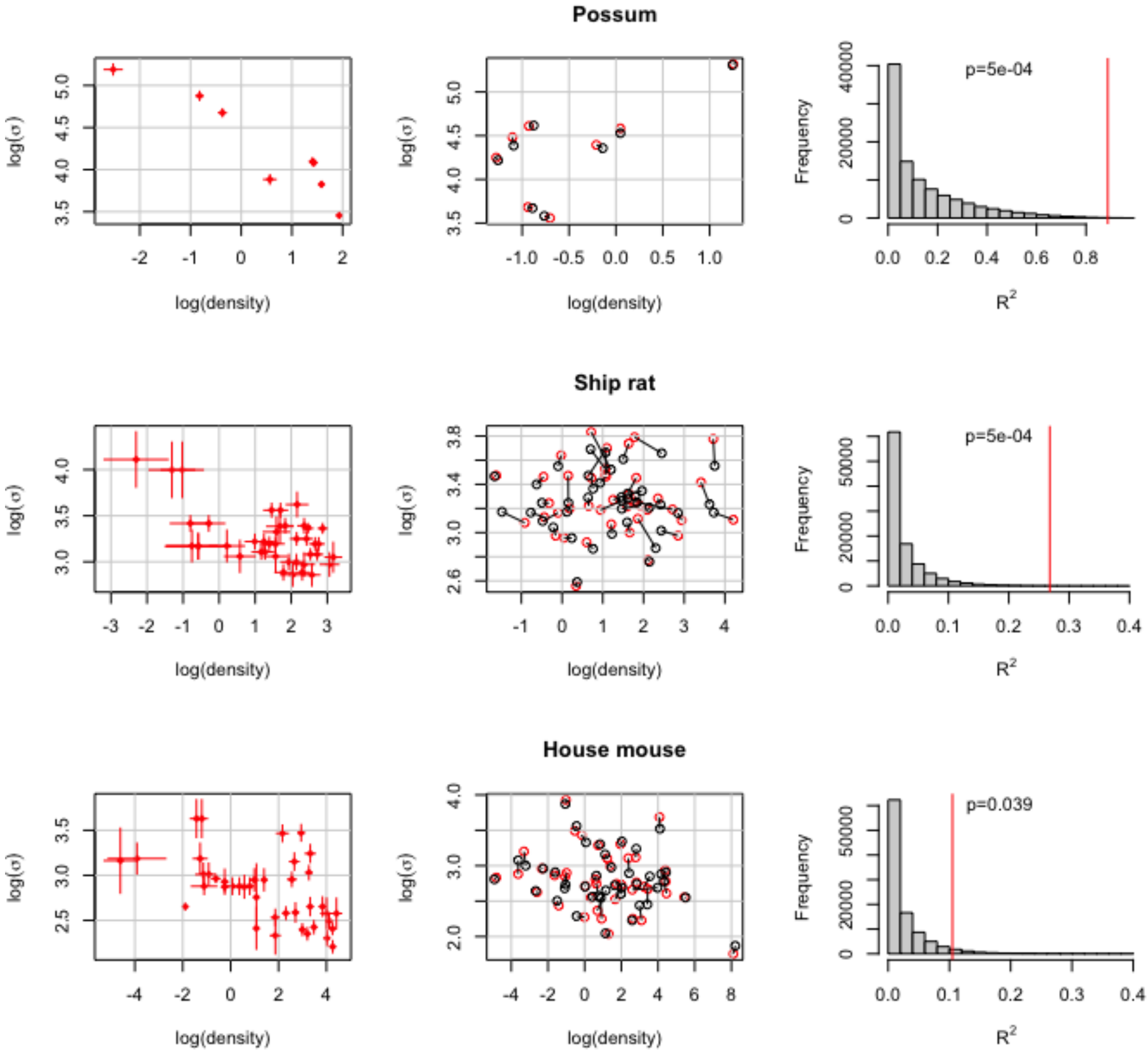
$$s_\sigma = \sqrt{SD_\sigma^2 - \frac{1}{N}\sum_{i=1}^{N}\left(k_{i,\sigma}\right)^2} \quad \text{(S3)}$$

with $SD_D^2$ and $SD_\sigma^2$ being the variances of the log-transformed reported estimates of density and $\sigma$ in the original data, and $k_{i,D}$ and $k_{i,\sigma}$ being the variances of each log-transformed estimate $i$. To verify this process was performing as required, we checked that the means and standard deviations of the simulated datasets were distributed evenly about the means and standard deviations of the original data.

We then fitted a linear model to the simulated observed values and compared the corresponding distribution of values of $R^2$ to the value associated with the original dataset. Note that, the smaller the reported standard errors, the more of the variability in the data is coming from underlying variability in the true values and the less from the noise from the estimation process. Since the underlying variability in true values is assumed to be uncorrelated under the null hypothesis, this means that smaller error bars translate into weaker correlation in datasets simulated under the null, and therefore a greater likelihood (all else equal) that the original observed data will be significantly more correlated that the simulated observed data.

For all these species, the original dataset has a significantly larger value of $R^2$ ($p < 0.05$) than the distribution of values of $R^2$ under our model of the null hypothesis (Appendix S6). Therefore, the null hypothesis is rejected at the 5% level, for all three species, in favour of the alternative hypothesis that the true values of density and $\sigma$ are, indeed, correlated. It is still possible that the observed relationships presented in Table 2 represent a combination of the relationship between the true values, plus correlated noise from the estimation process.

**Appendix S6.** Comparison of observed and simulated $\sigma$-density datasets and corresponding $R^2$ distribution resulting from model fittings, used to reject the null hypothesis that the true values of $\sigma$ and density are uncorrelated. Left column: reported data that had both a mean estimate and a standard error, plotted in log-space, with the symmetrical error bars used to generate the simulated datasets. Centre column: example simulated datasets with each true (black circles) / observed (red circles) pair. Right column: histograms of the $R^2$ resulting from the 100 000 regression models compared to the original $R^2$ value.




## References

Efford MG 2023. secr: Spatially explicit capture-recapture models. R package version 4.6.1. https://CRAN.R-project.org/package=secr

Efford MG, Borchers DL, Byrom AE 2009. Density estimation by spatially explicit capture-recapture: Likelihood-based methods. In: Thomson DL, Cooch EG, Conroy MJ eds. Environmental and ecological statistics 3: Modeling demographic processes in marked populations. Boston, Springer. Pp. 255–269.