Supplementary Material

Rattus management is essential for population persistence in a critically endangered passerine: combining small-scale field experiments and population modelling.

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Supplemental Methods

Appendix 1: Stage specific-survival rates

To estimate stage-specific survival rates, hazard models were used based on individually marked (in the nest), wild fledged birds born into the released, supplementary fed, island population from 2006 to 2013 (Ferrier et al. 2013; Hotopp et al. 2012; Maggs et al., 2009, 2010, 2011). This population is monitored on a daily basis, 365 days a year, providing continuous re-sighting data. Daily survival rates for both juveniles and adults were calculated in separate hazard models using the ‘Survival’ package in R version 3.0.1 with the function ‘survreg’ to account for censored data (R Core Team, 2013; Therneau and Lumley, 2014). We fitted separate models with exponential or Weibull error distributions to explore both constant and age-specific variation in hazard. These null models were then compared using a two-way analysis of variance and the error distribution with the lowest residual deviance was used. The parameter estimates from the chosen models were then transformed to generate the daily survival rate; these rates were then calculated to the power of 365 to generate annual survival for both juveniles and adults.

The hazard models were run using the Weibull error distributions due to the low residual deviance. Juvenile survival (i.e. first year) was estimated at 0.63 (approx. 95% C.I. = 0.23-0.86, n=32) and annual adult survival at 0.81 (approx. 95% C.I. = 0.72-0.87, n=16).

Survival data used, although from the same species, were derived from the supplementary fed, rat-free, island population, which may have generated higher survival rates than those seen in the mainland population. Nonetheless, the increase in the population multiplication rate remains comparable as the same survival rates were applied to each rat management treatment.

Appendix 2: Individual-based stochastic simulation model biological parameters

The model was parameterised from existing olive white-eye data collected between 2007 and 2011; available from internal reports (Cole et al., 2008; Maggs et al., 2009, 2010, 2011). These data were derived from studies on both the mainland population in the Combo region, an un-ringed remnant population which is monitored during the breeding season (August-March), and the reintroduced island population on Ile aux Aigrettes (20˚42′S 57˚7′E) which is ringed and monitored on a daily basis throughout the year.

Daily nest survival during nestling and incubation (DNS_I and DNS_N)

The DNS_I and DNS_N of nests during the 2010/11 experiment were generated from the described Mayfield logistic regression generalised linear mixed effects model (GLMM), extracting the parameter estimates and standard errors from the model output for Control, Trap and Poison management (section 2.4.2).

Mean initial first egg date

The mean and standard deviation was estimated using the mainland population data in 2010/11. The first nesting attempts of known breeding pairs were used, calculating the number of days from the start of the season (1st August as day one) until the first day of incubation. Observations are not taken on a daily basis so all values were rounded up to the nearest day.

Duration of nest building

This was measured using the mainland population data from 2007 to 2010. Only nests which were found during early nest building and which reached incubation were included as breeding pairs are known to abandon nests during the building stage and after completion. Nests are not observed daily and so all values were rounded up to the nearest day.

Hatching and fledging probability

Due to the inaccessibility of nests in the mainland population the hatching and fledgling probability was calculated using the island population nesting data from 2007 to 2010. This provided accurate clutch and brood sizes along with hatching and fledging rates. These rates were used to calculate the hatching and fledging probability of eggs and chicks with a GLMM framework run in the package 'lme4' using the analytical package R version 3.0.1 (Bates et al., 2013; R Core Team, 2013). A hatching or fledging rate binomial response variable was used with a survive numerator (number of eggs/nestlings hatching/fledging) and a fail denominator (number of eggs/nestlings failing to hatch/fledge) created using the 'cbind' function in R with no fixed effect and territory as a categorical random effect (to account for repeated nests from the same pairs). This generated the mean number of eggs hatching and nestlings fledging per nest without a rat predation risk.

Clutch size

Due to the inaccessibility of nests in the mainland population, nesting data from the island population were used from 2007 to 2010. Using the mean clutch size from the island nesting data, randomised clutch size values were generated for the parameter rounding up all values to the nearest integer.

Maximum number of successful nests

Most *Zosterops* species average two nesting attempts per season (Bennett & Owens 2002) and this would also be the case for the olive white-eye if they were successful. However, the maximum number of successful nests was set at seven as this was the maximum number of nesting attempts reached by individual breeding pairs in the 2010/11 season. This was set to prevent the simulation model allowing females to re-nest to unrealistic levels. A negligible amount of simulated females reached this value; less than 1% under each management treatment.

Maximum incubation and nestling periods

These values were taken from existing literature (Nichols et al. 2005).

Re-nesting probability

Re-nesting probability functions of mainland olive white-eye breeding pairs following a failed or successful nesting attempt were estimated from all nests in the mainland population which reached incubation during the 2010/11 breeding season using a GLMM framework run in the package 'lme4' using the analytical package R version 3.0.1 (Bates et al., 2013; R Core Team, 2013). Whether a pair re-nested following a nesting attempt was the binomial response variable (1 = yes, 0 = no), with the day of the nest outcome as a continuous fixed effect (in days from the 1st August) and territory as a categorical random effect (to account for repeated data from the same breeding pairs). Separate models were run for successful and failed nests and the parameter estimates for re-nesting and day were back transformed to calculate the daily re-nesting probability for each day of the season (211 days).

The daily re-nesting probabilities generated for pairs following a successful nesting attempt indicate that the activity of successful pairs declines steadily throughout the breeding season, whereas for pairs that fail the probability of re-nesting declines more sharply leading to a shorter breeding season (Fig. A1).

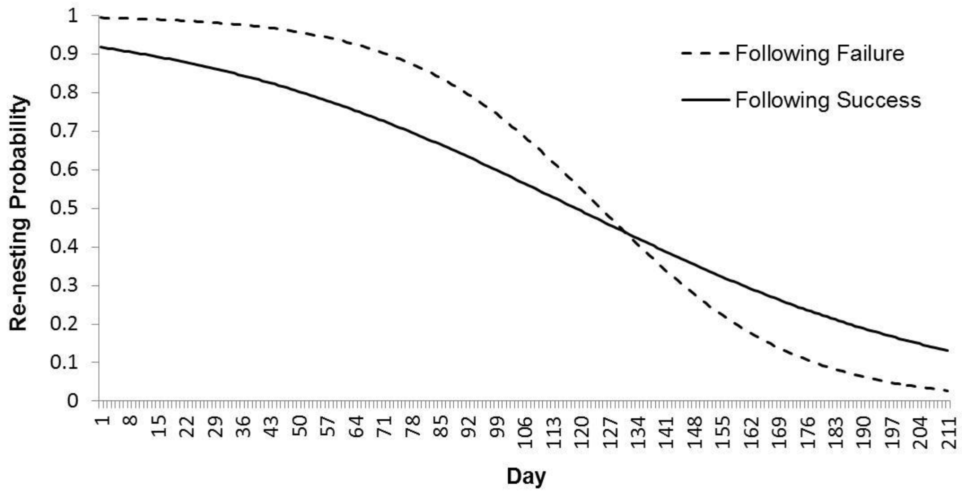

Figure A1. Re-nesting probability of Mauritius olive white-eye breeding pairs at Combo, following a successful or failed nesting attempt in the 2010/11 breeding season. The season is measured in days from 1st August and only included nesting attempts which reached incubation.

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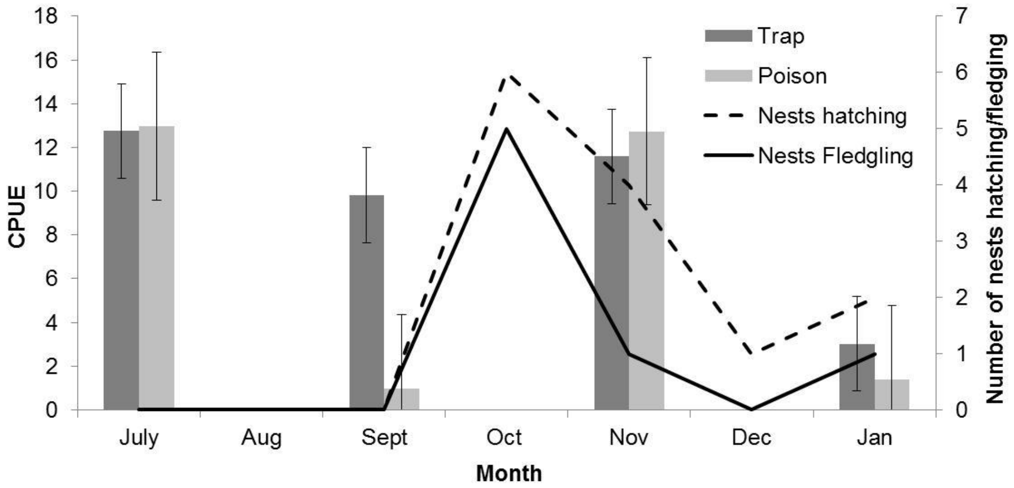

Fig. A2. Average rat catch per unit effort (CPUE) after accounting for sprung traps in Mauritius olive white-eye territories under different rat management techniques; snap-trapping only (Trap) and rat poisoning and snap-trapping (Poison). This is plotted against the number of Mauritius olive white-eye nests which hatched or fledged one or more nestlings in 2010/11. Bars represent standard error.