Predictors of fitness informal discussion

*Mixed Model Selection*

Choosing the random effects structure of the mixed model has a large effect on the significant fixed predictors retained after model selection and therefore the biological interpretation of the model. I chose a model selection procedure advocated by Ben Bolker in several texts and in the text I cite in the draft report (Zuur et al 2009). I decided on this approach in advance of fitting the data and ultimately stuck to that, but exploring alternative random effects structures revealed some interesting patterns that I describe at the end of this section.

For this project, we have fixed effects that are calculated entirely within the levels of the random effects. For example, release group sex ratio is the same for all individuals within a release group. But release group is also fit with a random intercept. This creates a potential problem: we are reducing our power to find significant predictors because the fixed and random effects structures are competing for the same information. Should we include release group fixed effects, release group as a random effect or both? The same goes for year (annual sex ratio fixed effect and year random effect).

I examined different random effect structures using AIC, with a full random effects structure showing up as best, but ultimately, the “best” random effects structure is a question about the inferences we'd like to make and AIC is only one piece of information to help us understand the relationship between parsimony and model fit, it doesn’t help us decide which inferences we’d like to draw from the model.

Since we are primarily interested in evaluating the significance of predictors, my preference was to be conservative and include them as random effects AND to include the fixed effects that are estimated within each level of the random effects. Failing to include year and release group as random effects would imply that we are uninterested in the correlation within groups. Inferentially, a model with no random effects for year or release group implies that the fixed effects at the level of release group or year (release group: sex ratio, density and year: n and sex ratio) are the only effects that might lead to correlation within the levels of the random effects, and we are free to pool across all levels of release group or year and attribute all variance to fixed effects. This seems far too anti-conservative for our report.

Even with fitting year as a random effect, the annual sex ratio was a strongly significant predictor that we retained in the final model. The same was not true for release group level fixed effects. Perhaps not surprisingly (given the annual GLMs) when we do not include the random effect of release group, many release group level variables become significant in model selection (e.g. release group density). To me this suggests that the overall variance other, unmeasured variables that effect fitness at the level of release group have a large effect on fitness and we can’t parse these from the fixed effects of density and release group sex ratio.

Putting this all together, model selection in the mixed model suggests that we only have enough information to infer that annual sex ratio and it’s interaction with sex is important. We did not find any strong evidence that other predictors of fitness are important.

.

*Multiple Comparisons and Collinearity Reduce Confidence in Annual GLMs*

We have five separate model selection procedures, and a lot of individual predictors being evaluated across all 5 years. This leads to a bit of a multiple comparison problem for the annual GLMs. Given that we only rarely have an effect with very low p-values, it is possible some spuriously significant effects are included in final models because of multiple comparisons. Also location nearly always produced multicollinearity in the model fits when used with all other predictors. Usually the multicollinearity could be eliminated by removing either release day or location, but not always. I always removed location for consistency, but the choice is arbitrary.

Taken together, significant effects in individual years should be considered with caution. Some trends are interesting though, especially considered with the mixed model results (below).

*Density*

Release group density has a significant effect (Wald test p < 0.05) and/or improves the fit the data (LRT p < 0.05) in 4 of the 5 annual GLMs. The effect does not initially appear to be consistent, until you consider the range of densities used in each year. When averaged across both males and females, density appears to improve TLF up to an optimum value somewhere above 75, then it declines. However, females and males demonstrate different fitness relationships with density.

When we combine all years into a single mixed model, we find the same pattern (see figure below), but it probably cannot considered significant. Density effects are not retained by either backward model selection by Wald Tests or by likelihood ratio tests. When fitting a saturated model with all possible effects, however, an interaction with density is marginally significant (sex \* density2 Wald test p-value 0.044). Some folks might include this as a significant effect, I’m not so sure. My inclination is to highlight that density might have an effect on TLF in the discussion, but ultimately we do not have high confidence. In any case, the effect size is pretty small.

![Chart, line chart

Description automatically generated]()

Figure: Estimated effect of release group density and sex from the saturated (initial) mixed model containing all possible effects (Wald test p-value of sex \* density2 = 0.044). Effect is conditioned on the “typical” value of all other variables in the model.

*Release Day*

A later release day is associated with increased TLF in 3 of the 5 annual GLMs. However the consistent confounding of release day and location precludes us from drawing any strong conclusions here. Release day does not appear to have a consistent effect in the mixed model that combines data across all years.

*Release Group Sex Ratio*

Extreme release group sex ratios are associated with lower fitness in 2 of the 5 annual GLMs.