Modelling Methods

To evaluate the influence of time out of water, air temperature, and carapace length on the post-release survival of *P. platyceros* captured in trap fisheries, we used generalized linear mixed-effects models (GLMMs) with binomial error structure to model the probability of survival. The models included random effects to account for the hierarchical structure of the experiment. Prior to statistical analysis, we excluded some prawns (488) from the dataset (n=5053) and assessed potential effects of our experimental design on the interpretation of results.

We excluded prawns for which one of the following pieces of information was missing: treatment group or carapace length. A small portion of the prawns (273) lost their coloured band during the release stage of the experiment (Figure 1); as the band colour denoted treatment group, prawns that lost their band could not be assigned to a treatment. To ensure we would not confound our results, we compared the size distribution of these prawns to that of the prawns that retained their band (Appendix 1). There was a statistically significant difference between the two groups (T=3.25, *p*=0.0013), however the difference was very small (1 mm, 3%) (Figure 2). These individuals were excluded from the final dataset. We excluded an additional 215 prawns that had damage on their carapace such that we could not measure length accurately. Although there appeared to be a correlation between carapace damage and treatment group (Figure 3-carapace damage per treatment), we assessed the influence of this potential bias and found it was minor.

We considered how two features of our experiment may have influenced results: prawns lost from the traps, and varying salinity across trials. We lost prawns in two ways: either through the mesh of the bags used during the treatment stage, or through the mesh of the traps during the release stage of the trial. We could not collect end-of-trial data for these individuals. To investigate whether there was a bias in prawn loss, we evaluated the percentage of prawns lost in each treatment. We found that we lost slightly more prawns at longer treatments times (Figure 3). To evaluate the influence of the potential bias in prawn loss, we simulated four scenarios for prawn loss: we lost no prawns; we lost only dead prawns; we lost only living prawns; we lost dead and living prawns with equal frequency. We evaluated the difference in survival estimates between the four scenarios to address whether loss of prawns could confound our interpretation of how survival did or did not differ across treatment groups. This analysis showed that for a typical percentage of prawns lost (20%) (Figure 3), even if we lost living or dead prawns more frequently, the effect on the estimated percentage of prawns that survived was minor (maximum 6% for most trials) (Figure 4).

The salinity of the water to which exposed prawns to in the treatment stage varied slightly across trials (figure X). Salinity could not be collected for trial 11 due to broken equipment. Because prawns are thought to be negatively effected by fresh/brackish water (Citation?), we excluded trial 11 to avoid underestimating survival.

We took a model selection approach to evaluate the relative importance of three fixed effects and their two-way interactions: time out of water, air temperature, and carapace length. We did not include the three-way interaction term because it is difficult to interpret. In total, we considered a suite of 18 candidate models (Table 1) to predict prawn survival. All models included a random effect on the intercept to account for variation in survival caused by the trap a prawn was in; there were 123 levels. We expected survival may vary between traps because location, time, and orientation on the ground varied between traps. We conducted all analyses in R (R core team 2023). For completeness, the models were fit in two ways: Gaussian Quadrature (10 points) with lme4 (Bates et al. 2015), and Laplace approximation with glmmTMB (Brooks et al. 2017). To prioritise simplicity and interpretability, we compared models using Bayesian Information Criterion (BIC) (Table 1).

Results

Leaving prawns out of water for 0-120 minutes resulted in a significant number of dead prawns (2149/4598, 47% mortality). Prawns left out of water for longer died more than those released quickly (Figure 1). Temperature also influenced survival; individuals that were treated on hot days died more than those treated on cool days (Figure 2). Contrary to expectations, short prawns survived slightly more than long prawns (Figure 3), although only by a slight margin. Very small prawns (<29 mm), which were mostly juveniles, survived the most (Figure 4), although that may have been due to the trials in which they occurred (Table ). For mid-size prawns (29-38 mm), which were primarily males and transitionals, there were slightly more living prawns than dead prawns. The biggest prawns (>38 mm), transitionals and females, died slightly most often (Figure 4).

To assess wheth­er our estimates of mortality were accurate and not right-censored (i.e. whether prawns died due to treatment after the experiment), we assessed the surviving prawns for a suite of reflex behaviours. Surviving prawns retained most of their reflexes (Figure 5), indicating that the treatment did not severely damage them. Stoner et al. (2009) exposed prawns to different types of stress, recorded how many reflexes each prawn had lost (impairment score), and monitored their survival for a month in a lab setting. They found that impairment score was a good predictor of mortality for that time period and created a model which gives the probability that a prawn will die within a month, as a function of its impairment score. Using this model, along with the impairment scores recorded for each treatment, we calculated the number of prawns expected to die within a month after the experiment, for each treatment (Figure 6). Across treatments, the predicted post-experiment mortality ranged from x-x%; it was higher for shorter treatments, due to the number of surviving prawns.

* + Transition Sentence

For the model selection, BIC did not select a single best model but instead scored five models similarly (Table 2). The five ‘best’ models all included treatment time and air temperature as main effects and as an interaction; four of the top five models included length as well. We performed model averaging based on BIC scores and compared the averaged model against the top model (BIC=0) and a model with only main effects (Table 3). The averaged and best models predict very similarly; the largest deviance between the probability of survival predicted by the two models was 0.0x%. The main-effects-only model also predicted similarly to the averaged model, with a maximum deviance of 5.x% from the averaged model. The accuracy was also very similar for the three models, all within 78-80%. The coefficients in all three models were similar. Because the average model and top model predict similarly, we decided to present results based on the latter for simplicity.

Note: Think about legal changes and implementation the whole time

The top model included two interaction terms, treatment time x temperature and temperature x length, and three main effects, treatment time, temperature and length. The amount of time prawns spent out of water had the biggest effect on prawn survival (Table 3) and the effect increased with temperature (Figure 7). The top model predicted longer prawns will die more frequently at low temperatures, however as temperature increases longer prawns will do better. The effect of length and the temperature length interaction are both relatively small(Figure 8).

Treatment time had the largest effect size after we standardized all three variables, followed by temperature (), and length () (Table 3).

Figure 1 <-Unbanded per trial Histogram #REPLACE WITH TRIAL TABLE

Figure 2 <- Unbanded vs banded length violin plot

Figure 3 <- prawn loss per treatment

Figure 4 <- Loss thought experiment

Figure 5 <- Treatment Survival histogram

Figure 6 <- Temp survival

Figure 7 <- Length survival

Figure 8 <- Stage Dist?

Figure 9 <- Reflex Dist

Figure 10 <- predicted release mortality stacked barplot---- discussion?

Figure 11<- 3 panel Survival curves by temperature with temperature-binned survival average points.

Figure 12<- Survival 9 curves, showing relative influence of length and temperature

Table 1 <- Trial summary table

Table 2 <- BIC Table

Table 3 <- Model Comparison table

Appendix 1 <- multi-page trial summary

References

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