Preregistration

Study preregistration

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Study Information

Title

Does novel competition drive selection on morphology?

Through their long-term, empirical study Grant & Grant (2006) provided one of the few examples of natural selection acting on traits in a native population in response to novel competition and despite their call for future studies to replicate their work, none have done so. Therefore, we will use 49 years of data to replicate Grant & Grant (2006) by testing for selection on bills in a native population of birds in response to novel competition for seeds with a non-native population of birds.

Hypotheses

We are investigating whether bill size influences survival in song sparrows.

Predictions

Given that fox sparrows are the larger, dominant competitor and reduce over-winter survival in song sparrows, we expect directional selection to be acting on the bills of song sparrows throughout the study, and have alternative predictions regarding the outcome of selection on bills depending on whether niche differentiation from fox sparrows is possible on such a small island (6ha):

a. Given selection in favor of niche differentiation from fox sparrows (broad feeding niche), we expect directional selection to cause a reduction in bill size (PC1) of song sparrows over time, as predicted by Grant & Grant (2006).

b. Alternatively, given selection in favor of maximizing feeding efficiency on the limited and relatively large seeds on Mandarte Island (narrow feeding niche), we instead expect directional selection to cause an increase in bill size (PC1) of song sparrows over time, as predicted by Abrams (1987) and Johnson et al. (2018).

Design Plan

Study type **Observational Study**. Data is collected from study subjects that are not randomly assigned to a treatment. This includes surveys, natural experiments, and regression discontinuity designs.

Blinding No blinding is involved in this study.

Study design This empirical study was started by Jamie Smith in 1975, so while this preregistration does not precede data collection, the methods for monitoring and collecting data on the song sparrows of Manadarte Island were used consistently for the past 49 years and are described in detail in (Smith, 2006). In short, all birds are uniquely identified by their combination of colored bands and a numbered metal band (hereby bind identity), allowing researchers to track individuals from hatching until their disappearance. Because birds are banded as nestlings, we know their exact age at any given time, they are captured in mist nets and measured throughout their lives, and once they become territorially active we identify their sex.

Sampling Plan

Existing data **Registration following analysis of the data**. As of the date of submission, you have accessed and analyzed some of the data relevant to the research plan. This includes preliminary analysis of variables, calculation of descriptive statistics,

and observation of data distributions. Please see https://cos.io/prereg for more information.

Explanation of existing data

As inidicated above, I am creating this pre registration after having analyzed my data. But I planned my hypothesis, predictions, and analyses prior to analyzing my data while submitting an application for funding (NSERC-CGSM, which I imagine is available online). I finished collecting my data in August 2023 which was well after the application for funding was due (December 2022), so thats as much of a guarantee as I can give that I did not review my data before planning my study.

Data collection procedures

Repeatable procedures:

Our study is working to replicate Grant & Grant (2006) which focused on two populations of finches in the Galapagos Islands. Clearly our focus species and location is different but the principles are the same:

Monitoring birds

Birds are uniquely identified and monitored consistently throughout the breeding season (at least weekly from April-August) throughout the entire study.

Morphology measures

Birds are captured in mist-nets and measurements of bill length, depth and width are taken using vernier calipers to the nearest 0.1mm. A consistent effort to capture and measure birds was employed throughout the study. To ensure high repeatability of measures among observers, the same observer measured birds and trained other observers to measure similarly for 41 of 49 years. Only fully-grown birds will be used in analyses. Smith & Zach (1979) found song sparrows were fully grown at 58 days old.

Survival status

Over-winter survival is used to measure selection on song sparrows, following Johnson et al. (2018), which is assessed in April each year and is scored as a binary response. Birds are considered to have survived if they were seen with two independent sighting or a very confident sighting (ie. caught in a net, there were notes that bands were double-checked, or bird movement mapped by a skilled observer).

Location/species-specific circumstances potentially affecting repeatability:

There are several distinct features about the species and location used in our study that would need to be considered carefully by a future researcher attempting to replicate:

1. Mandarte Island is the only recorded place where song and fox sparrows compete for food. Unlike mainland populations, native populations on oceanic islands can be subject to greater competition with invasive species for food resources (Soares et al., 2021). The island is made up of bare rock and a handful of shrub species that produce seeds for the sparrows to feed on, however, they overlap completely for their preference of seeds (Johnson et al., 2018). The geographical location and vegetation of Mandarte likely make the competitive environment here unique and its hard to say whether these species would compete under different conditions.
2. Song sparrows are widespread and vary dramatically in morphology across their range, and even vary within the Haro Straight metapopulation that the song sparrows of Mandarte Island exist in. This study is driven by the contrast in size between song and fox sparrows, but if this study was repeated somewhere in the world where the size difference between song and fox sparrows is different than this study, it would be hard to say whether the researchers would find the same results.
3. Historically, fox sparrows were considered to be a migratory species, but populations in the Haro Straight have contradicted this since the late 1970s when individuals began over-wintering on islands in the straight, including Mandarte. Because this is an empirical study, a future study would need to also rely on having data available before a novel competitor (fox sparrows) colonized the island (1975 in this case) as well as in the several decades following this colonization.

Sample size

Because of the monitoring effort on Mandarte Island, this study does not focus on a sample but rather the entire population. The population varies dramatically in size over time, but years with low population sizes are still useful because they help inform how/why selection may be acting. That being said, the planned analyses include combining all years into one model so small population sizes in certain years are not of concern for running models.

Sample size rationale	Not applicable.
Stopping rule	In 2023 the song sparrow population became functionally extirpated given that no females on the island were resident birds. The only females were immigrant birds from nearby islands who genetically differ a surprising amount from resident birds. The immigrant genes are causing the population to be quite unlike the resident population at the beginning of the study (e.g. fitness). Further justification is that our work provides us with 49 years of selection data which is more than the 33 years of the study we are emulating (Grant & Grant, 2006). Finally, the principle investigator and project supervisor are retiring.

Variables

Measured variables

- Survival is measured as a binary response.
- Using bird identity we will calculate an average bill length, depth and width for each for each bird, taking advantage of repeat measures of individuals to maximize precision and correct for variation among observers. Bill length, depth and width will then be reduced to two morphological characters by extracting the first two principal components: PC1 bill size and PC2 bill shape.

Analysis Plan

I will calculate selection gradients to test for directional selection on traits.

Dependent= Survival (0,1)

Independent=Bill size (PC1), Bill shape (PC2)

Statistical models

Necessary context: We will merge our file of averaged traits (1 row for each unique bird) with a survival file that contains one row for each year of a birds life (1+ rows for each unique bird) so that each bird is present in the data in each year it is alive and has an associated score (0,1) indicating whether it survives the following winter, but its traits are averaged across its life for maximum precision.

***Model*:** We will separate our data to get 4 classes: fully grown female yearlings, fully grown male yearlings, adult females, adult males. We will test for selection within each class using generalized linear mixed models (GLMMs) using the glmer function from the lme4 package in R studio. The model will include the dependent and independent effects described above as well as 2 random effects. Year will be a random effect in each GLMM, while bird identity will be random effect only in GLMMs for adults because unique adults may appear in the data in multiple years while unique yearlings are only present in the data once.

Transformations

We will follow other selection studies using morphological data which recommend z-standardizing traits prior to analyses (e.g., Grant & Grant, 2014; Mumme, 2023). We found mixed opinions on whether traits should be ln-transformed prior to standardization (e.g., Schluter & Smith, 1986) so we will compare results when traits are and are not ln-transformed.

Inference criteria

We will use the standard $p<0.05$ to test whether logistic regression suggest results are significantly different from those expected if the null hypothesis (no selection) were correct. The sign of the regression coefficients will indicate the direction of selection, which will inform our a-priori predictions. If models are unable to converge we may have to adjust the optimizer or number of iterations. If any bill size and shape are highly correlated we may have to remove one of them or analyze them separately, though we don't anticipate this to be an issue because using PCAs usually avoids this issue. If we find directional selection is not operating on traits we will test for stabilizing selection which is not what we expect to see but would only be operating if bills of song sparrows are near their phenotypic optimum.

Data exclusion	We will only use birds which are fully grown (58 days or older). Male song sparrows are larger than females so when we clean the data we will separate the birds by sex then remove any measures which exceed 3 standard deviations from the trait mean. After this, measures for each unique bird will be averaged to increase precision and correct for variation among observers.
Missing data	If an individual is missing a bill length, depth, or width measurement we will not be able to calculate PC1 or PC2 for the individual so they will not be included in analyses. If an individual does not have a survival status assigned (0,1) it will be omitted completely.
Exploratory analyses (optional)	Given that we have measures for wing, tarsus and mass as well we could calculate PC1 body size. We expect there could be some correlation between bill and body size but have no specific expectations as to whether selection is acting on body size.

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