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Using Artificial Selection to Understand Orientation Behavior in Drosophila

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Introduction

Several studies suggest that the fruit fly *Drosophila melanogaster* can use magnetic fields for orientation[1-4]; however, the responses to magnetic fields are not consistent across studies and experiments investigating the mechanism of magnetoreception rely on magnetic fields that are at least 10 times stronger than the magnetic field of the Earth[5-6]. We are attempting to determine whether *Drosophila* have the ability to detect Earth-strength magnetic fields by running flies through a progressive Y-maze and then selectively breeding the flies based on their choices in the maze.

There are two main hypotheses about the mechanism of magnetoreception in animals. The first is based on the use of magnetite, which forms long chains and serves as a magnetic dipole and has been found in organisms such as bats[7]. The other hypothesis is based on a light-dependent magnetic response utilizing the cryptochrome photoreceptor[8]. While the predominant hypothesis is that fruit flies use cryptochrome to detect magnetic fields[1-6], experimental results have shown that most invertebrates use magnetite or both magnetite and cryptochrome.

Methods

- Wild-type flies (Generation 0) were collected from a composting site in Monmouth, OR.
- We used a progressive Y-maze with 10 branch-points (Figure 1), allowing flies ten choice points to go north or south (right or left).
- The maze was orientated randomly so North was directed to both the right and left throughout the trials.
- All experiments were performed blind. The researchers setting-up the maze and the researchers recording results did not know which population of flies they were using.
- After each run, the top 20% of the north-selecting or south-selecting flies were collected and used to breed the next generation of flies.
- Data were scored so 10 north choices was recorded as a 10, and 10 south choices was recorded as a 0.
- As controls, we bred light- and dark-selected flies in the same manner as the north- and south-selected flies. The only difference in the maze setup is that there was a light gradient across the maze. Data were scored so 10 light choices was recorded as a 10, and 10 dark choices was recorded as a 0.
- We have completed 15 generations of breeding flies and are currently performing replicate trials. We will ultimately perform ten replicates for each treatment condition.

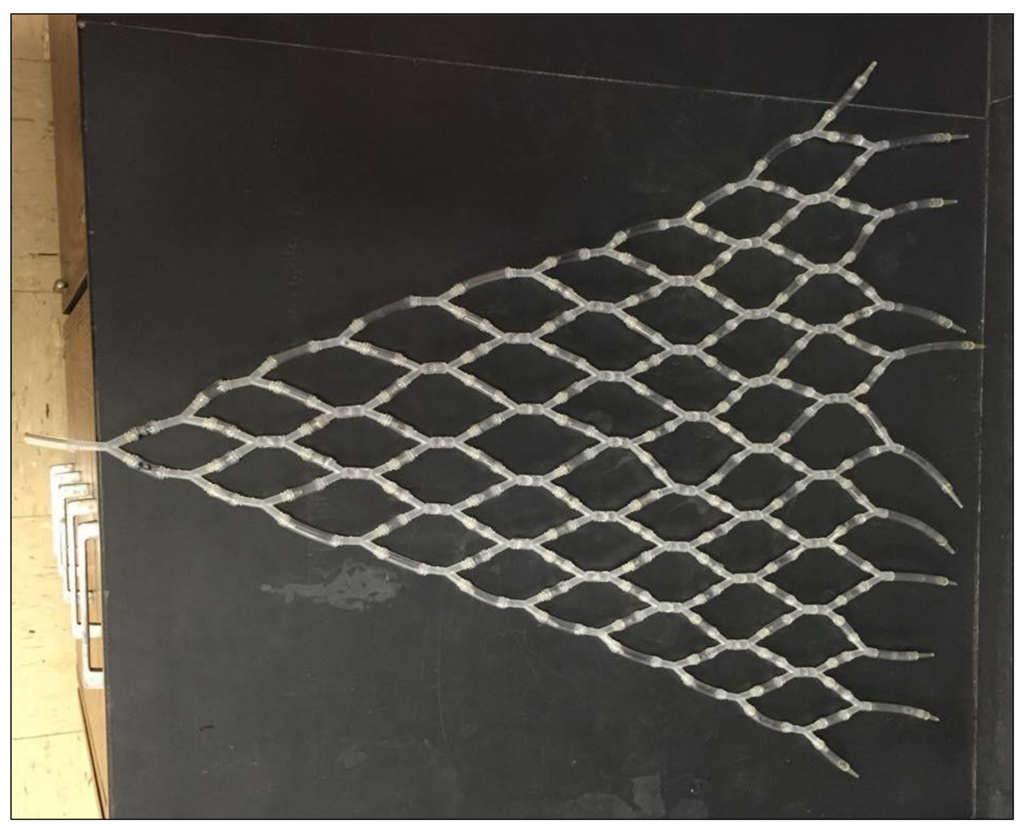

Figure 1: Photo of the Y-maze utilized in assay of the flies for directional orientation or phototaxis. The entry point from the start vial is to the left in the image.

Results

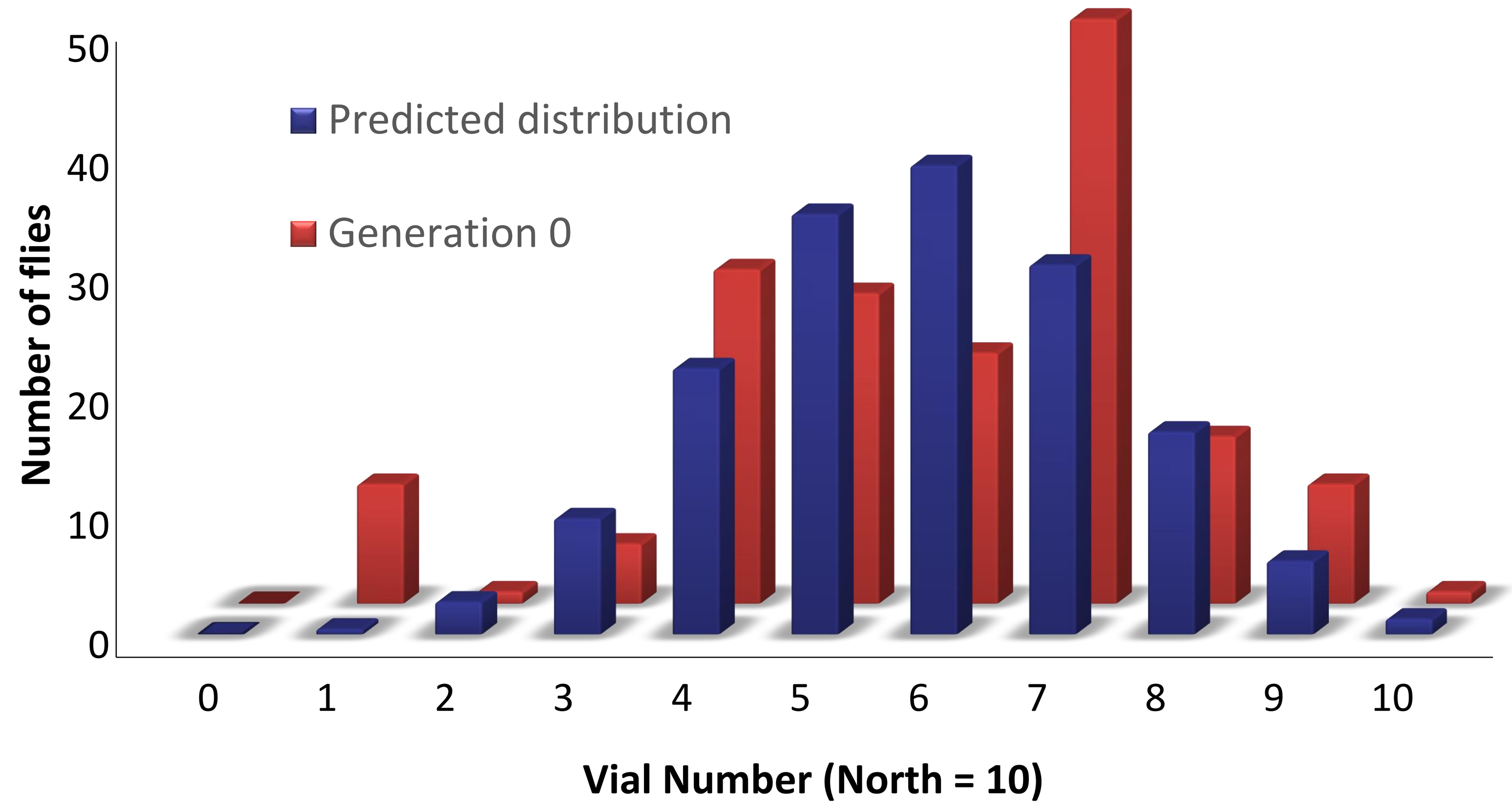

Figure 2: Flies do not move independently of each other through the maze. Predicted distribution versus actual distribution of the flies in each vial from one of our Generation 0 North-South trials with an average vial choice of 5.8. The actual distribution was significantly different than a normal distribution ($\chi^2_{0.05,10}$ = 235.6, p < 0.001).

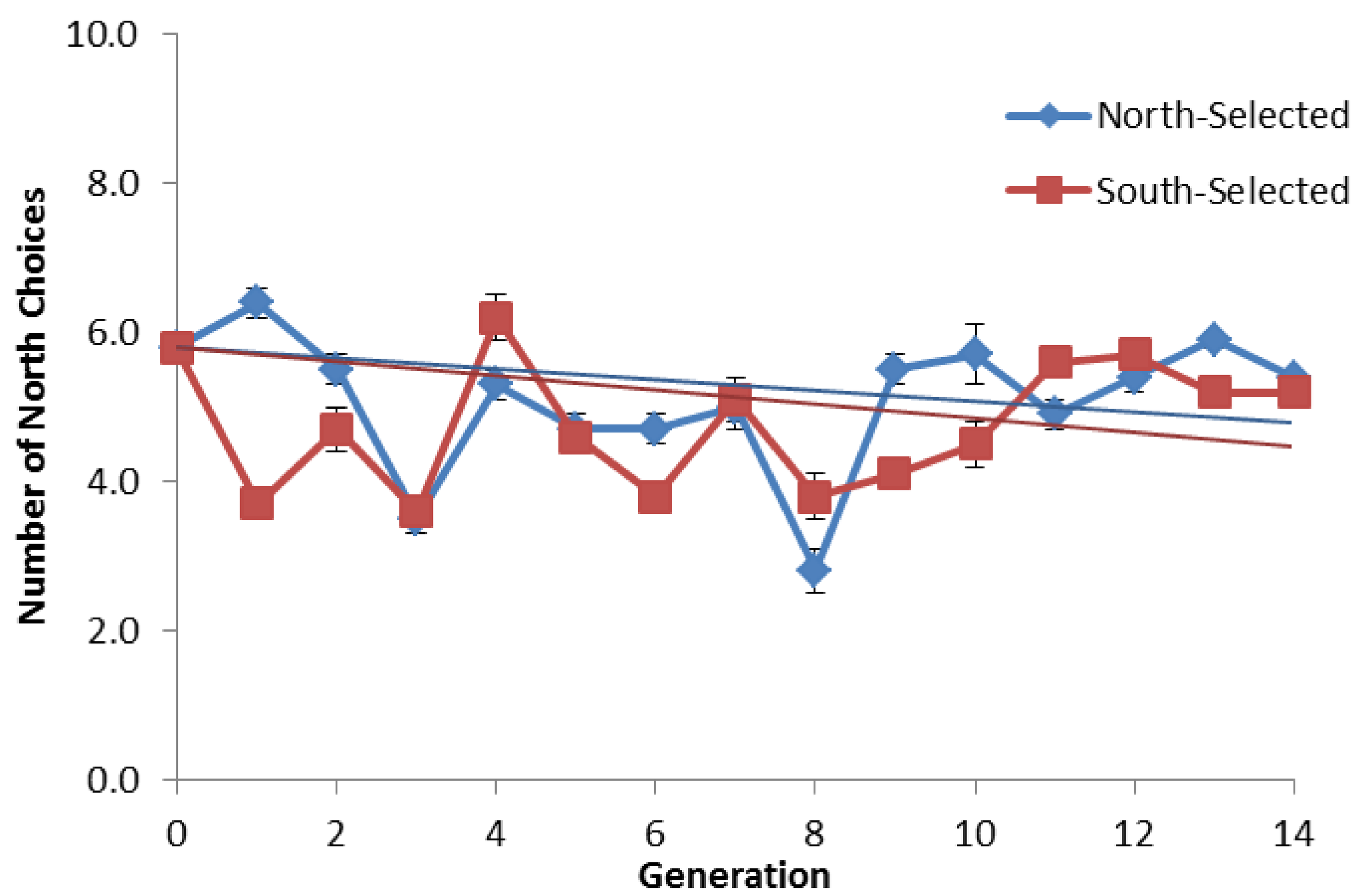

Figure 3: North- and south-selected flies did not show divergence in directional orientation. Average number of north choices for 14 generations of north- and south-selected flies. There was no observed difference in directional preference between the north- and south-selected flies in generations 1-7 (t-test, p= 0.31), or in generations 8-14 (t-test, p= 0.56). Each trial consisted of 136 +/- 13 flies (mean +/- SEM).

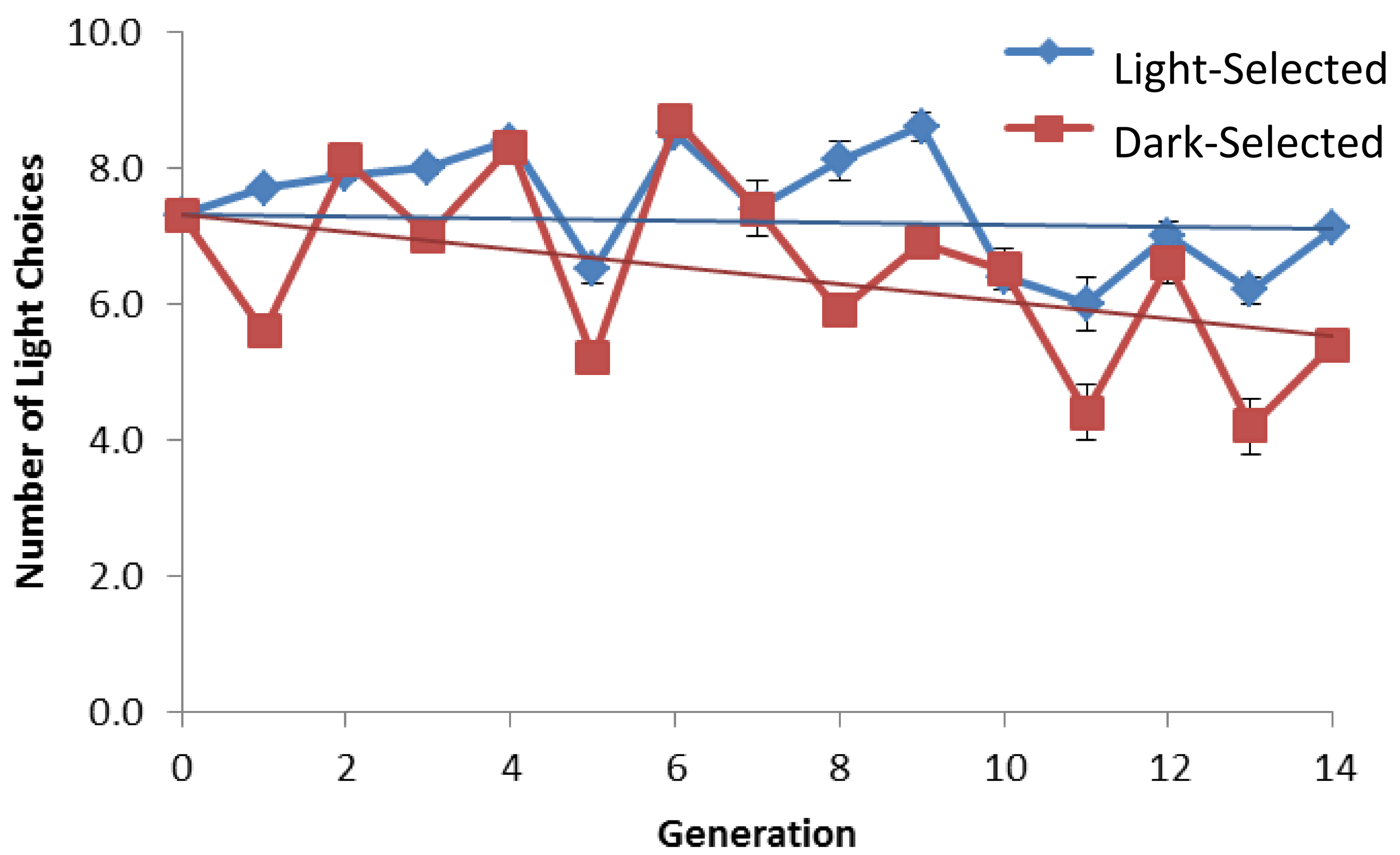

Figure 4: Light- and dark-selected flies appeared to diverge in phototaxic orientation. Average number of light choices for 14 generations of light- and dark-selected flies. There was no difference in phototaxis between the light- and dark-selected flies in generations 1-7 (t-test, p= 0.13), but there was a difference between the generation 8-14 flies (t-test, p= 0.01). Each trial consisted of 123 +/- 14 flies.

Results

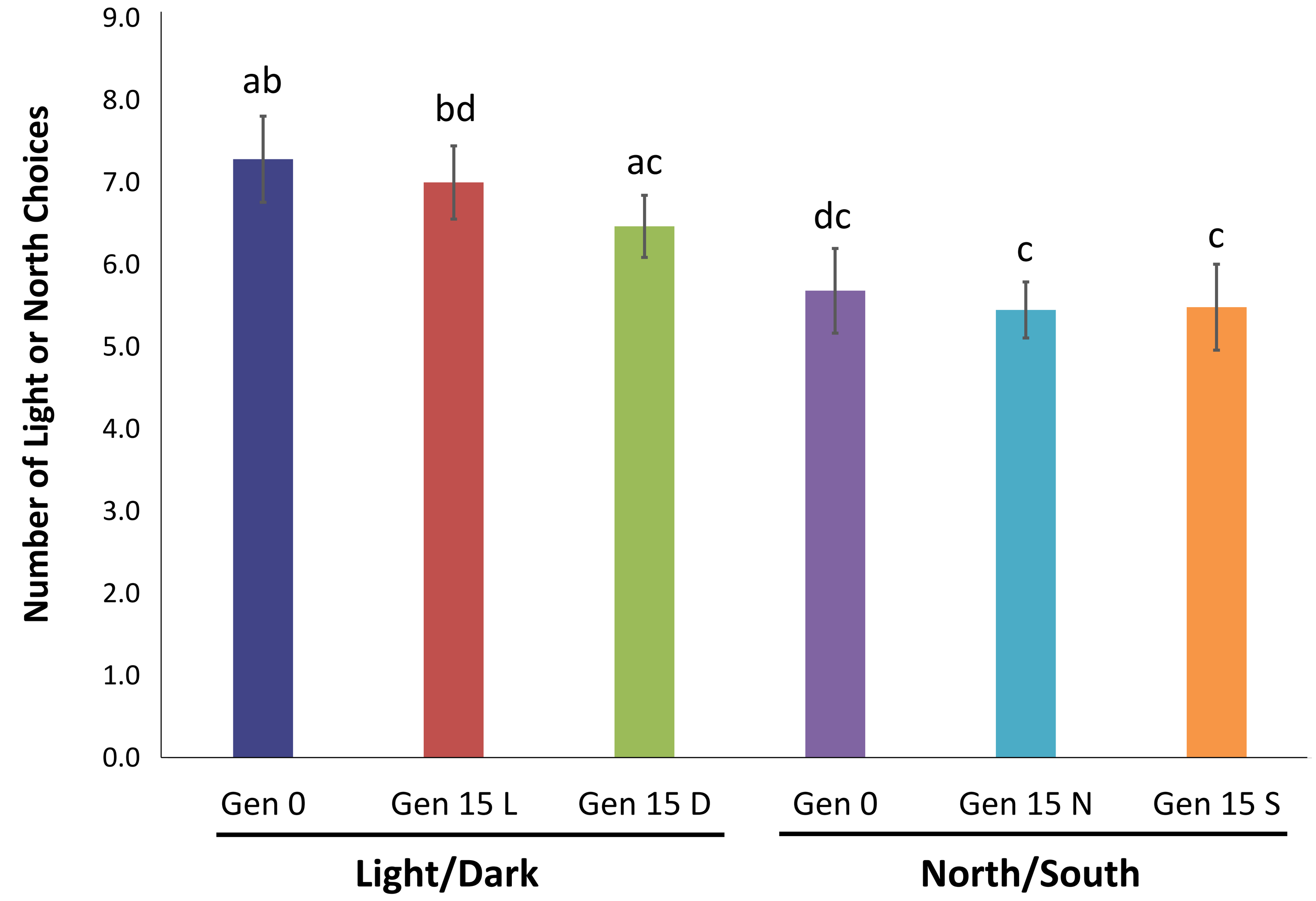

Figure 5: Orientation of flies after 15 generations of selection. Average number of light or north choices (+/- SEM) made by Generation 0 and Generation 15 flies. Bars with different letters are significantly different (ANOVA, p = 0.02; t-tests, p < 0.05; n = 6). The generation 0 flies had different distributions in the Light/Dark and North/South conditions, indicating an innate positive phototaxic behavior. Generation 15 light-selected flies (Gen 15 L) have a stronger phototaxic behavior than generation 15 dark-selected (Gen 15 D) flies. The orientation of generation 15 north-selected (Gen 15 N) and generation 15 south-selected (Gen 15 S) are not significantly different.

Conclusions and Future Directions

- During an individual maze trial, the distribution of flies in the collection vials was different from a normal distribution (Fig. 2). This indicates that the flies interact within the maze and the flies within an individual trial cannot be considered independent data points.
- Our results indicate that our artificially-selected flies do not have a directional preference based on Earth-strength magnetic fields (Fig. 3, 5).
- After 15 generations of selection, the strength of the phototaxic behavior of light-selected and dark-selected flies was different (Fig. 4, 5).
- As originally planned, we will perform 10 replicate trials for all of our fly populations.
- We are also sexing the flies to see if there is a difference between the maze choices of the male and female flies[1].

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