Exploring the Behavioral Enigmas of *Drosophila melanogaster*: Insights into Thigmotaxis and Centrophobism During Mating

Abstract

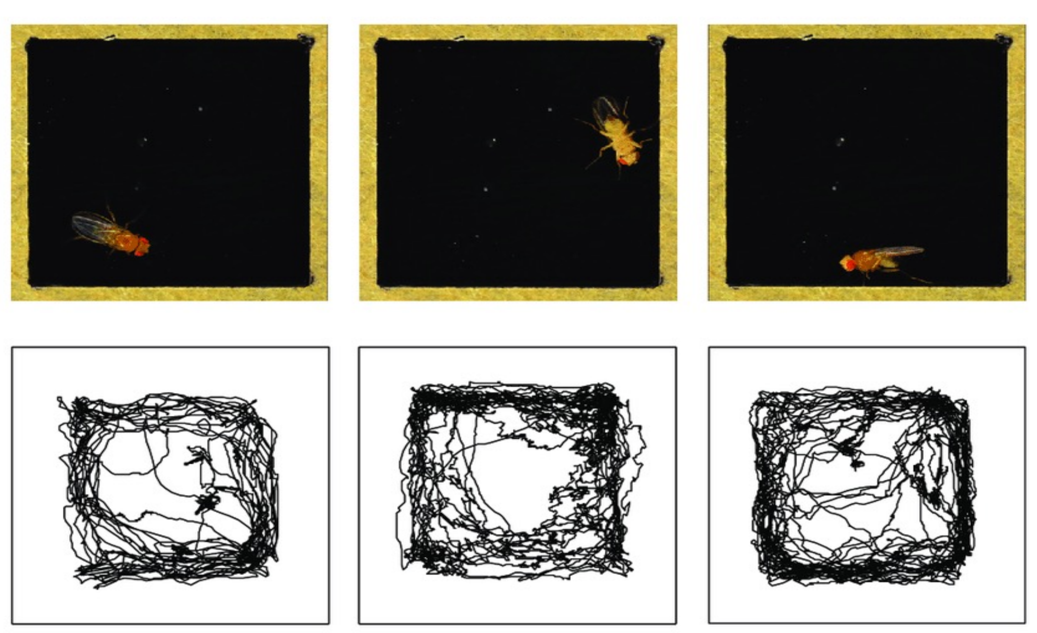
In *Drosophila* melanogaster, mating behaviors are influenced by genetic factors and environmental cues, affecting social interactions and evolutionary outcomes. Taxis behaviors guide navigation and survival by responding to environmental stimuli. Centrophobism is a preference for peripheral locations over central spaces in an environment, reflecting innate anxiety-like behaviors and survival strategies. However, the impacts of mating on thigmotaxis and centrophobism behaviors remains largely unexplored. The research shows that *Drosophila* melanogaster exhibits a significant increase in time spent in the center during mating compared to non-mating periods. Previously, it was thought that behaviors in *Drosophila* melanogaster might not significantly alter spatial preferences within an environment, focusing instead on the role of external stimuli such as pheromones and visual cues. The main result of this study adds to our understanding by demonstrating a clear shift in spatial behavior during mating, with a marked preference for the center of the arena, suggesting an intrinsic behavioral change linked to mating status. This is also able to be manipulated by different genotypes and hormones such as Sex Peptide. The findings from this study on *Drosophila* melanogaster mating behaviors extend beyond the specifics of fly biology, offering insights into the broader principles of animal behavior. This can then lead to novel fixes to anxiety in humans as *Drosophila* can be used as a model organism to study fear and anxiety. This can lead to gene therapies being developed at a higher throughput.

Introduction

Drosophila melanogaster as a Model Organism:
- Central to genetic, neurological, and behavioral research.

Behaviors in *Drosophila*:
- Exhibits thigmotaxis/ centrophobism (preference for edges)
- Mating alters *Drosophila* behavior based on social presence and potential for mating.

Figure 1. *Drosophila* Wall-Following (Mohammad et al., 2016)



Understanding Human Psychology:
- Studies suggest a genetic basis for fear and anxiety-like behaviors, paralleling findings in other animals and mammals.
- Research into *Drosophila* may offer insights into anxiety in humans.

Research Gaps and Future Directions:
- Limited understanding of the effects of mating on thigmotaxis and centrophobism especially regarding sexual reward.

Materials and Methods

Behavior Essays:
- Recording rate: 10 frames per second, each arena being 6 mm high.
- Strains used: Canton-S (CS) / Corazonin (CRZ)
- Total assays tested: 255 and 447 respectively
- Initial observations confirmed no significant preference for specific areas by Canton-S strain which was used for female control.

Figure 2. Mating Assays (1 cm radius) and Vials (Photograph by Researcher)

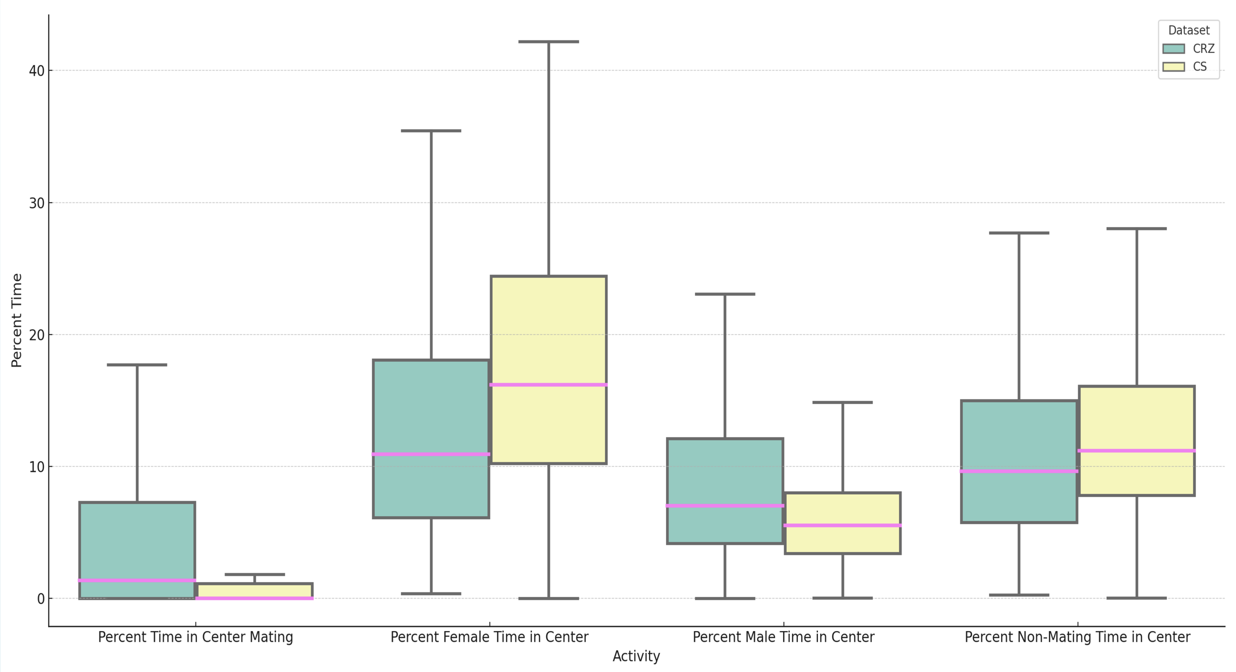
Video Analysis:
- Software capabilities include tracking the onset and duration of mating, spatial analysis, and compiling data.
- Red is non-mating flies, green is a fly in the center (mating/non-mating), blue is mating on edge, and yellow is contact.

Results

Statistical Analysis:
- Data graphed/analyzed by Python's matplotlib/pandas module.
- All graphs were made solely by the researcher.
- Analysis based on 170 CSW and 187 CRZ assays, cleaned by if the arena had mated flies are not.
- Statistical tests used were Mann-Whitney U tests and PearsonR test.
- Outliers are data points that fall below Q1-1.5IQR or above Q3+1.5IQR.

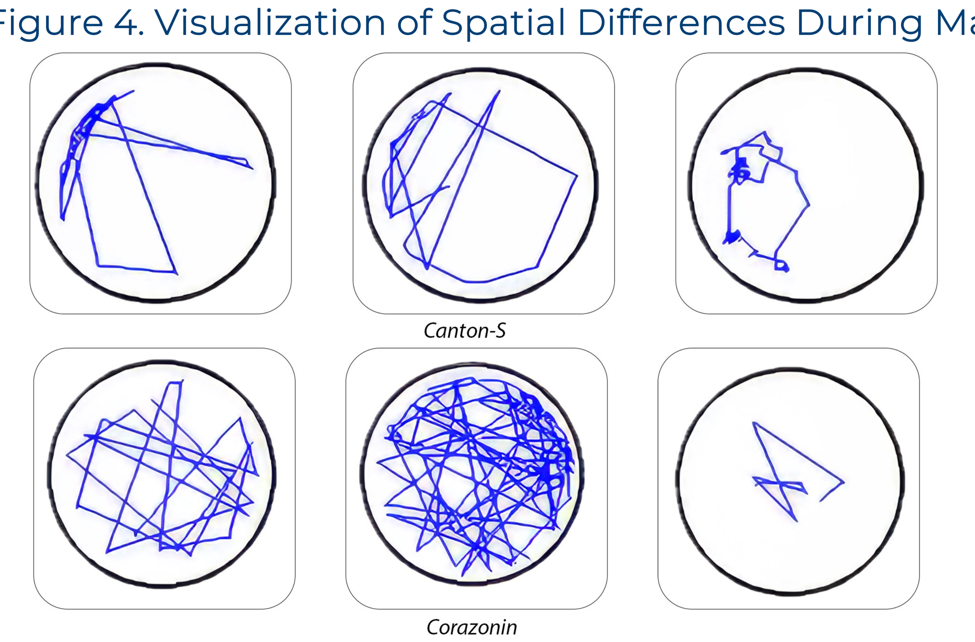
Spatial Preferences During Mating:

Figure 3. Comparison of Percent Time Spent in the Center: CRZ vs CS



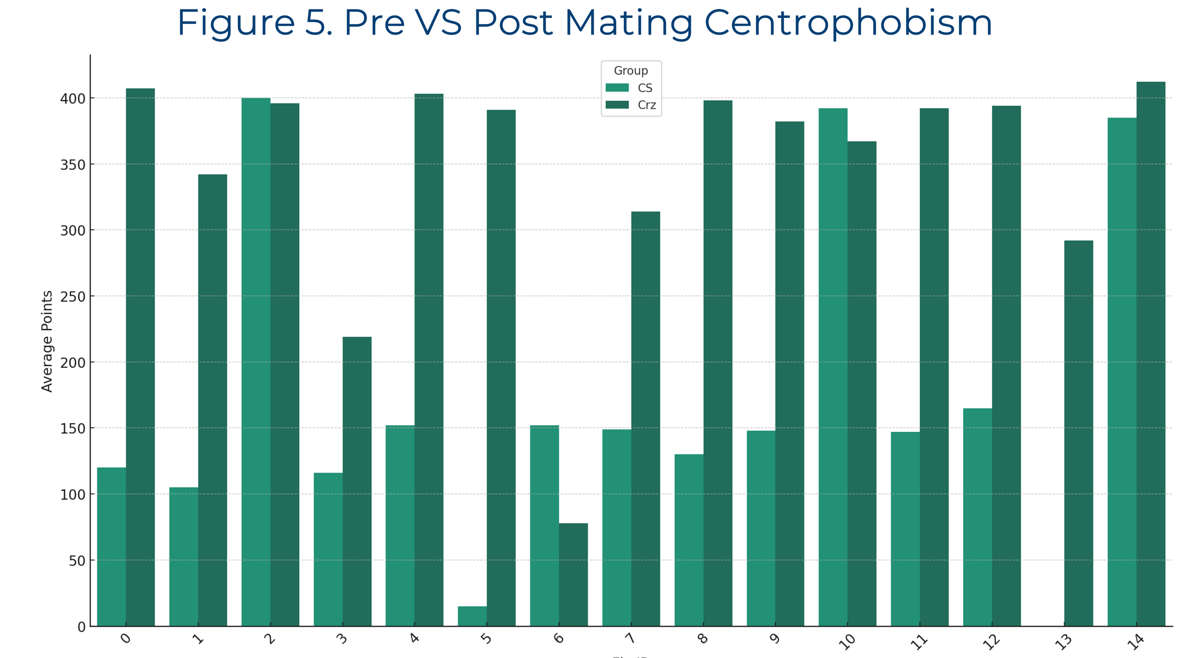
- *Drosophila* spends a significantly lower mean/median percent of the time in the center of the arena during mating (0.15/0.00%) compared to males (5.70/5.27%), females (16.63/15.05%), and average non-mating (11.16/10.88%) percent time in the center.
- Difference in Sex values with U-value of 22854.0 and ρ-value of 7.7e-31
- There is also evidence that the Corazonin affects the spatial patterns with the mean/median percent of time in the center during mating being increased (3.05/0.43%).
- Comparison of Canton-S and Corazonin percent times results in a U-value of 5758.0 and a ρ-value of 5.32e-15.
- There is an increase in male time spent in the center (6.72 /5.93%) and a decrease in female time spent in the center (10.56/9.46%)
- This is also statically significant with a U Statistic of 12390.0 and a ρ-value of 1.99e-6 for females and a U Statistic of 20454.0 and a ρ-value of 0.00278 for males.

Figure 4. Visualization of Spatial Differences During Mating



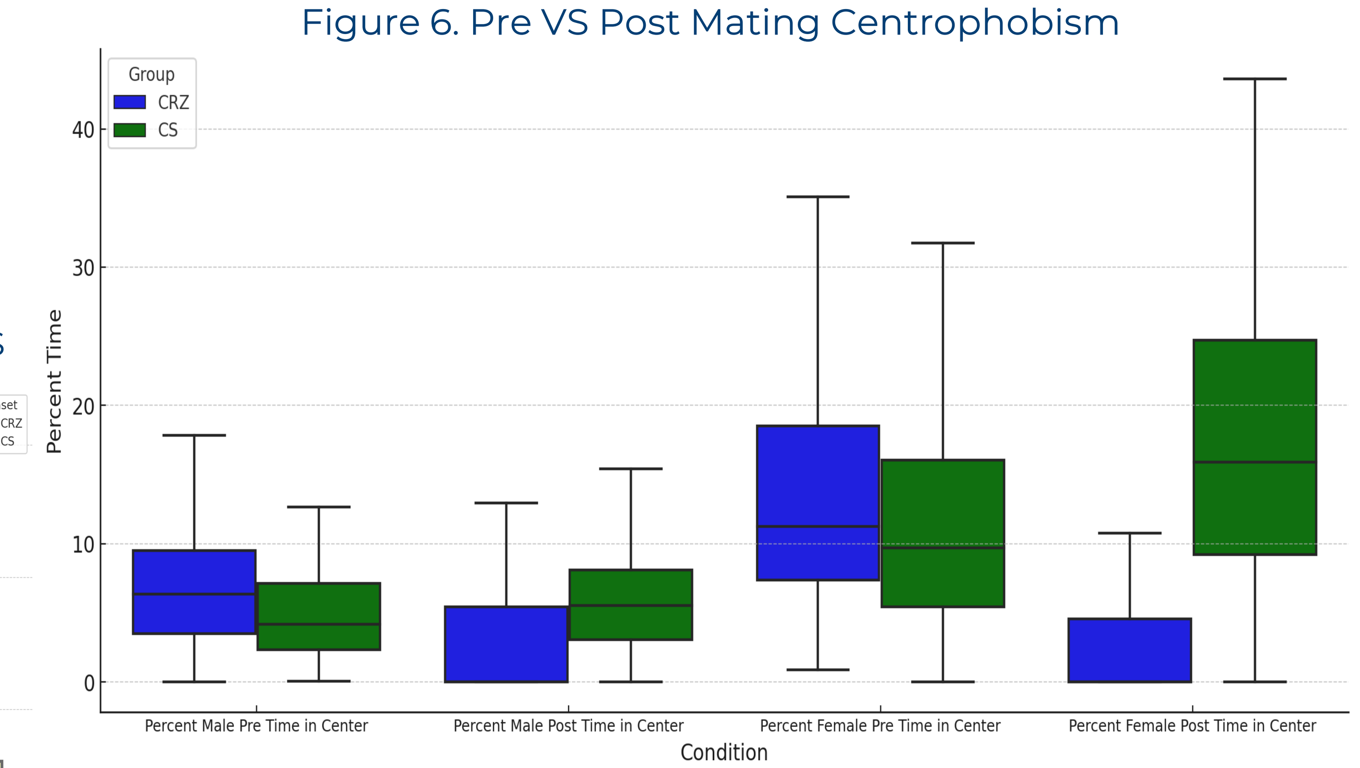
- Corazonin exhibits more movement than Canton-S.
- Average movement for Canton-S is approximately 171.73
- Average movement for Corazonin is approximately 345.8.
- Mann-Whitney U test results in a U-value of 37.5 and a p-value of approximately 0.002, showing a statistically significant difference.

Figure 5. Pre VS Post Mating Centrophobism



Pre VS Post Mating Spatial Behaviors:

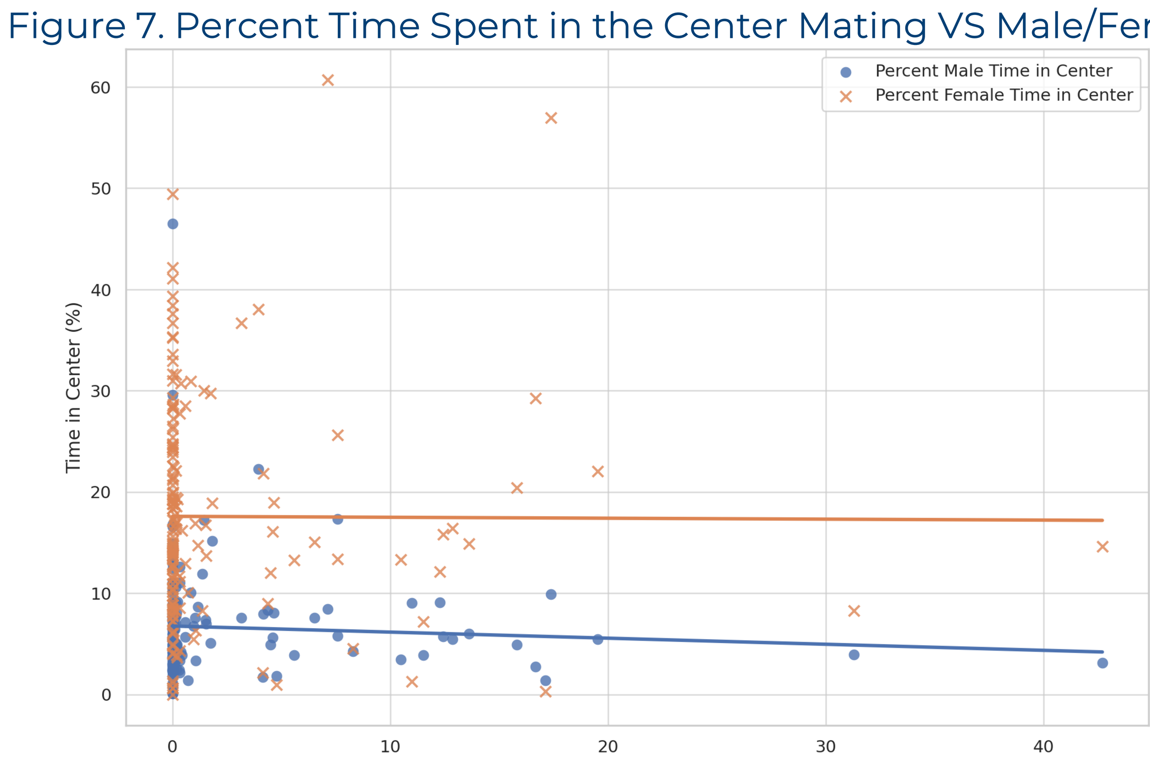
Figure 6. Pre VS Post Mating Centrophobism



-*Drosophila* spends statistically more time in the center pre-mating in females. This is shown in mean/median where the pre-mating in females is 9.87/8.90% while the post-mating is 0.96/0.00%.
- Female pre vs post results in a U-value of 10174.0 and ρ-value of 2.38e-6.
- There is no difference in males ' U-value of 12278.0 and ρ-value of 0.0166
- Corazonin also affects these spatial patterns increases in the post-mating times of males (4.28/3.68%) and females (16.10/15.00%).
- There is also statical significance with the lowest ρ–value being 0.021.
- It also shows a different trend than Canton- S, with statistically less time in the center pre-mating in females than post-mating.
- Female pre vs post results in a U-value of 29178.0 and ρ-value of 4.4e-31.

How Sex Affects Mating:

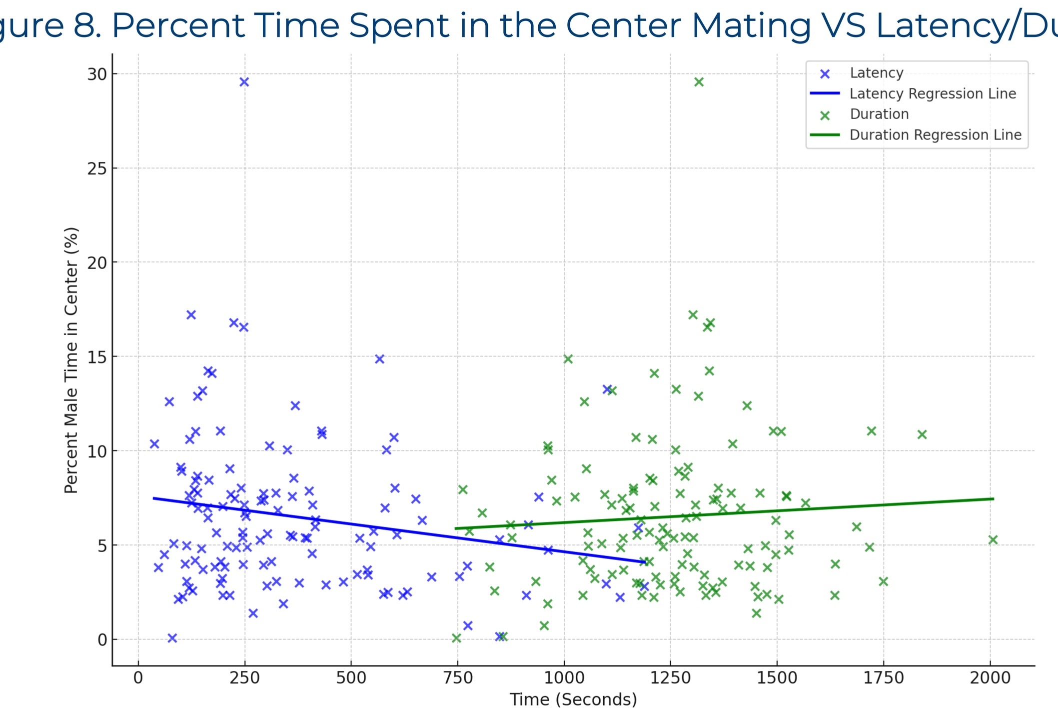
Figure 7. Percent Time Spent in the Center Mating VS Male/Female



- There is no correlation between the percent time spent in the center during Mating and the percent time spent in the center for either sex.
- Pearson correlational coefficient is 0.031 and ρ-value of 0.691 for females
-Pearson correlational coefficient is -0.064 and ρ-value of 0.420 for males

How Sex Affects Mating:

Figure 8. Percent Time Spent in the Center Mating VS Latency/Duration



-There is a correlation between the percent time spent in the center during Latency; no correlation is there for Duration.
- Pearson correlational coefficient is -0.191 and ρ-value of 0.032 for Latency.
- Pearson correlational coefficient is 0.069 and ρ-value of 0.446 for Duration.

Conclusion

- Investigation focuses on spatial behaviors of *Drosophila* during mating shows that fear or anxiety-like behaviors might be decreased during mating
- Research shows mating activities significantly impact *Drosophila's* survival strategies.
- Demonstrates how mating modulates survival tactics like predator avoidance.
- Observations of sexual dimorphism in spatial preferences highlight evolutionary significance.
- Behaviors are critical for mating strategies, sexual selection, and reproductive success.
- Findings enhance understanding of *Drosophila* behavior and contribute to knowledge of evolutionary biology.
- Illustrates the balance between survival and reproduction in the context of evolutionary pressures.

Implications:
- *Drosophila* sex peptide or seminal fluid causes differences in Centrophobism as there is a change in post-mating with Corazonin having different Centrophobism behaviors than Canton-S there being general decreases in anxiety in females.
- Sexual reward causes a decrease in anxiety as Corazonin flies mate longer in the center than standard males.
- This suggests that predator avoidance might be decreased as the need to mate grows stronger.
- Increased sexual reward causes there to be more movement
- Sexual dimorphism suggests that males are naturally more fearful or anxious than females.
- When it takes longer to find a mate as shown through latency there is a minor increase in the amount of free or anxiety in the *Drosophila* which could be evolutionary to help find a mate.

Future Directions

Further Research on Behavioral Mechanisms:
- Explore the neurobiological and genetic bases of changes in spatial behavior.
- Investigate the processing of mating signals and their impact on behavioral alterations.
- Examine the molecular pathways involved in these behavioral changes.

Investigation of Environmental Influences:
- Study the impact of different environmental contexts on mating behaviors and spatial preferences.
- Analyze the adaptability and plasticity of mating behaviors in response to these environmental changes.
- Investigate how different habitat types influence mating behaviors and strategies.

Investigation of Environmental Influences:
-Understand how natural and artificial rewards affect Centrophobism and anxiety-like behaviors.
- Model these behaviors through different methods.

Sexual Reward System:
- How does sexual reward impact *Drosophila* risk-taking behaviors through evolution
- Does lack of natural reward cause an increase in anxiety that can be filled to the same degree with artificial reward?
- Pathways link addiction with anxiety-like behaviors in both *Drosophila* and mammals that can be tested.

Bibliography

- Mohammad, F., Aryal, S., Ho, J., Stewart, J., Norman, N., Tan, T., Eisaka, A., & Claridge-Chang, A. (2016). Ancient Anxiety Pathways Influence *Drosophila* Defense Behaviors. Current Biology, 26(7), 981–986. https://doi.org/10.1016/j.cub.2016.02.031
- Bath, E., Thomson, J., & Perry, J. (2020). Anxiety-like behaviour is regulated independently from sex, mating status and the sex peptide receptor in Drosophila melanogaster. Animal Behaviour, 166, 1–7. https://doi.org/10.1016/j.anbehav.2020.05.011
- Gunaratne, G. H., Pletcher, S. D., & Roman, G. (2012). Open-field arena boundary is a primary object of exploration for Drosophila. Brain and Behavior, 2(2), 97–108. https://doi.org/10.1002/brb3.36
- Finn, D. A., Rutledge-Gorman, M. T., & Crabbe, J. C. (2003). Genetic animal models of anxiety. Neurogenetics, 4(3), 109– 135. https://doi.org/10.1007/s10048-003-0143-2
- All charts

Full list of references