**University of Leicester**

**BBSRC MIBTP Studentship Project 2024-5 entry.**

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| **Project Reference** |  |

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| **Additional Supervisor** |  |

**Section 2 – *Project Information***

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| **Project Title** | The Evolution of Vision in Mosquitoes  |
| **Project Summary**  |
| **Background** Due to their capacity to transmit viruses such as Zika and parasites like *Plasmodium* (the causative agent of malaria), mosquitos are regarded by the World Health Organization as one of the most lethal organisms on our planet (WHO | Global vector control response 2017–2030, 2020). Mosquito-borne diseases affect over half of the global population, with more than 300 million people falling ill each year (Franklinos et al., 2019). Unfortunately, this staggering figure is expected to rise due to factors like global warming and human activities expanding mosquito habitats into previously temperate regions, including the United Kingdom (Medlock and Leach, 2015; Simons et al., 2019).  Recently, we (Feuda et al., 2021) have identified that the genes responsible for encoding light-sensitive opsin pigments have undergone significant molecular diversification in mosquitos. Additionally, work by Zhan and colleagues (Zhan et al., 2021) has demonstrated that mutations in opsin genes of *Aedes aegypti* can eliminate vision-guided target recognition. This, in combination with the role of light in modulating the biting response in mosquito (Coetzee et al., 2022), suggests that light cues can be used to mitigate the effect of mosquitoes on human populations. However, many aspects of visual system organisation in mosquitos remain relatively enigmatic (Montell and Zwiebel, 2016). **Objectives**  The objective of this project is to characterise the visual system of different species of mosquitos. To achieve this, we will use a combination of genomics, single-cell biology, and advanced imaging. We have outlined three specific goals, each constituting a distinct chapter within the PhD thesis: **Methodology**  1. **Characterizing the Evolution of Opsin and Phototransduction Genes:** You will use phylogenomic analysis, molecular evolutionary methods (e.g., dn/ds ratio and chromosomal position), and the sequencing of new chromosomal-level genomes for key mosquito species to clarify the duplication and pattern of positive selection of opsin and phototransduction genes. 2. **Constructing a Cell Atlas for Mosquitos Visual Systems:** You will use single-cell biology techniques to construct a cell atlas for the visual systems in both males and females of *Aedes aegypti*, *Anopheles gambiae*, and *Culex quinquefasciatus*. This dataset will facilitate comparisons of cell type diversity between sexes and among different species. 3. **Comparative analysis of the visual system organisation:** In the last phase, Hybridization Chain Reaction (Choi et al., 2016) will be combined with tissue-clearing protocol to validate cell types and provide insights into the shared characteristics and distinctions in the organisation of the visual system across various sexes and species. In the short term, our research aims to reveal sex and species-specific variations in the visual system organisation. Over time, these differences can be leveraged to impact mosquitoes' ability to detect humans (Zhan et al., 2021). This project will equip the student with a unique combination of expertise in experimental and computational biology and data analysis that can be applied to a large, diverse set of problems. You will be part of the neurogenetic research group that includes 7 PIs, 15 PhD students and 4 PDRA working on different aspects of neurobiology (from physiology to computational genomics). This position offers ample opportunity for training and collaboration in the U.K. and Europe. Finally, this project will also provide the opportunity to publish in international 4-star general journals, which are regularly generated by the Feuda group. Techniques that will be undertaken during the project* Mosquito rearing
* Single-cell RNA sequencing
* ATAC-sequencing
* Bioinformatics analyses
* Immunohistochemistry
* Confocal.

These diverse sets of skills will provide the student with robust training highly valued in academia and industry.  |
| **References** |
| Choi, H.M.T., Calvert, C.R., Husain, N., Huss, D., Barsi, J.C., Deverman, B.E., Hunter, R.C., Kato, M., Lee, S.M., Abelin, A.C.T., Rosenthal, A.Z., Akbari, O.S., Li, Y., Hay, B.A., Sternberg, P.W., Patterson, P.H., Davidson, E.H., Mazmanian, S.K., Prober, D.A., van de Rijn, M., Leadbetter, J.R., Newman, D.K., Readhead, C., Bronner, M.E., Wold, B., Lansford, R., Sauka-Spengler, T., Fraser, S.E. and Pierce, N.A. (2016) Mapping a multiplexed zoo of mRNA expression. *Development (Cambridge, England)*, 143(19) 3632–3637. Coetzee, B.W.T., Gaston, K.J., Koekemoer, L.L., Kruger, T., Riddin, M.A. and Smit, I.P.J. (2022) Artificial Light as a Modulator of Mosquito-Borne Disease Risk. *Frontiers in Ecology and Evolution*, 9. Available from https://www.frontiersin.org/articles/10.3389/fevo.2021.768090 [accessed 25 September 2023]. Feuda, R., Goulty, M., Zadra, N., Gasparetti, T., Rosato, E., Pisani, D., Rizzoli, A., Segata, N., Ometto, L. and Stabelli, O.R. (2021) Phylogenomics of Opsin Genes in Diptera Reveals Lineage-Specific Events and Contrasting Evolutionary Dynamics in Anopheles and Drosophila. *Genome Biology and Evolution*, 13(8) evab170. Franklinos, L.H.V., Jones, K.E., Redding, D.W. and Abubakar, I. (2019) The effect of global change on mosquito-borne disease. *The Lancet Infectious Diseases*, 19(9) e302–e312. Medlock, J.M. and Leach, S.A. (2015) Effect of climate change on vector-borne disease risk in the UK. *The Lancet Infectious Diseases*, 15(6) 721–730. Montell, C. and Zwiebel, L.J. (2016) Chapter Ten - Mosquito Sensory Systems. In: A.S. Raikhel (ed.) *Advances in Insect Physiology*. Progress in Mosquito Research. Academic Press, 293–328. Simons, R.R.L., Croft, S., Rees, E., Tearne, O., Arnold, M.E. and Johnson, N. (2019) Using species distribution models to predict potential hot-spots for Rift Valley Fever establishment in the United Kingdom. *PLOS ONE*, 14(12) e0225250. WHO | Global vector control response 2017–2030 (2020) Available from http://www.who.int/vector-control/publications/global-control-response/en/ [accessed 13 April 2020]. Zhan, Y., Alonso San Alberto, D., Rusch, C., Riffell, J.A. and Montell, C. (2021) Elimination of vision-guided target attraction in Aedes aegypti using CRISPR. *Current biology: CB*, 31(18) 4180-4187.e6.   |

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