

Statement of Purpose - Vasudha Kulkarni

My interest in biology and research was fostered by teachers and mentors who were passionate about the subject and fantastic at transferring that knowledge and passion to their students. I became interested in animal behaviour when I audited the animal behaviour course as a first-year undergraduate. After my second year, guided by Prof Raghavendra Gadagkar at IISc Bangalore, I read several books on animal cognition, brood parasitism, and the evolution of female sexuality in primates while also doing a literature review on principles of social immunity. This review on how insect societies deal with infectious diseases shifted my curiosity towards group-level behaviour in eusocial insects. I wanted to study how local interactions between individuals can give rise to such astounding complexity in the regulation and functioning of the colony as a whole.

Prof Sylvia Cremer has done pioneering work on group-level anti-parasitic behaviour in eusocial insects, known as social immunity. I joined her lab the summer after my third year to study social immunity in ants. I worked with Linda Sartoris, a PhD student, who was studying the effect of pathogen experience on hygienic behaviour. Her study showed that an ant with a recent pathogen experience reduced its larval grooming. To understand this unexpected result, I conducted a survival experiment, revealing that low concentrations of fungal spores were fatal to larvae but not worker ants due to their self-grooming ability. Thus, ***the pathogen-experienced ant reduced larval grooming to minimise the risk of low-level contamination.*** Expanding on this work, I tested if recent pathogen experience affects *induced* larval grooming by exposing pathogen-experienced ants to contaminated larvae. Despite the lack of conclusive results, this experience fueled my passion for experimental work, enhancing my skills in designing, conducting and analysing controlled experiments. I also acquired lab skills and techniques like maintaining ant colonies, fungal spore extraction, DNA extraction and qPCR.

During my fourth year at IISER Pune, I worked with Dr Raghav Rajan, exploring the mechanisms underlying song initiation in zebra finches. Zebra finches begin their songs with short, repeated syllables called introductory notes (INs), which are hypothesised to have an important motor preparation function in the execution of the song. I wanted to test whether adult male zebra finches could reduce the mean number of INs in their song. I developed a closed-loop negative-reinforcement-based behavioural assay to test if we can reduce the mean number of INs in zebra finches. I modified a Python-based audio recording program to ***detect INs in real time and punish the bird with white noise for singing multiple INs.*** I managed to significantly reduce the mean number of INs in a test bird. Further studies will show how this reduction in INs affects the song structure and initiation. With this project, I enjoyed working with quantitative behavioural data and learning new software and programming to solve specific tasks in gathering and analysing this data.

I wanted to use my experience with quantitative behaviour and computational methods in studying complex social interactions in primates. I approached Prof Judith Burkart at the University of Zurich to work in her lab studying cooperation in common marmosets and secured funding by applying to the A.H. Schultz Foundation for a grant. Like humans, marmosets exhibit

proactive prosociality, group-level coordination and joint action via perspective-taking. Bio-behavioural synchrony is hypothesised to be the proximate mechanism of cooperation in humans. Through my project, I aim to study ***behavioural synchrony and pose imitation in marmoset dyads before and after they perform a cooperative task***. I'm using DeepLabCut to quantify posture synchrony and gaze following in marmosets and correlate their synchrony with their level of cooperation. Studying the process of synchronisation in marmosets will help us understand the overlap of proximate mechanisms regulating cooperation and social cognition in humans and marmosets.

Through this research experience, I have expanded my skill set, working with marmosets, fabricating experimental tasks and building an analysis pipeline. I have experience working with and handling diverse animal models across behavioural paradigms and have developed the ability to learn new tools and software swiftly. In addition to my research experience, I have fortified my theoretical background through advanced elective courses in ecology, evolution, animal behaviour, and neuroscience, as well as statistical learning, generalised linear models and bioinformatics.

I'm committed to pursuing an academic career studying social behaviour in animal societies, and I believe that the EEB PhD program at Princeton offers the best opportunities to develop the necessary skills for a future researcher in this field. I want to understand various facets of group dynamics, including the evolution of sociality, cooperation and conflict within groups, factors shaping social structure organisation and the role of communication in maintaining sociality. In my prospective PhD research, I aim to study social behaviour in insect colonies using controlled experiments to answer specific questions and mathematical modelling approaches to identify patterns in complex behaviour, build theories, and make further predictions. In particular, I would like to work with Prof. Sarah Kocher, using my experience with automated tracking and social insects to investigate group dynamics and social networks in bumble bee colonies. I would combine fine-grained behavioural observations with individual tracking to empirically examine the mechanisms of collective responses to various external pressures, like environmental perturbation, predation or pathogen threat, and internal disturbances.

I have cutting-edge research experience with diverse animal models and proficiency with various experimental and analytical tools. I want to build upon my competencies and use multidisciplinary approaches to understand the principles underlying behavioural phenomena. If accepted into the program, I'd like to rotate with Prof. Christina Riehl to study the means of conflict resolution in cooperatively breeding birds, and Prof. Corina Tarnita to develop models of complex social behaviour. The intellectually vibrant and multidisciplinary environment at the Ecology and Evolutionary Biology department at Princeton promises not only to enrich my academic journey but also to foster interdisciplinary collaborations that will enhance the depth and breadth of my research pursuits.

Personal Essay - Vasudha Kulkarni

I grew up in an orthodox community where education is valued, but not for women. I set high goals for myself, fought for my ambitions and moved to a different city for my undergraduate studies. I supported myself by securing a grant from the Indian government after clearing a very competitive exam in high school. I also acquired funding for my research internship at ISTA and secured a grant to support my master's thesis at the University of Zurich.

In my first year of undergraduate studies, lacking a strong background in maths and programming, I struggled to keep up with the courses and didn't perform well in them. I confronted my fears and chose to study challenging elective classes such as mathematical biology, statistical learning, climate modelling and generalised linear models, through which I acquired the skills needed to pursue my research interests. I also relearned programming in Python and R by working on research projects with a computational component, thus developing the resilience required to overcome academic challenges.

Recognising the interdisciplinary nature of knowledge, I studied humanities courses such as science and society, political ecology, and discourse around diseases, through which I could appreciate that science does not exist in a vacuum; it is deeply embedded in the socio-cultural, historical, and ethical dimensions of the society. I believe that it is important for scientists to acknowledge this and engage with the public and stakeholders who are impacted by their research. One way we can achieve this is through science communication. I'm passionate about science communication and outreach. One of my articles on brood parasitism in cuckoos was published on a well-known website (<https://sciwri.club/archives/12003>), showcasing my proficiency in translating complex concepts for a broader audience.

I am also deeply committed to promoting inclusivity within academia. When individuals from varied backgrounds, experiences, and perspectives come together, it enriches the academic environment and helps us address systemic inequalities. I worked on an investigative journalism project, interviewing several PhD students about their experience and writing an article about the challenges they face in the Indian academic landscape (<https://kalpa.iiserpune.ac.in/a-balancing-act/>), which is characterised by diminishing funding and at times, a toxic work culture. In writing that article, I aimed not only to shed light on the struggles but also to initiate conversations and actions towards creating a more supportive and inclusive academic environment for all. Through my active participation, I aspire to advocate for inclusivity and representation, bridging diverse perspectives and backgrounds within the scientific community.