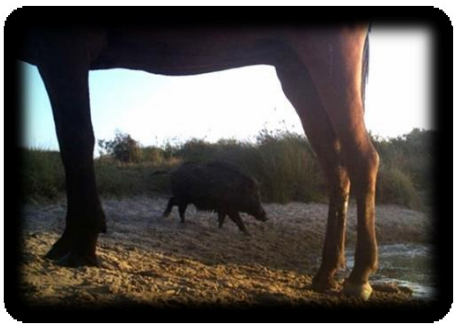
MIGSAA PhD project Nora Tanner

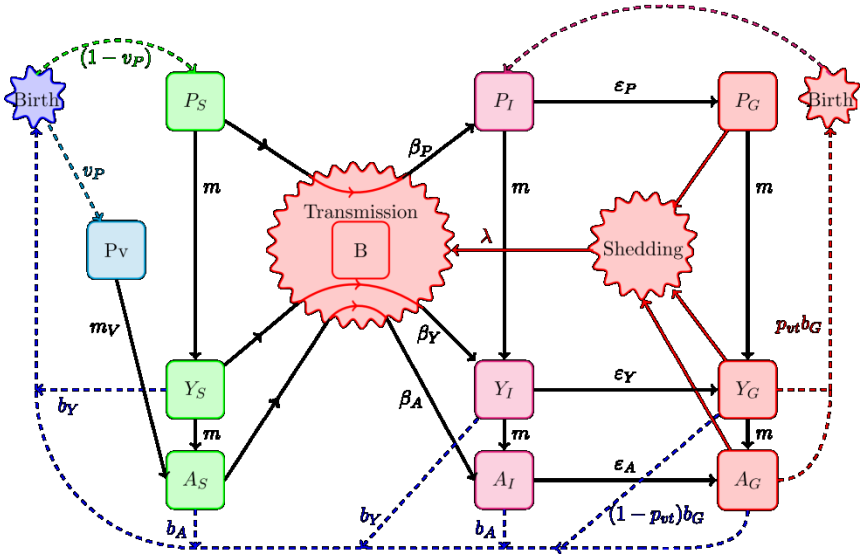
Nora Tanner is a third year MIGSAA student working on a PhD in Mathematical models to inform policy and practice for infectious disease management. Her supervisors are Andy White (Heriot-Watt University) and Tibor Antal (University of Edinburgh).

Tuberculosis (TB) is a bacterial infection that can infect humans and a wide range of farmed and wildlife mammal species. It is a particular problem in the cattle industry as TB infected cows must be slaughtered to prevent further infection. While TB infection can be managed in farmed animals it is much more difficult to manage in wildlife species which act a reservoir to allow the disease to persist. In the UK badgers have been suggested as a key reservoir population for TB and interaction between badgers and livestock can lead to the infection of cattle. In central Spain (and other regions worldwide) wild boar are the primary reservoir species and TB can reach a prevalence of up to 90%. Transmission between wild boar and livestock is likely to occur through environmental contamination (caused for example from infected faeces) at shared water holes, becomes scarce in the summer months.



Wild boar at a shared water hole

As part of a MIGSAA studentship supervised at Heriot-Watt University we are working with The National Institute for Game and Wildlife Research (IREC), Spain to develop mathematical models that can be used to direct infectious disease management programmes to reduce the prevalence of TB in wild boar. We have developed a model that includes the key stage structure of the wild boar system (piglets, yearlings and adults), the key infection status of individuals (susceptible, infected, super-excretor) and in which the infection is transmitted by environmental contamination. This model is being used to assess the effectiveness of an oral vaccine for piglets (developed by IREC) on reducing the prevalence of TB and the density of infected and super-extretor individuals. Our model results have been used to support the findings of a pioneering oral vaccination trial.



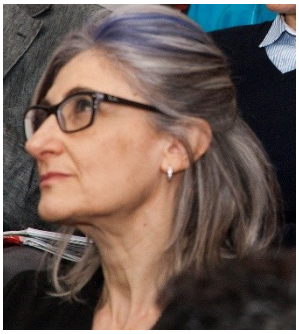
A schematic of the mathematical model of wild boar-TB dynamics

The model findings were critical in explaining the epidemiological dynamics which indicate that vaccination can reduce the prevalence of disease but in so doing reduces the overall burden of the disease in wild boar populations. This allows the overall density of wild boar populations to increase and so the actual abundance of TB infected individuals is largely unaffected. This work highlights how interdisciplinary collaborations that combine mathematical modelling with biological studies can be used to understand the impacts of infectious disease management strategies. Through the collaboration with The National Institute for Game and Wildlife Research the findings can be used to inform policy and farming practice that aim to minimise the impacts of infectious disease.

An interdisciplinary MIGSAA PhD experience:

Tim Hurst is a second year MIGSAA student working on a PhD in statistical mechanics with Ben Goddard (UoE Maths) and Raffaella Ocone (HW Engineering).

Tim did his first year extended project with Ben on quantum molecular dynamics, in particular developing an efficient and accurate mathematical/numerical method for describing the complex nonadiabatic transitions between energy levels with two-dimensional avoided crossings. Tim's progress with the project was much more rapid than we initially expected and it reached a natural endpoint. Whilst there is plenty of scope for further research in the area, many of the possible directions are very uncertain and not ideal as PhD projects. However, Tim was still keen to continue in the general area of molecular modelling. As such, we decided that it would beneficial for Tim to move to another, related project with Ben. Fortunately, Tim has wide interests and was happy to look at other options.



Raffaella and Ben had recently met at a MIGSAA mini-project event and discovered that they had similar interests. Since undertaking a postdoc in Chemical Engineering, Ben has been interested in the mathematical fundamentals and numerical implementation of statistical mechanics for complex fluids, as well as their industrial applications. Raffaella has recently been awarded an EPSRC Advanced Fellowship which requires detailed mathematical studies of similar systems, aiming to derive a statistical mechanics/continuum model for granular media and hard particles from first principles. Whilst they were both very keen to start an active collaboration, as is normal in such circumstances, time was the limiting factor and they discussed a number of possibilities, including applying for a joint grant and trying to get a joint PhD student.

Ben was particularly interested in the mathematical and numerical aspects of the projects described in Raffaella's grant, and it was clear that undertaking such research really requires someone with a mathematics degree, rather than someone with a typical engineering undergraduate experience. Tim was a natural candidate for this, and a collaboration with mathematicians would certainly benefit the project. However, neither of the supervisors wanted to force a PhD student into a project that they were not seriously interested in and, as such, they decided to meet Tim to give him an overview of possible projects and let him decide if he was interested or would rather pursue a different direction.

After discussing the general area with Tim, he found it very interesting and, as such, it was decided

that he should undertake a project jointly supervised by Ben and Raffaella. The supervision is genuinely joint; the aim is to have weekly meetings with Tim and both supervisors. Tim was initially given a range of papers to read and encouraged to find a particular topic/direction that interested him. In particular, this allowed him to get a glimpse of many different areas, both from a mathematical and engineering viewpoint, and to see how the disciplines can interact. This will be a particular strength of undertaking an interdisciplinary PhD; Tim will understand the same area from two different viewpoints, and be able to talk about his research to both disciplines. He will also be able to attend relevant seminars in both fields and benefit from interactions with groups both in Chemical Engineering and in Mathematics.

Over the next three years, Tim aims to investigate and produce new methods for modelling granular flow, and apply the methods computationally, in particular to real-world problems. This mix of mathematical modelling, analysis and applications/industrial work fits perfectly with MIGSAA and will give Tim a well-rounded PhD experience with scope to proceed into a wide variety of fields, both in academia and industry. In addition, this is an excellent way to kick-start an interdisciplinary collaboration in an exciting and rapidly-evolving field.

Tim's viewpoint:

"So far, my time as an interdisciplinary PhD student has proved very beneficial to me. I have been able to utilise experience drawn from two different fields through my supervisors, giving differing interpretations of the problems in the area. This has, for example, widened my scope of literature; I see papers which I may not have come across as a student in a more traditional setting. In the future I look forward to accessing the resources and support of chemical engineering and mathematics, as well as the additional assets of interdisciplinary study."