The Glasgow Naturalist (2024) Volume 28, Supplement, 140-142

https://doi.org/10.37208/tgn28S21

One Health: expanding the frontiers of zoology

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The study of parasites and infectious diseases at the University of Glasgow has a rich history that is closely intertwined with that of Zoology and the Zoology building. Early examples of major scientific contributions linked to the department include the discovery of Zika virus by Alexander J. Haddow, a Glasgow Zoology graduate who later became a Professor and Dean of the Faculty of Medicine in the University, and the pioneering work on sleeping sickness and antigenic variation by Keith Vickerman, who was Head of Department and Regius Chair of Zoology (see other articles in this volume). Just as the study of Zoology requires consideration of environment and ecology (as reflected in various incarnations of the zoological community in the Graham Kerr building: the Division of Environmental and Evolutionary Biology, and then of Ecology and Evolutionary Biology), it became natural to combine our strengths in pathogen biology and evolutionary ecology to include infectious disease ecology. The creation of the College of Medical, Veterinary Sciences and the formation of the Institute of Biodiversity, Animal Health and Comparative Medicine (IBAHCM) in 2010, under the leadership of Professor Dan Haydon, marked the start of the latest chapter in this long history linking zoology and infectious disease at Glasgow.

Infectious disease ecology was already something of a poster-child for the increasing expectation of funders that research should become more interdisciplinary, benefitting as it does from the inputs of so many other disciplines including molecular biology, mathematical and statistical modelling, and social science. But by bringing together researchers from ecological, evolutionary and veterinary backgrounds, IBAHCM also reflected an increasing realisation that the health of human and animal populations, whether free-living or domestic, as well as that of the ecosystems supporting them, are intimately linked and interdependent. This concept, commonly referred to as One Health, became more widely recognised in the early 2000s and has risen to increasing prominence since, not least due to its relevance for addressing the threat of emerging infectious diseases, as highlighted by recent global pandemics caused by influenza, HIV, and SARS-Cov2. Central to the One Health paradigm is not only an emphasis on humans and other animals sharing pathogens and other factors impacting their health, but also the acknowledgement that solutions to these problems require the collaboration and integration of disciplines, including those of the veterinary and medical professions. The existence of a highly regarded School of Veterinary Medicine within the University created a unique opportunity to achieve such disciplinary integration when IBAHCM was formed. Fully merging the Institute and the Veterinary School in 2022 to form the School of Biodiversity, One Health and Veterinary Medicine, was a logical progression on this trajectory and resulted in a department with even greater critical mass to address global environmental and health challenges in a holistic way.

The importance of a One Health approach is exemplified by rabies, a viral zoonotic disease for which our department has produced world-leading research over the past two decades. Rabies virus is maintained in animal reservoir populations, most commonly domestic dogs, so its surveillance and control had been traditionally regarded as a veterinary problem. This has made it difficult to address rabies as a public health issue, despite infections, if left untreated, being invariably fatal and continuing to cause about 60,000 human deaths each year. Research led by Glasgow scientists has demonstrated the crucial role of domestic dogs as the main animal reservoir and the feasibility of canine rabies control and elimination through mass dog vaccination. Importantly, these research findings were crucial for driving major policy change and strategy within global governing bodies, including the World Health Organisation (WHO). In settings where wildlife acts as a major rabies reservoir, such as vampire bats in South America, research within the department has led to the pursuit and evaluation of novel control strategies, including the intriguing possibility of transmissible vaccines.

For most zoonotic diseases, the burdens fall predominantly on communities within the global south. Building long-term and equitable partnerships with institutions and governmental agencies in those countries most affected, has therefore been a hallmark of One Health research at Glasgow. Connections have been particularly strong in East Africa, especially Tanzania, where research has focused on diverse challenges including the control of human malaria and schistosomiasis, antimicrobial resistance, human-wildlife conflicts, and livestock health. The latter is another poignant example of the interdependencies lying at the heart of One Health, given that the livelihoods of communities in the global south often critically rely on livestock as a source of food and income. At the same time, the land inhabited and used by livestock-owning communities can also support biodiverse ecosystems, creating opportunities for pathogens to cross species boundaries and resulting in complex transmission patterns involving wildlife, domestic animals and people. Many of our scientists have been working in these settings for much of their

careers and the research emanating from this has become a major part of what the department is now internationally known and recognised for. Long-lasting collaborations across sub-Saharan Africa, such as with the Ifakara Health Institute in Tanzania, have also resulted in a consistent flow of visiting students, postdocs and staff to the department over the years, and thus have shaped the international research network it is embedded in.

Addressing One Health challenges such as anti-microbial resistance or disease emergence often requires solutions that combine biological, medical, environmental, economic and social components. This has forced Glasgow researchers to forge highly interdisciplinary teams, either by recruiting staff members with relevant expertise into the department or by finding this expertise elsewhere. The former of these two approaches has led to the novel appointment of staff coming from non-biological backgrounds, including mathematics, computer science or economics. The second approach has resulted in strong links over the years to other Schools and Colleges within the University, including Mathematics and Statistics and Social and Political Sciences. These links were formalised through the creation of the Boyd Orr Centre for Population and Ecosystem Health, a virtual grouping founded in 2008 and named after Sir John Boyd Orr, a University of Glasgow graduate (and student of John Graham Kerr) who was awarded the Nobel Peace Prize in 1949 for his work on human nutrition and leadership as the first Director of the United Nations Food and Agriculture Organization (FAO). Inspired by Boyd Orr's vision of science that delivers real world impact by improving people's health and wellbeing, the Centre emphasises approaches that are both pragmatic and quantitatively rigorous. For its innovative contributions to improving human and animal health, the Boyd Orr Centre was awarded the Queens Anniversary Prize in 2013 (Fig. 1).

In addition to parasites and infectious disease, the One Health concept also highlights the value of a comparative approach to animal and human health. Many of the issues affecting the latter, such as ageing, epigenetic effects, and cancer, can be studied in a wide range of animal models, including wild and domestic species. Over the past twenty years, research within the Institute/School has very productively pursued this angle to One Health to answer, for example, the question why some individuals age faster than others or whether even after exposure to environmental pollutants has stopped, the health of future generations may be affected by epigenetic effects.

The academic merits of extending and connecting broadly zoological ideas into so many interdisciplinary spaces has not gone undebated. It has, however, broadened and diversified our research funding base and led to a significant expansion of our staffing numbers; it has enriched the societal impact of our research, contributed to a rich academic environment that has attracted research fellows from far and wide, and placed

Fig. 1. Members of the Boyd Orr Centre for Population and Ecosystem Health visiting Buckingham Palace in February 2014 to attend the Queen's Anniversary Prize ceremony. From left to right: Joaquin Prada, Dan Haydon, Caroline Millins, Minnie Parmiter, Barbara Mable, Richard Reeve, Rowland Kao, Sarah Cleaveland, Richard Orton, Sunny Townsend, Tiziana Lembo and Louise Matthews. (Photo: Rowland Kao)

our research community increasingly towards the centre of College affairs.

Attracting researchers studying the ecology and evolution of infectious disease and One Health has also had a profound effect on our teaching. Since 2013, we have been offering a popular Level 4 course on Disease Ecology as part of the Zoology and Marine and Freshwater degree programmes. At the postgraduate level, we have introduced multiple Masters degrees, providing training and skills in areas such as in quantitative epidemiology, infectious disease modelling, and anti-microbial resistance. The case of One Health shows how zoology as a field continues to find new applications and relevance in the context of other disciplines. Seeing zoology becoming embedded in the broader, more diverse research teams that characterise One Health, highlights its essential contribution to tackling some of the most pressing research problems of our times.

I thank Dan Haydon for useful comments and suggestions.