Research

How do interactions between hosts and their parasites impact on disease epidemiology and control?

The impact of parasites on the health and well-being of the human population is colossal, particularly in the developing world. For example, around one million people die of malaria each year, primarily children under the age of five in sub-Saharan Africa. Parasites are of considerable agricultural concern infecting domestic and wild animals, fish stocks and food crops. Museum researchers study the diversity, behaviour, ecology and evolution of parasites – helping to support programmes of disease eradication and control.

Schistosomiasis is a water-borne disease that causes serious problems for rural communities in Africa – this possible transmission site is in Senegal.

Understanding the spread of tropical diseases

Neglected Tropical Diseases (NTDs) are now firmly on the global health agenda. The 14 diseases currently listed as NTDs have been grouped together to increase awareness of parasitic and other diseases afflicting some of the world's poorest populations. Most NTDs can be prevented or eliminated, but the scale of the problem is colossal. Over one billion people, one sixth of the world's population, suffer from one or more NTDs and children are often the most affected.

Several NTDs are transmitted by insect vectors: onchocerciasis is carried by black flies; leishmaniasis by sandflies; Chagas disease by 'kissing bugs'; lymphatic filariasis by mosquitoes; and sleeping sickness by tsetse flies. Schistosomiasis is transmitted via freshwater or amphibious snails. Research scientists at the Museum play an important role by providing the necessary expertise for the identification of medically important insects and snails. They also help to determine the complex transmission patterns of NTDs, information that is important in the context of epidemiology and control strategies.

The Museum is proud of its role as a World Health Organisation Collaborating Centre for the identification and characterisation of schistosomes and snails. Schistosomiasis affects about 200 million people worldwide and several million people suffer from severe morbidity as a consequence of infection. It is estimated that 85 per cent of cases can be found in sub-Saharan Africa, and it is here where our schistosomiasis research is focused. Schistosomiasis is a disease of rural communities and exists in areas where water, snails and people come into close contact. The drug praziquantel is used for treatment, and many countries are now developing national control programmes for the widespread mass administration of praziquantel at school and community levels in an effort to reduce the morbidity inflicted by this persistent disease. A partnership between us and the Ministry of Health and Social Welfare in Zanzibar, funded in part by the Health Foundation, has made excellent progress in reducing both schistosomiasis and intestinal worms in school-aged children.

However, if the cycle of re-infection is to be broken, closer attention needs to be paid to the important role that environment and host-parasite interactions play in determining disease transmission. We are a leading partner in the European Union Framework 6 research programme CONTRAST (Control of Schistosomiasis Transmission) which is exploring ways to look at genetic diversity within schistosomes and snails and to identify better control methods at the local level. This important initiative involves 14 partners representing Europe, west, central and east Africa. A major step forward has been the development of five research nodes (molecular, host-parasite interactions, disease mapping, social science and a database) in endemic areas of disease to promote exchange of skills and collaborative endeavours.

Observations around the African Great Lakes suggest more than 60 per cent of children may be infected with schistosomiasis in some shoreline villages, and there is increasing concern as to whether pre-school children may be missing out on early treatment. A new Wellcome Trust funded project will seek to clarify the natural history of intestinal schistosomiasis within infants and pre-school children and help formulate disease control strategies. *David Rollinson*

From the bowels of the earth

Parasitic worms (helminths) are innately fascinating, not just because they are relatively large and multicellular, yet still manage to make their home in others, but because of the lengths they have taken to achieve what are often highly complex life history strategies. Whether by increasing their fecundity, adapting their bodies to hostile environments, switching between ecosystems to find suitable hosts, or developing ingenious mechanisms of transmission, helminths are ubiquitous and few ecosystems are uninfected or unaffected. The Parasitic Worms Section at the Museum has curated, described and studied parasitic helminths (Platyhelminthes, Nematoda, Nematomorpha and Acanthocephala) for well over 100 years. Their systematics is notoriously difficult. With a plethora of hosts, a multitude of developmental stages that often bear little resemblance from one stage to another, and with most forms remaining cryptically hidden in other animal guts and tissues, it takes time and effort to become familiar with their biodiversity. Collaborating with others, using all means of tools available, always looking out for new opportunities, systematic parasitologists often do their study organisms proud.

Recent collaborations involving Museum staff include the completion of the *Keys to the Trematoda*, a multi-author seminal set of volumes of classical taxonomy. Other recent work includes a study combining morphological and molecular data to reveal a new order of Cestoda (tapeworms), the Rhinobothriidea (Healy, C.J. *et al.* 2009). Through a $3 million National Science Foundation grant, 22 experts from 13 countries have begun new collections of tapeworms from the digestive tracts of vertebrates. The project is expected to yield 1,600-1,700 tapeworm species new to science and will ultimately lead to a global understanding of tapeworms and their hosts that is unprecedented for any host/parasite system to date. Complete mitochondrial genomes have now been characterised for a diversity of helminth parasites of socioeconomic importance. The Museum is working with partners at the University of Melbourne to investigate further the opportunities for high throughput mitogenomics, to reveal new molecular markers tailored for a range of purposes from epidemiology to larval identification and molecular ecology.
Tim Littlewood

References:
Keys to the Trematoda, volumes 1 (2002), 2 (2005) and 3 (2008). CABI International and Natural History Museum

Healy, C.J., Caira, J.N., Jensen, K., *et al*. 2009. Proposal for the new tapeworm order Rhinebothriidea. *International Journal for Parasitology*, **39**: 497–511. **DOI**: 10.1016/j.ijpara.2008.09.002

Investigating mosquito-borne viruses

The threat posed by emerging viruses increases as humans encroach on the natural environment. A Museum team is currently investigating the genetic and ecological factors that result in the emergence of flaviviruses in vertebrate hosts and mosquito vectors, in a project funded by a Sir Henry Wellcome postdoctoral fellowship. Flaviviruses cause human diseases such as dengue, yellow fever and West Nile fever, and we hope to gain insights into how they have evolved to exploit different hosts and vectors.

Preliminary collaborative work with the Uganda Virus Research Institute in Entebbe led by Dr Shelly Cook resulted in the collection of more than 2,000 mosquitoes. The majority were used as voucher specimens for morphological and molecular identification studies, and a sample of about 500 were screened for viruses that cause human diseases. An objective of the work is to develop accurate and easy techniques for clarifying which mosquitoes transmit these viruses to humans, and then to transfer these techniques to local scientists in Uganda. This should allow the community to target their control efforts and make the most efficient use of limited resources. We have been notably successful in identifying potential sources of viral emergence with the discovery of four new flaviviruses in various mosquito species. Studies of mosquitoes collected in Thailand and Vietnam are now underway. *Ralph Harbach*

Bryozoans and PKD

Research on freshwater bryozoans has flourished since our discovery that these colonial invertebrates are hosts to a parasite that causes a devastating disease of salmon and trout, proliferative kidney disease (PKD). Parasite spores that develop in bryozoans are released into rivers and lakes where they contact and then infect wild and farmed fish.

The source of PKD had been sought for many years as the disease is not transmitted from fish to fish – now it has been identified, we are able to investigate the epidemiology of the disease by characterising the ecology of bryozoan hosts and the associated development of the parasite. Recent experimental studies provide evidence that increasing temperatures and nutrient levels in the water promote the growth of bryozoans and the development of parasites, resulting in higher concentrations of parasite spores. These results may help to explain why PKD outbreaks are particularly exacerbated by higher water temperatures and increases in nutrients through human activities.

This work is of special interest in view of the increasing evidence that PKD may be an emerging disease, expanding in geographic range and showing increased severity of outbreaks. *Beth Okamura*