**Birds and bornaviruses**

**Dr Susan Payne** works with a group of researchers investigating the evolution, ecology and virulence of animal viruses. We speak to her about her recent work with avian bornaviruses and some of her team’s findings.

**How can avian viruses affect humankind and endanger the animal world?**

Avian viruses can have significant impacts on human health and wellbeing. Highly pathogenic avian influenza viruses (HPAIV) threaten poultry producers with high costs of culling and disposal in the event of an outbreak. Earlier in 2015, a shortage of eggs in the US was caused by HPAIV in commercial layer flocks. In countries with chronic food shortages, HPAIV can have more widespread effects on food availability and, therefore, impact cost.

There is also the effect of avian viruses on wild bird populations to consider. Birds in North and South America, but it doesn’t just affect birds – people and horses can be infected too. WNV perfectly illustrates the role of birds in the spread of viruses over long distances.

My veterinary colleagues see the impact of avian viruses among their clients.

Some pet birds live for decades and are beloved members of their families. The emotional and financial tolls associated with proventricular dilatation disease (PDD) – caused by a bornavirus – are often significant. Outbreaks of PDD among captive, breeding populations of endangered birds are particularly heartbreaking.

**Avian bornavirus (ABV) was not identified until 2008. When did you first become aware of ABV and what sparked your interest in this ‘emerging’ disease?**

Before we knew about ABV, we were studying PDD in captive parrots, of which one key characteristic is a greatly enlarged proventriculus (akin to our oesophagus) in some affected birds. We suspected that PDD had a viral aetiology but, despite considerable effort, the agent remained a mystery.

In 2006, I began collaborating with a group of colleagues at the College of Veterinary Medicine at Texas A&M University. Using traditional methods for virus culture and isolation, we tried to identify viruses from PDD birds. A breakthrough was made by two other groups in 2008 – they detected bornaviruses in the brains of birds with PDD. We used the published sequence data to confirm that we were, in fact, growing the virus in duck cells. Bornaviruses are difficult to detect in cell cultures because they do not kill the cells or cause any other signs we associate with virus infection.

**How does ABV compare with borna disease virus in horses (the only known bornavirus prior to 2008), and how common is ABV today?**

Bornaviruses infect neurons. In birds, neurological damage can cause a gastrointestinal disorder. However, birds also have other neurological issues – such as problems with perching or blindness. The most obvious symptoms of borna disease in horses are movement and sensory dysfunctions, which are similar to what we see in birds. Avian bornaviruses are most often found in captive birds and, unfortunately, the infection is not uncommon in parrots.

Birds can be infected with the virus for many years without showing any signs. Indeed, they may never get the disease. We don’t understand what events trigger disease development. There is evidence that eggs contain the virus and some reports suggest increased mortality in infected hatchlings.

**Have any of your recent investigations provided a clearer perspective on the relationship between infection of waterfowl with avian influenza viruses and bornaviruses?**

No, we have not looked into the relationship between these two viral infections. Many of the samples we originally tested for bornaviruses were collected for the specific purpose of influenza virus surveillance. However, only samples testing negative for avian influenza viruses were shipped to us for testing. Bornaviruses cause lifelong infections, while influenza viruses cause acute or short-term infections. We don’t know whether or not infection with one could influence the course of infection by the other.

**You have been working with partners across the US to determine the prevalence of ABV in gull species. How have these investigations varied from your work on waterfowl?**

It is more difficult to obtain gull samples as they are not hunted. The gull samples we obtain are from nuisance birds collected from airports or landfills. We have found positive birds from a few locations where there are also a lot of waterfowl, but we haven’t found bornaviruses in gulls collected from inland locations. The virus seems to be more prevalent in geese, swans and ducks. The gull infections may represent ‘spillover’. Current understanding of bornaviruses in wild bird populations is still in its infancy.
Avian bornaviruses are a significant cause of disease and death in both captive and wild birds. Researchers from Texas A&M University in the US are attempting to characterise the viruses recovered from a wide variety of birds to help alleviate their suffering.

**ECOSYSTEMS ARE BIOLOGICAL** communities composed of interacting living organisms and non-living components. Highly complex, the functioning of an ecosystem is reliant upon all of its parts; if one is damaged, there is a resounding impact on the rest. To restore the balance of an ecosystem, it is therefore important to identify any significant causes of disease or death, so that the potentially profound effect can be curbed quickly and effectively.

In the mid-1970s, proventricular dilatation disease (PDD) – a fatal neurological disease found in captive parrots and macaws – was discovered. Caused by a virus, it has been identified in more than 80 different species of parrots, although similar symptoms to those of PDD have been reported in waterfowl, raptors and passerines. As the disease leads to partial paralysis of the digestive system, typical symptoms include weight loss, intestinal enlargement, regurgitation, starvation and, ultimately, death. However, the disease can also attack the central nervous system, so birds might not show any gastrointestinal signs and still have the disease.

**BORNAVIRUSES**

There are several potential causes for the development of PDD but, thus far, only one has been discovered. In 2008, researchers managed to pyrosequence the cDNA from the brains of several parrots that were suffering from PDD and, in doing so, identified the presence of a novel bornavirus called avian bornavirus (ABV). Bornaviruses are unsegmented, enveloped, negative strand RNA viruses that replicate in the cell nucleus and tend to attack the nervous system. Before 2008, only one bornavirus was known – the Borna disease virus of horses.

Bornaviruses cause intense suffering in birds, one of the many reasons motivating researchers to investigate means of preventing, diagnosing and treating the condition effectively, and to determine exactly which birds are affected by it. With this in mind, a team of researchers from Texas A&M University has been working on ways to learn more about the virus. Led by Dr Susan Payne, the group has so far identified two means of diagnosing viral infections. The first is to actively look for the virus itself, while the other is determining whether a bird has made antibodies in response to it. As the virus often infects a bird’s kidneys (and is therefore spread in the urine), bornaviruses have been detected in bird droppings – where the white portion is urine. However, not all infected birds develop problems in the kidneys and the test is not 100 per cent effective. The group continues to work on developing technologies, such as antibody tests, that could lead to more effective means of diagnosis.
The virus has also been found to affect multiple gull species, meaning that coastal ecosystems could be significantly impacted upon, with potentially far-reaching consequences.

**WILD BIRDS**

Although ABV was originally found in parrots and macaws, and the team has previously focussed its energies on the disease in captive birds, the researchers have recently shifted their attention to investigating the presence of the viruses in wild birds. The team has found no evidence that the viruses transfer between water birds and parrots, but have identified that bornaviruses in water birds affect around one-quarter of mute swans, 15 per cent of geese and 10 per cent of wild ducks in North America.

Payne and her team have examined bornavirus samples discovered in wild waterfowl and found that the viral genomic sequence appeared sufficiently different to ABV in parrots – findings that have proved to be enigmatic. “A comparison of North American water bird bornaviruses to captive parrot bornaviruses reveals that the virus did not ‘jump’ between these birds. There is some preliminary evidence that parrot bornaviruses exist in wild parrots, but a group in Japan has recently reported finding ‘parrot’ bornaviruses in wild cranes and ducks. The origins, distribution and ecology of these viruses therefore remain a mystery,” explains Payne.

**GENETIC CATEGORISATION**

The virus has also been found to affect multiple gull species, meaning that coastal ecosystems could be significantly impacted, with potentially far-reaching consequences. Gulls are known to inhabit many different types of landscape, suggesting that ABV could impact rocky shores, beaches and coastal wetlands. In the case of the latter, habitat, gulls and other waterfowl are known to interact within them, so the epidemiology of ABV is directly relevant to the functioning of coastal ecosystems.

One of the group’s main research objectives is to genetically categorise ABV recovered from a wide variety of birds. Thus far, they have managed to test small numbers of many different bird species but, in most cases, the sample size has proved too small to determine the prevalence of the virus. However, the tests have led to some curious findings that may, in turn, lead to new directions in which to take their investigations. “Interestingly, we have found a few positive raptors, such as eagles and hawks, that were brought to wildlife rehabilitators in Texas. It is possible that these birds encountered the virus through infected geese or ducks but, so far, we have not been able to determine if the bornavirus sickened the raptors – it is an interesting possibility we would like to pursue,” enthuses Payne.

**VACCINE DEVELOPMENT**

Excitingly, Payne and her team have made huge strides in the development of a highly effective vaccine against PDD in parrots. The research — supported by the Schubot Center — has been hugely encouraging so far, although it is still too soon to predict when any vaccine will be commercially available for both aviculturists and veterinarians. The safety and effectiveness of the vaccine must be extensively field tested, but it is a step in the right direction.

Parrots and other captive birds are, often, important members of the family, so any cure for ABV and PPD will prevent the suffering of birds and their owners. Ultimately, it could also lead to a cure for waterfowls and gulls, which would ensure the continuation of unburdened coastal ecosystems, which is of benefit to all of us.