



Animal &  
Plant Health  
Agency

# APHA Annual Science and Evidence Review 2019

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# 1. Introduction

This document sets out a wide range of science highlights achieved throughout the year in support of the [Animal and Plant Health Agency \(APHA\) Science Strategy 2015-20](#). It shows the range of animal and plant health expertise within the agency and demonstrates the importance and value of linking surveillance and research activities to rapidly investigate and respond to new threats; including those with potential public health impact. It also shows our important role in the protection of animal and plant health and animal welfare.

The science highlights are grouped around our science portfolios as well as the main scientific disciplines working across the APHA. Important achievements are also published regularly on the [APHA science blog](#) on GOV.UK. The aim of the blog is to improve the communication of our science to a wider audience. It covers a range of scientific highlights from special interest stories on our scientists through to more detailed reports on the excellent science we do.



Dr Kath Webster  
APHA Director of  
Scientific Service

## 2. Science Portfolios

### 2.1 Animal and Zoonotic Viral Diseases Portfolio (AZVDP)

This portfolio provides active and passive surveillance, diagnostics and applied policy-relevant research on animal and zoonotic viral diseases through multi-organisational funding and global collaboration. The portfolio assesses the impact of viral pathogenesis on animal health and welfare, the economy, the food chain and human health. Having unique expertise, skills and facilities within the UK, APHA maximise the value of our national resource through collaborative working with academia and public sector research establishments (PSREs) and is reactive to all viral disease hazards. Systematic syndromic disease profiling combined where relevant with earth observation data allows us to scan the horizon for viral disease threats and risks. Our national and international engagement with public and private sector stakeholders ensures our sustainability. Working within this environment allows us to work on disease intervention/prevention and for example analyse the host response and microbiome interaction. Through our international engagement we also contribute to United Nations Sustainable Development Goals particularly to ensure food security.

The structure of the portfolio is focussed to ensure rapid detection of exotic viral disease threats as well as influence control and mitigation strategies. Our work reduces the impact of viral disease threats to livestock, companion animals and wildlife. Our remit with zoonotic diseases also enables protection of public health and occupational exposure, and informs on potential reverse zoonoses that may threaten animal health. Our research, surveillance and diagnostics is supported by both Defra and Non-Defra funding and as such is highly collaborative with close relationships existing with numerous academic institutes, PRSEs and commercial bodies globally. Our core staff resource supports a minimal national capability for emergency laboratory response to incursions of viral pathogens across a wide spectrum of biocontainment requirements. We also provide numerous reference laboratories for notifiable and non-notifiable diseases – both exotic and endemic viral pathogens, and disease consultancy.

#### Highlights

The AI and ND European Union Reference Laboratory function was successfully handed over to our colleagues in Italy and the International Reference Laboratory for avian and swine influenza and Newcastle disease established at APHA. Maintaining the function for the UK National Reference Laboratory for Avian Virology and Mammalian Influenza, and expanding our global outreach as these viral hazards continue to transit worldwide. New participatory avenues such as the UK Research and Innovation (UKRI) Global Challenges Research Fund (GCRF) One Health Poultry Hub and Centres of Excellence for Influenza Research and Surveillance (CEIRS-Royal Vet College) collaborations are set to facilitate this process.

APHA have developed infrastructure and technical expertise to expand our capabilities with African swine fever virus (ASFV), we are now able to offer differential diagnostics for 'swine fevers' – Classical Swine Fever (CSF) and ASF viruses and also carry out targeted research as required. Our Virology experts participated in workshops in China and Japan in year. The Department of Epidemiological Sciences has also been working on pig and wild boar disease models as the risk of ASFV incursion into the UK has escalated during 2019.

The Arbovirus team have assessed UK mosquito species as potential vectors for exotic viruses including Rift Valley fever virus (RVFV). They concluded that native mosquitoes could transmit this zoonotic virus under the environmental conditions found in the UK. A consensus species distribution model for competent RVFV mosquitoes and a vector borne disease livestock model for spread of this disease has been developed within the department for Epidemiological Sciences in collaboration with the arbovirus and wildlife teams. Diagnostic molecular tests have been validated for use for detection of RVFV in collaboration with The Pirbright Institute (TPI). APHA participated in a SAGE Exercise (Scientific Advisory Group for Emergencies, GO-Science). Genomic barcoding of mosquitoes and other arboviruses has been established at APHA via international collaborations thus enhancing our vector competence studies of colonised mosquitoes to study Arboviruses.

All three work groups have seen a strengthening of their research with respect to host response to viral pathogens – pigs, poultry and animal model species (e.g. rodents, ferrets).

Two Equine Infectious Arteritis Virus (EIAV) outbreaks occurred during the year, involving five horses in the UK – the first since 2012. Investigations included WGS to differentiate between previous (2010/12) and current outbreaks (2019) to determine the global situation of EVA and possible routes of infection.

Influenza D has been detected in the UK for the first time, in pigs from Northern Ireland. The mammalian influenza team had already established molecular, serological and virological assays as this pathogen began to be detected in pigs and cattle from more global locations including USA and Europe in recent times. Research based surveillance is underway.

The Rabies and Viral Zoonoses group has extended their work in collaboration with Liverpool University investigating the detection of rodent borne viruses in rats on pig farms in England and occupational exposure to these zoonotic pathogens. The hantaviruses detected were compared to those detected in pet rats, reptile food trade rats and wild rats. The recently identified zoonotic rat specific Hepatitis E virus (HEV) was also detected in wild rats in similar geographical locations – Northern half of England. Connecting this work and the swine HEV work for Defra and the Food Standards Agency (below).

The Mammalian Virology team has developed an oral dose in vivo model for HEV infection in pigs, along with molecular characterisation tools and successful virus isolation. This will enable a better understanding of HEV transmission into the human food chain as zoonotic transmission has been demonstrated for the HEV genotype(s) present in European pigs.

## **Avian Virology and Mammalian Influenza**

The Influenza and ND team at APHA have undertaken a broad range of activities during 2019. External facing activities:

### **Avian**

Applied research on AI and ND viruses: Defra and Non-Defra: APHA focused and collaborative studies spanning numerous National and global partnerships.

WGS techniques continue to be optimised for Influenza viruses, an essential part of understanding the host species, epi-genetics and geo-spatial factors of highly mutable RNA



genomes that are capable of genetic reassortment. The key sponsors of this work have been the EU via the [COMPARE project](#) for technical and analytical bioinformatic advances, Defra FluFutures project to optimise protocols for clinical samples from influenza A virus infected hosts; both experimental and field, APHA via the CoVetLab programme on swine influenza A viruses and UKRI via BBSRC funding for Influenza A virus dynamics – pandemic H1N1. These projects have all completed in 2019/early 2020. Substantial advances have been gained and further funding is being sought to continue these streams of research (Defra, APHA, UKRI and via North American funding streams).

## Avian influenza virus

WGS of all RNA (host and viral) in clinical samples is enabling genotypic changes in H5Nx and H7N7 AI virus strains to be assessed following transmission in different avian species (chickens, ducks and turkeys). Multi-basic cleavage site mutations are being assessed using reverse genetics to establish determinants of pathogenicity whilst host receptor density in tissues of chickens and turkeys have suggested viral adaptation through the utilisation of different receptors to cause severe disease. This work utilises our specific expertise in *in vitro* (cells), *in ovo* (embryonated eggs), *ex vivo* (organ cultures) and *in vivo* (animals) drawing on virology and pathology knowhow at both bio-containment levels 2 and 3, laboratory and animal facilities.

Part of this unique expertise is cross-species bio-systematic virus incursion and transmission studies to understand the pathogenesis of AI A viruses both within species, across avian species and the possibility of avian to mammalian disease jumps. This included wild bird (waterfowl model – duck) to terrestrial poultry (chickens and turkeys) models such as H5N8 and H5N6 (Defra & HU-H2020 DeltaFlu projects). This data is helping researchers understand how changes in the virus affects the host bird species that can be infected, which links to the role of wildlife in recent disease outbreaks. Related to this, global collaboration through the International Atomic Energy Agency (IAEA) funded work is investigating the utility of stable isotope analysis of primary avian flight feathers in determining the geographical origin of AIV-infected wild birds. Wild birds as a source of AI A virus ingress into the UK is under taken by Defra funded surveillance of birds found dead, collaborative research has also allowed us to undertake some targeted waterfowl surveillance at sites such as Abbotsbury Swannery (with University of Oxford) and wider via environmental sampling (water, water body sediment, muck – mud and faeces, feathers) at numerous UK wetland and other key high risk sites via the DeltaFlu project. Similar work is being undertaken in Canada, Sweden, Germany and Italy to different extents by our collaborators for comparative outcome analyses.

Understanding Influenza A virus survival in complex environments has continued in 2019 via a combination of Defra and Delta-Flu funding streams. The focus this year has been on H7N7 viruses from 2015 outbreaks in England, The Netherlands and Germany, using a high security broiler barn scenario - *in vivo* model. The key scientific questions here are virus ingress modelling and transmission between infected and in-contact naïve birds and the transition of low pathogenicity (LP) virus to highly pathogenic (HP) viral forms, linking to the *in vitro* reverse genetics construct analyses. We are also now more able to investigate the poultry host responses during these LP to HPAIV to determine the role of host factors in this viral evolution to increased virulence. The latter has been advanced via a PhD student and collaboration with the Roslin Institute, a DeltaFlu project partner.

Other research highlights include the evaluation of drivers of genetic shift with low pathogenicity AIV (LPAIV) to focus on how different parental strains of AIVs may mix or 'reassort' their

segmented genomes through mixed infections of chickens with H7N9 and H9N2 funded by Defra and the BBSRC, in collaboration with TPI. In 2018, dual infection experiments demonstrated the presence of possible reassortant viruses which consist of the H9 gene with various permutations of internal genes derived from the H7N9 parental virus, and including in some instances the N9 neuraminidase (NA) gene. In 2019, all nine 'progeny' virus genotypes were shown to replicate *in vitro* and investigation of the genome replication machinery (polymerase genes), found that the H9N2 PB1 or PA alone could enhance replicative fitness. One novel, and highly prevalent reassortant virus - H9N9, has been investigated for zoonotic risk in a ferret (human model) bio-aerosol transmission study.

These viruses naturally co-circulate in places such as markets with live birds commonly found in Asian countries. Both H7N9 and H9N2 can and do infect both poultry and humans, and as such represent a considerable potential threat for on-going zoonotic influenza A virus emergence and pandemic threat.

Experts from Epidemiology continue to advise the European Food Standards Agency (EFSA) on European surveillance activities in effectively monitoring poultry and wild birds for AI through their working groups and surveillance reports. (i.e.

<https://www.efsa.europa.eu/en/efsajournal/pub/5945>)

APHA virologists and epidemiologists have hosted scientists from Korea, Japan and Qatar interested in our expertise in the surveillance and diagnosis of AI.

### **Avian Paramyxoviruses (APMV-1) including NDV**

This group of viruses has undergone several taxonomic name changes in recent years - APMV-1, became Avian Avulavirus type 1 (AAV-1) and in 2019 Avian orthoavulavirus (AOAV-1). The key viruses of concern are those that cause ND and pigeon paramyxoviruses. This programme of work funded by Defra focuses on transmission of viruses in poultry and gamebirds such as pheasants and partridges. In 2019, the notable outcomes have been improved virus isolation ability, reduction of time taken *in ovo* and generation of species specific cell lines such as pigeon cultures. The movement of live virus around poultry premises has also been extended from simple virus survival parameters to complex matrices such as 'rubber with tread' (footwear and vehicle tyres) and paper / card (egg trays and documentation) aimed at assisting minimisation of virus dissemination on farm – ingress of disease or during outbreaks. The effectiveness of disinfection has also been modelled *in vitro* to determine the time taken to reduce virus levels from a high viral titre to that of the minimal infectious viral dose required to establish infection in birds and extrapolation to virus extinction.

The other key area of research investigation has been to identify a more robust vaccine candidate for NDV. Current vaccines have variable efficacy and vaccine breakdown disease cases have occurred potentially allowing vaccine escape mutants to evolve. Using a range of approaches we have examined the genome sequence major lineages of AOAV-1, selected a subset (16) that represents the diversity of strains and analyses of the key antigenic sites in both linear and protein conformational formats in an attempt to identify a more robust immunogen that may be considered as a future vaccine candidate. Using a range of serological assays (HAIT, virus neutralisation and ELISA) and antigenic cartography, an invaluable tool in influenza A vaccine strain selection, it has been possible to carry out a similar process for the first time on viruses capable of causing NDV. This work has formed the bulk of a PhD studentship due to complete in 2020.



## **UK notifiable avian disease detections: AIV and NDV**

Both the UK Poultry Survey (serology) and the notifiable avian disease investigations (clinical suspicion) were completed successfully in 2019. 18 'report cases' were investigated in the field, 13 were submitted for laboratory diagnosis of which four were via the private poultry industry sector 'testing to exclude' (TTE) function and five were from non-negative H5 sero-surveillance follow-ups. The positive outcomes were one avirulent AOAV-1 (NDV), two non-notifiable H6N5's, and one H5N3 LPAIV. No influenza A virus wild bird positives were detected in 2019, in contrast to the two previous years where H5N8 and H5N6 'bird flu' was found.

The TTE five year review has been completed and manuscripts prepared – currently held by Defra policy team, there have been 37 submissions in total since May 2014. Seven during 2019 of which four were non-negative (above). Differential diagnosis to establish other causes of clinical disease manifestations, has been undertaken on a small number of cases where notifiable avian disease has been excluded in conjunction with the Avian Expert Group.

## **Mammalian Influenza**

Swine Influenza Virus (SwIV) surveillance, diagnosis and characterisation (Defra) has detected new introductions, reverse zoonoses, of human pandemic H1N1 into UK pig herds, pre-2019 reassortant (rH1N2) and new reassortant viruses (pdm backbone with variable endemic N1/2 or rH1avN1) now co-circulate in our pig herds. WGS (via Defra research, APHA CoVetLab and IRL) plays a critical part in the molecular phylogeny determination and human risk assessment for these pathogens. Similar findings are being described across mainland Europe and further afield. We have maintained and instigated additional global collaborations (including funding initiatives) to keep abreast of these hazards and threats to the UK pig industry.

Influenza D was first isolated in 2011 in the USA causing mild respiratory disease in cattle. There is modest (70%) similarity to Influenza C viruses but less with Influenza A and B viruses (40%). In the past APHA has been engaged in studies indicating that an influenza-like pathogen may be present in cattle in the UK, however, this could not be substantiated as a pathogen could not be isolated and as such Koch's postulates could not be met. It has now been shown that there are two Influenza D lineages in circulation across a wide range of geographical locations – Europe, Asia, North and South America. Isolates have been found in cattle and pigs, with serological evidence extending to sheep, goats, horses and camelids. There is serological evidence for Flu D in cattle herds in the UK (APHA and AFBI-NI) and a virus isolate obtained in NI. The toolbox has been established at APHA (PCR, serology and culture) and investigations will continue.

Collaborative work on influenza A virus vaccines continues to produce results and maintain zoonotic animal model competencies – pigs and ferrets, and provide income from Non-Defra sources (commercial and UKRI).

The APHA team has delivered work for a Biotechnology and Biological Sciences Research Council (BBSRC) funded collaborative study with TPI, completed in year. The work involving extensive in vivo transmission chain experiments in pigs to investigate the serial transmission of pandemic swine H1N1 influenza viruses, utilizing recombinant viruses containing genetic barcodes to enable virus tracking. Transmission between groups of naïve pigs and pigs vaccinated with an antigen heterologous to the challenge barcode virus has been completed and including WGS to determine the genotypic changes observed in the presence or absence of immune-mediated selection pressure, publications submitted and in preparation.

## International Reference Laboratory Activities

Alongside work supporting the activities described above, the OIE/FAO International Reference Laboratory (IRL) for avian and mammalian influenza, and ND provided updated reports to the European Commission and Defra on epidemiology and surveillance relevant to H5Nx HPAI outbreaks reported throughout 2019. Following the EURL handover to Italy last year the IRL continue to provide consultancy as requested and our outreach has expanded globally (e.g. Asia, Africa and the Middle East) and is continuing to accelerate attracting funding from a range of sources. Examples include the One Chick poultry hub (UKRI GCRF), CEIRS - Centres of Excellence for Influenza Research and Surveillance, DTRA - Defence Threat Reduction Agency,

An unusual avian Influenza H3N1 virus causing clinical poultry disease in Belgium and Northern France caused concerns for the UK over the summer, IRL tools were checked in preparation for this threat and an *in ovo* pathogenesis study was undertaken in collaboration with the pathology department via the VetBioNet H2020 project to investigate its atypical virulence.

Working collaboratively with the APHA Lasswade and Starcross regional laboratories, RVC and non-government organisation – marine life rescue, the IRL and pathology departments completed an investigation into a seal influenza virus infection (H3N8). The studies included molecular phylogeny, animal and zoonotic risk assessments to contribute to our understanding of avian-origin 'flu viruses adapting to mammals; marine and terrestrial.

The IRL has also been liaising with various international bodies through different projects to support genetic analysis of AIVs. Examples include the analysis of AIV samples from the Middle East through linkages within the FAO; Asia via the BALZAC project continuing in 2019; and sustained tracking of the emerging AI situation in Europe and the rest of the world through WGS of the currently emerging strains (HPAI H5Nx), to assess virus diversity and potential human risk markers.

IRL activities around ND monitoring have included characterisation of virus from ongoing sporadic outbreaks in Eastern Europe with genetic assessment of emerging virus strains currently circulating in northern European countries. Collaborations with Middle Eastern countries where this disease is endemic and vaccination variable continue, with linkages to the Defra research (above).

## Mammalian Virology

Applied science within the team during 2019 has encompassed a wide range of hosts and pathogens: a key focus was on equine disease outbreaks and swine fever viral diseases with EIAV UK outbreaks and ASFV/CSFV threats highlighted above. The APHA research and surveillance (NRL) teams have worked closely with colleagues across Europe and Asia to carry out inter-laboratory proficiency testing and harmonisation of approaches for swine fever viruses, sustaining our disease expert capabilities and enhancing our international reputation.

The APHA teams have contributed extensively to an African/classical swine fever (ASF/CSF) DERC (disease emergency response committee) preparedness as ASFV become the highest UK incursion risk with respect to exotic disease during 2019. Following an exercise in 2018 which simulated a medium scale outbreak and demonstrated our ability to respond effectively, this year we (APHA - Virology, Wildlife and Epidemiology departments) were asked to prepare for investigations and risk assessments with respect to wild boar-domestic pig interfaces and

potential import of ASFV contaminated pork products at border inspection points (on behalf of Defra and the H2020 COMPARE projects).

The Pestivirus research group completed a collaborative CSFV challenge study investigating the immunological mechanism of protection of a novel subunit vaccine compared to the live attenuated CSF vaccine. Both vaccines protected against clinical disease but induce slightly different immune pathways. A subunit vaccine would have the benefit of Differentiating Infected from Vaccinated Animals (DIVA) testing being available. Studies on myeloid immune cell populations and transcriptome network analyses within the porcine tonsil following the infection with CSFV vaccine enhanced our knowledge of host protective immune responses that need to be triggered by a successful host against CSFV vaccine (core capability funded research, including PhD studentship).

Similar to our work with swine fever viruses APHA have also succeeded in establishing an oral infection model for animal (genotype 3) Hepatitis E virus (HEV) in pigs. APHA continues to work in partnership with colleagues from the Food Standards Agency (FSA) and Public Health England (PHE) to combat threats to food safety and food security, including regular reviews for the UK Zoonoses, Animal Diseases and Infections (UKZADI) group. While a rodent specific HEV has also been detected on pig farms (above, Rabies and Zoonotic Viruses workgroup), although this has not been found in pigs and the pig HEV not detected in rodents to date.

Following two negated swine fever investigations we detected pathogenic porcine reproductive and respiratory syndrome virus (PRRSV) and Porcine Circovirus (PCV-3) respectively in these cases. The clinical disease caused by PCV-3 in the UK was one of the first events globally of this virus and severe disease association. The impact of PCV-2 and -3 is of importance to British pig production and requires further investigation.

Porcine reproductive and respiratory syndrome virus (PRRSV) remains the highest impact disease on pork production in the UK and globally (outbreaks of ASF, such as in China notwithstanding). PRRSV vaccines are fraught with problems, in being either not efficacious or creating escape variants, i.e. may be detected in non-vaccinated animals. Recombination associated with live attenuated vaccine viral strains has been previously documented (e.g. by APHA in 2013), but recently became of interest again with the recombination of two vaccine strains being detected. Further in depth analysis will be required to determine the impact and find better vaccines to provide sustainability and trade in an increasingly valuable product (pork) – and protect breeding animals.

Conservation and wildlife protection includes working with a wide range of stakeholders to detect pathogens and where possible support mitigation strategies. At APHA we provided squirrel pox (SQPV) and adenovirus (SQADV) screening, which are primarily responsible for the decline of red squirrels. Use of antivirals (interferon type 1, IFN I) for the treatment of Elephantid betaherpesviruses infections, was successfully utilised during a clinical case – curbing progression to disease and survival in a juvenile UK zoo based elephant, based on research carried out at APHA. We provided evidence that increased fatalities in UK rabbits and hares was/is due to infections such as a novel rabbit haemorrhagic disease virus (RHDV) genotype, and European Brown Hare Syndrome Virus (EBHSV). In collaboration with the RVC the team also detected a novel adenovirus in lung tissue of a fatal disease in reindeer.

## **Rabies and Viral Zoonoses**

### **Rabies Virus and Other Lyssaviruses**

The rabies research team, funded by Defra (SE0431) and EU H2020 projects – RABYVAX and EVAg, have had a productive year with outputs involving rabies vaccine and their efficacy for classical rabies virus (RABV) and the wide range of other lyssaviruses with variable divergence from RABV, and other anti-viral products – immunoglobulin and antibody fragments. A considerable number of rabies-causing lyssaviruses are not neutralised by rabies vaccines and post-exposure treatments, it is hoped that these approaches will allow new products to be pre-clinically tested and eventually reach markets where they are required.

Rabies and lyssavirus diagnostics has also taken a step forward with the OIE recognition of the RT-PCR test being accepted as a front line test, in addition to the traditional viral antigen detection test, important for those without access to bio-containment facilities. The tests has also received recognition via video publication in the Journal of Visual Experimentation.

Defra funded research studies also continued to improve our surveillance and diagnostic capability for the UK, and in particular reduce diagnostic turnaround times. During 2019, the presence of European bat lyssavirus type-1 (EBLV-1) in Serotine bats from Dorset has been confirmed with three cases added to the two cases found during 2018, all within a 20km radius. The closest match being an EBLV-1b virus from Brittany in North West France. Defra has provided additional funding under the new and emerging disease fund to gather further epidemiological and phylogenetic data prior to the emergence of these bats from hibernation. Only one detection of European bat lyssavirus type-2 (EBLV-2) in a Daubenton's bat was detected in 2019, a substantial reduction from 2018 with a high frequency of eight cases. Stakeholder engagement continues to be strong - Defra, PHE, Health Protection Scotland and the Bat Conservation Trust.

The team have also been active in human diagnosis with fatal rabies being confirmed ante-mortem in a high profile case of an adult UK traveller bitten by a suspected rabid cat in Morocco. Global Rabies Day was again supported by APHA as 59,000 deaths worldwide continue to occur as a result of this, classical rabies, vaccine preventable disease.

The excellent international reputation of APHA has been maintained through the provision of expertise, knowledge transfer to diagnostic centres in endemic areas and international collaboration. 2019 activities included projects in India (OIE Twinning) and Tajikistan (MoD). Our reputation has also been enhanced through international publications, national and international presentations and both taking the lead, and contributing extensively to expert reports for both the WHO and the OIE.

Finally the APHA rabies team have been pivotal in the preparations for EU Exit to ensure that testing is available to support pet travel if required, ramping up from 6000 to a possible 150000 tests per year.

### **Vector Borne Diseases**

The vector borne disease team have continued to enhance capabilities in both diagnostic evaluation of suspect samples and research on the vector competence of UK mosquitoes for exotic pathogens (renewed Defra funding SE4116). The molecular and serological West Nile

Fever (WNV) testing has helped increase our virus investigation capability. Numerous samples (avian and equine) have been evaluated during 2019, all have been negative, with the exception of a small number of racing pigeon export sera, cross reactivity with Usutu virus was suspected. APHA continues to work closely with internal and external groups to evaluate all submissions as required. The recent detection of WNV in humans, horses and wild birds in Northern Germany has demonstrated that the risk of virus introduction to the UK in future years is increasing with climate change and Defra through the new and emerging disease programme has funded some additional sero-surveillance for WNV in horses in Southern England where competent vectors have been located. Collaboration with entomologists and virologists across Europe and Latin America to investigate mosquito biodiversity, species barcoding and virus transmission has been developed.

APHA have also collaborated extensively with PHE to assess abundance and distribution of tick populations (primarily *Haemophysalis punctata*, the Red Sheep Tick); detections this year indicated an expanded disease vector range in southern England and demonstrated that it hosts a range of pathogens (Medlock et al., 2018 *Med Vet Entomol.* 32, 473-480). The detection of tick borne encephalitis virus (TBEV) by PHE in the common sheep tick (*Ixodes ricinus*) for the first time in the UK this year has emphasised the importance of continued monitoring of UK vector populations.

DNA barcoding has been developed at APHA to support identification of British mosquitoes (Hernández-Triana et al., 2019 *Zookeys* 832, 57-76) and applied to more detailed investigation of a particular West Nile vector, *Culex modestus*, in southern England (Hernández-Triana et al., 2019 *Med Vet Entomol* published online). This study suggested that the species is a recent introduction near to the Thames Estuary and has spread rapidly along the Essex and Kent coasts. The barcoding approach has also been applied to confirm the presence of an exotic tick species in Dorset, *Hyalomma rufipes*, a vector of Crimean-Congo haemorrhagic fever virus. In addition to more 'exotic' zoonotic pathogens (also see below) the arbovirus team also contributed to an investigation of a louping ill virus (LIV) outbreak: an endemic tick-borne disease in GB. An outbreak of clinical disease in NE Wales during 2019, was investigated in collaboration with the Veterinary Investigation Laboratory at Shrewsbury and the Pathology Department at Weybridge. Histopathological investigation indicated evidence of encephalitis and serological tests were positive for LIV infection. RT-PCR confirmed the presence of LIV genome. Phylogenetic analysis indicated that the virus showed the highest identity with LIV sequences from west Wales and was distinct from other LIV isolates found in the north of England. This case study highlights the ongoing threat to UK sheep from LIV, it also has some zoonotic potential.

Our expanding ability to work with arbovirus pathogens in high containment with vector host has led to the demonstration of vector competence of UK mosquito species. This includes exotic viruses such as Rift Valley Fever virus (RVFV), Batai virus and Usutu virus under tri-partite collaboration between APHA, the University of Surrey and PHE (Lumley et al., 2018 *Parasites & Vectors* 11, 308). It concluded that native mosquitoes can be infected with RVFV, demonstrating that these mosquitoes could transmit this zoonotic virus under the environmental conditions found in the UK and developed a transmission model for RVFV with the Department of Epidemiology at APHA. We have also demonstrated a lack of competence of some UK mosquito species for bovine ephemeral fever virus (in collaboration with TPI) and investigated the capacity of invasive mosquitoes to vector Zika virus (Hernández-Triana et al., 2019 *Parasites & Vectors* 12, 204), as recently observed in France with three human autochthonous cases (non-travel associated), Japanese encephalitis virus vector studies are planned for 2020.



In collaboration with APHA scientists within the Department of Epidemiological Studies, the arbovirus team has developed species distribution models to predict potential high risk areas where a combination of the appropriate mosquito species and livestock density might support transmission of Rift Valley fever virus (Simons et al., 2019 PLoS One 14, e0225250). The benefit of this approach is to identify hot-spots to which surveillance could be directed if the risk of a mosquito-borne virus introduction increases.

APHA in collaboration with University of Liverpool have demonstrated that rodent-borne zoonotic Hantaviruses virus presence in pet and pet food commodity rodents in recent years, they have also now shown that rats on a quarter of pig farms tested in the Midlands harboured Hantaviruses. Hepatitis E virus and LMCV co-infections were also detected in rats. Occupational human exposure and infection are substantial risks.

One health has been an AZVDP focus for 2019, 75% of new diseases in the last 10 years have been zoonotic pathogens and three-quarters are due to viral pathogens, 1-in-3 people fall ill every year from an animal-borne disease, 20% of food production is lost every year through animal disease, and animal health and welfare are substantially impacted. Healthy animals produce healthy, nutritional and disease-free food. [Source information below]

- [Centers for Disease Control and Prevention: Zoonotic Diseases](#)
- [Global One Health at Wageningen University & Research](#)
- [Future threats to agricultural food production posed by environmental degradation, climate change, and animal and plant diseases](#)
- [The Global One Health Paradigm: Challenges and Opportunities for Tackling Infectious Diseases at the Human, Animal, and Environment Interface in Low-Resource Settings](#)

## **Risk Assessment and Horizon Scanning**

A generic spatial release assessment framework has been developed within DES through the SPatial Assessment of Risk for Europe (SPARE) project. The model utilises freely available global datasets to predict the probability of entry of exotic pathogens to European Union (EU) Member States via different routes of introduction such as trade or vectors. The model was parameterised for African Swine Fever, Classical Swine Fever, Bluetongue and Rabies. A web-based user interface has also been developed which can show results for specific stages of the risk assessment. The model can help to drive risk-based surveillance activities by providing detailed quantitative comparisons to indicate which pathogens are most likely to enter the EU and UK. A special issue of Microbial Risk Analysis on the SPARE project was recently published.

Research estimating the risk of African swine fever introduction and infection across Europe has been performed, using a generic framework (applicable to multiple diseases) from the COMPARE project. At a fine spatial scale, the model can output hotspots of potential disease infection. To assess the quality of generic risk assessments such as in the COllaborative Management Platform for detection and Analyses of (Re-) emerging and foodborne outbreaks in Europe (COMPARE) and SPARE projects, the Generic approaches for Risk Assessment of Infectious animal Disease introduction (G-RAID) project analysed multiple such models across Europe and applied them all to a case study of African swine fever, to see if predicted risks were

comparable. Results were generally in line with each other, improving the validity of our own generic risk assessment models.

These tools allow policymakers to estimate the risk of disease incursion into the UK over time as outbreaks of exotic notifiable diseases occur in Europe and beyond. This is particularly relevant with outbreaks of ASF moving westwards.

## 2.2 Bacterial Diseases and Food Safety

Our strategy is aimed at providing robust scientific evidence, assurance and biosecurity advice to Government; to enable effective control of exotic bacterial disease threats to livestock, and to protect public health and the reputation of British food animal production through definitive characterisation and control of zoonotic diseases, chemical toxicity incidents and antimicrobial resistance (AMR) in livestock and the food chain.

### Highlights

Guidance on the control of *Salmonella* in broiler chicken has been strengthened following the investigation of sources of infection in feed mills and hatcheries and improved management of resident *Salmonella* contamination.

APHA has been investigating and managing an increase in *Salmonella* Enteritidis cases in egg laying flocks, linked to over 120 human cases, in collaboration with the British Egg Industry Council (BEIC), PHE, FSA and Local Authority staff. By using WGS we were able to establish that the laying hen farm cases form two genetic clusters, each of which has involved free-range farms that shared a common egg packing centre.

A vaccine strategy for *Salmonella* Typhimurium control in pig herds has been trialled working in close collaboration with the industry. The results of applying vaccination at the top of a breeding pyramid have been promising, particularly for strains linked to human illness. *S. Typhimurium* was no longer detected on the breeder site and had substantially reduced in the production farms down the pyramid. The team have been actively engaged with the Pig Health and Welfare Council – *Salmonella* food safety subgroup, which is assessing how the industry as a whole should be controlling *Salmonella*.

An outbreak of *Salmonella* Typhimurium in sheep that started in 2017 was linked to over 350 cases of human illness. We identified that businesses such as dealers, where sheep (particularly cull ewes) are regularly bought and sold, are at increased risk of introducing *Salmonella* to their premises and in maintaining the infection on the holding. Guidance was issued to around 500 high risk sheep buyers in England and Wales to advise on steps to prevent introducing *Salmonella* to their premises, reduce the risk of clinical disease if *Salmonella* infection was introduced and manage the risk to the food chain.

In 2018, we established an International Reference Centre (IRC) for AMR formed by three Defra Group agencies. This is an important step in the UK's global approach to tackling the threat of AMR and brings together the AMR expertise of the Centre for Environment, Fisheries and Aquaculture Science (CEFAS), the Veterinary Medicines Directorate (VMD), and APHA. The Reference Centre is providing assistance to partners located in low and middle income countries to support capacity development in the veterinary and aquaculture sectors to assist

with the implementation of National Action Plans on AMR. In 2019, the IRC was designated by the United Nations' Food and Agriculture Organization (FAO) as an [FAO Reference Centre for AMR](#) which acknowledges the powerful and unique synergy of complementary expertise from each of the three institutes.

A study reported the first survey for the presence of extended spectrum beta lactamase, ESBL-producing *Enterobacteriaceae* in British beef cattle. Faecal samples were obtained from farms in 2015. Ten (25%) of the farms tested positive for ESBL-producing CTX-M *Enterobacteriaceae*, 15 (37.5%) of the farms were positive for AmpC phenotype *E. coli* and none were positive for carbapenem-resistant *E. coli*. Buying bulls and bringing in fattening cattle from another farm were identified as significant risk factors for positive samples harbouring CTX-M *Enterobacteriaceae* or AmpC phenotype *E. coli* respectively indicating that maintaining a closed herd may reduce the introduction of resistant *Enterobacteriaceae*.

Following reports of the detection of transferable tigecycline resistance genes in *Enterobacteriaceae* in animals and meat in China, examination of sequence data at APHA found that the genes were not detected in the archived sequences of bacteria (*E. coli*, *Salmonella*) recovered from livestock in the UK. This work emphasises the power of WGS to rapidly scan archived isolates for tracking new incursions and inform decisions for outbreak control.

We are part of a landmark [One Health partnership](#) (European Joint Programme) between 38 institutes (veterinary, medical, environment and food) in 19 countries to increase action on foodborne zoonoses, antibiotic resistance and emerging threats. This will strengthen inter-sector collaboration to improve disease prevention and control.

## Endemic Zoonoses and Food Safety

This area is focused on control of public health risks with a major role in the control of *Salmonella* in livestock. The research programme and *Salmonella* National Control Programme (NCP) have successfully controlled serovars of high public health impact in poultry and resulted in a large reduction in human disease. Continued effort is needed to maintain a favourable *Salmonella* control situation and to prevent establishment of epidemic drug resistant non-resident strains, as well as minimising *Salmonella* in other livestock and understand the impact of changes in farming systems on disease risk and transmission dynamics.

## Defra research

Defra core research on endemic zoonoses comprises a synergistic combination of field, laboratory, epidemiology and mathematical modelling research that has helped develop multi-disciplinary teams and share expertise to the benefit of addressing issues holistically.

Field studies on *Salmonella* control in broilers have investigated sources of *Salmonella* within feed mills, hatcheries and broiler farms. We have worked with feed and poultry companies to introduce and evaluate remedial actions. Improvements have been observed in both feed mills and hatcheries through improved management of resident *Salmonella* process contamination. Training videos have been produced on feed mill, hatchery and broiler farm investigations and wider industry guidance on control has been updated. Intensive investigation of premises where *Salmonella* Enteritidis, *S. Typhimurium* and *S. Infantis* have been found have identified sources

and led to clearance of infection. WGS is being used to rapidly and definitively identify important strains so that control efforts can be prioritised.

Pork can be a source of *Salmonella* food poisoning and effective measures are needed to reduce infection in pigs. We are currently trialling a vaccine strategy for *Salmonella* Typhimurium control in pig herds working in close collaboration with the industry. The results have been promising, particularly for strains linked to human illness. A study applying vaccination at the top of a breeding pyramid has finished. Monophasic *S. Typhimurium* was no longer detected on the multiplier site and had substantially reduced on the farms down the pyramid. Full economic analysis will show whether the strategy is cost-effective. Reducing infection in pigs will also reduce the risk of spread of *Salmonella* to other farms, such as neighbouring poultry units. The team have been actively engaged with the Pig Health and Welfare Council – *Salmonella* food safety subgroup, which is assessing how the industry as a whole should be controlling *Salmonella*. APHA has collated findings from recent research on *Salmonella* control into an [information note for pig farmers and vets](#). Advice on cleaning and disinfection is published on The Agriculture and Horticulture Development Board (AHDB) Pork's website in a webinar and leaflet:

- [Cleaning and Disinfection Webinar](#)
- [Disinfectant Checklist](#)

We have developed a method to determine *Salmonella* serotype based on WGS. Accurate results are produced by linking three analytical pipelines and the methodology has benefited from funding and collaborations in EU projects. WGS-based typing will facilitate real-time outbreak detection and comparison with human isolates and could replace most AMR testing, phage typing, vaccine testing and molecular testing with a single, rapid and high throughput process. The validation of the bioinformatics pipeline has been completed. The accuracy of the pipeline has been compared with the 'gold standard' ISO/TR 6579-3:2014 serotyping method to fulfil the criteria for EU ISO16140-6 validation, as well as providing assurance needed for UK surveillance testing, with an aim to achieve UKAS accreditation to ISO17025 for *Salmonella* serotyping by WGS. This work is closely linked with developments at PHE, Europe and world-wide so there is synergy across animal and human sectors and interpretation of data from a one-health perspective.

## Surveillance

Since the introduction of National Control Programmes (NCPs) for *Salmonella* in commercial flocks of chickens and turkeys, the risk of contracting the most significant zoonotic *Salmonella* serovars from poultry has reduced. However, 2019 has seen a rise in *Salmonella* Enteritidis from 4 cases in laying flocks in 2018 to 14 in 2019. This has been linked to over 120 human cases and has been highlighted in the media. APHA (Bacterial Diseases & Food Safety and Advice Services One Health teams) has been investigating and managing these outbreaks in collaboration with the British Egg Industry Council (BEIC), PHE, FSA and Local Authority staff. All the incidents in 2019 were phage type 8. By using WGS we were able to establish that the *S. Enteritidis* laying hen farm cases form two genetic clusters, each of which has involved free-range laying farms that shared a common egg packing centre. Both packing centres and all affected farms were visited and *Salmonella* control advice provided. Replacement flocks are sampled at an early stage of lay to check that there has been no carry-over of infection. All positive farms in recent years have been mainly free-range, suggesting an increased

environmental risk. There are also concerns about the effective administration of *Salmonella* vaccines, rodenticide resistance in mice and rats and the impact of longer production periods of many laying flocks. These issues are subject to ongoing consultation between BEIC, vaccine manufacturers and pest control specialists.

An outbreak of *Salmonella* Typhimurium in sheep that started in 2017 was linked to over 350 cases of human illness. We identified that businesses such as dealers, where sheep (particularly cull ewes) are regularly bought and sold, are at increased risk of introducing *Salmonella* to their premises and in maintaining the infection on the holding. Guidance was issued to around 500 high risk sheep buyers in England and Wales to advise on steps to prevent introducing *Salmonella* to their premises, reduce the risk of clinical disease if *Salmonella* infection was introduced and manage the risk to the food chain. Premises at risk were identified by an algorithm based on animal movement records and control measures were supported by a [formal risk assessment carried out by APHA mathematical modellers](#). We have also been considering other options for additional surveillance to improve our understanding of the prevalence of *Salmonella* in sheep.

The Advice Services One Health team have continued to successfully oversee the implementation of the five *Salmonella* National Control Programmes in the chicken and turkey sectors which, as described above, have had a significant impact on human salmonellosis cases since their introduction. The One Health team have acted as a channel for expert advice to industry and policy, working closely with PHE and FSA in England and with parallel bodies in the rest of the UK in relation to all the *Salmonella* outbreaks described above. In addition One Health have continued to work closely with PHE in relation to a longer running but continuing outbreak affecting over 600 diagnosed human cases to date associated with *Salmonella* - contaminated feeder mice that are imported primarily to feed pet reptiles. Actions undertaken included drafting correspondence for the Chief Veterinary Officer to send to her counterpart CVO in the source Member State in an attempt to control the outbreak.

A review was published on the current trend in feeding raw meat to dogs and cats with particular reference to microbiological hazards. Another published review summarised the present state of knowledge of field interventions against colonization of broilers by campylobacter.

APHA (Bacterial Diseases & Food Safety and Advice Services One Health teams) has supported PHE in the investigation and control of a number of zoonotic disease incidents in people including outbreaks of *Salmonella*, cryptosporidiosis, shiga-toxigenic *Escherichia coli* (STEC) and *Corynebacterium ulcerans*. APHA provide appropriate expertise and this ensures practicable measures are pursued to help control the specific incident. WGS supported investigations of potential sources of human outbreaks demonstrating the power of this technology. One benefit is that we can clearly see when action taken at farm level is having an impact on reducing or stopping human cases of the outbreak strain.

In addition to their active involvement in specific Incident Management Teams convened by PHE, PHW or HPS when animal-associated threats may be linked with an outbreak of human disease, the One Health team provide veterinary advice to national risk assessment scientific groups, including the Veterinary Risk Group (VRG), the Human Animal Infections Risk Surveillance Group (HAIRS), the Advisory Committee on the Microbiological Safety of Food (ACMSF), The Advisory Committee on Animal Feed stuffs (ACAF) and the Defra Antimicrobial Resistance Coordination (DARC) Group. They also provide input to identify and manage new and emerging risks which have previously included hanta virus, Ebola and Monkey pox and



liaised with PHE, FSA and Industry on the emergence of Hepatitis E from pigs as a zoonotic threat.

In addition the One Health team also fulfil an educational and training role. One Health coordinated a well-received national training event for APHA staff involved in the implantation of the *Salmonella* National Control programmes. Similarly an event was organised for APHA Egg Marketing Inspectors by members of the One Health team. In addition to APHA staff delegates from each UK policy team and poultry inspectors from across the UK also attended. This event was well organised and widely appreciated by participants. The UK-wide cooperation helps maintain a consistent UK-wide policy approach to inspections across the UK.

In a collaborative initiative organised with PHE, FSA, HSE and the Chartered Institute for Environmental Health a series of regional training events was organised during 2019 for staff from APHA, PHE and PHW, FSA and local authorities to enhance the approach to managing future animal-associated human health incidents. Excellent feedback was received from delegates and further courses in other areas of the country and an advanced tier of similar training are now being pursued as a result. In a similar way One Health positively influenced the Pet Food Manufacturers Association drafting of their Code of Practice for raw pet food manufacturers to help mitigate the potential public and animal health risks associated with feeding raw pet food. EU legislative changes to sampling methods permitted for the *Salmonella* NCPs in early 2019 also required One Health team action to notify farmers via our NCP stakeholder group, and to revise the APHA Operations Manual and the farmer guidance on NCP sampling on gov.uk accordingly. Again close cooperation with colleagues in the APHA Bacterial Diseases & Food Safety team, others across Government and with industry stakeholders was critical to a successful adaptation to the new options.

A paper was jointly published with PHE on an [outbreak of shiga toxin-producing \*Escherichia coli\* O157 linked to raw drinking milk which was resolved by rapid application of advanced pathogen characterisation methods](#), including WGS for highly discriminatory strain typing.

Identifying the source of infection caused by STEC other than serogroup O157 is hampered by the unavailability of sensitive methods for detecting these pathogens. [APHA has developed novel tools for detecting \*E. coli\* O55](#), which has recently caused outbreaks of disease in people. The new tests may assist in identification of the potential environmental source for *E. coli* O55 which has not yet been established.

## Antimicrobial Resistance (AMR)

AMR is recognised as an emerging issue in the National Risk Register for Civil Emergencies. We are at the frontline of AMR surveillance in GB livestock and key priorities are to maintain this monitoring evidence stream and provide statutory data for EU requirements.

In 2018, we established an International Reference Centre (IRC) for AMR formed by three Defra Group agencies. This is an important step in the UK's global approach to tackling the threat of AMR and brings together the AMR expertise of the Centre for Environment, Fisheries and Aquaculture Science (CEFAS), the Veterinary Medicines Directorate (VMD), and APHA. The Reference Centre is providing assistance to partners located in low and middle income countries to support capacity development in the veterinary and aquaculture sectors to assist with the implementation of National Action Plans on AMR. In this way countries can access

technical assistance, training and quality assurance programmes as they build AMR surveillance capacity across sectors.

In 2019, the IRC was designated by the United Nations' Food and Agriculture Organization (FAO) as an [FAO Reference Centre for AMR](#) which acknowledges the powerful and unique synergy of complementary expertise from each of the three institutes. We completed scoping and training visits to Ghana, Bangladesh, Nigeria, Laos, Philippines, and Ethiopia. Support in establishing quality management systems was identified as a common requirement. The training delivered coaching in establishing AMR and antimicrobial use (AMU) surveillance systems and analysis and interpretation of data; antimicrobial residue testing; determinative bacteriology and antimicrobial susceptibility testing (AST); and establishing policy frameworks to regulate antimicrobials and other veterinary medicines. In the UK the AMR IRC hosted visitors from several countries. We are also developing [Proficiency Testing schemes for AST of priority pathogens and commensals](#) (including *Escherichia coli*, *Campylobacter jejuni/coli*, and *Vibrio spp.*).

A review was published that summarized the present state of knowledge of the influence of biosecurity on the presence of AMR in the farm environment. Aspects of biosecurity have repeatedly been identified as risk factors for the [presence of AMR on farm premises](#), but there are large gaps in our understanding of the most important risk factors and the most effective interventions.

[A study reported](#) the first survey for the presence of extended spectrum beta lactamase, ESBL-producing *Enterobacteriaceae* in British beef cattle. Faecal samples were obtained from farms in 2015. Ten (25%) of the farms tested positive for ESBL-producing CTX-M *Enterobacteriaceae*, 15 (37.5%) of the farms were positive for AmpC phenotype *E. coli* and none were positive for carbapenem-resistant *E. coli*. Buying bulls and bringing in fattening cattle from another farm were identified as significant risk factors for positive samples harboring CTX-M *Enterobacteriaceae* or AmpC phenotype *E. coli* respectively indicating that maintaining a closed herd may reduce the introduction of resistant *Enterobacteriaceae*.

An article on the field studies carried out within the VMD funded core research was [published in Farmers Weekly](#). This good news story highlights how alternative approaches such as vaccination overcame *Salmonella* infection on a pig farm and reduced the need for antibiotics.

A genomic epidemiology study, involving APHA scientists, and published in *The Lancet Infectious Diseases* (Day MJ, Hopkins KL, Wareham DW et al. 2019), found that most bloodstream infections with ESBL- *E.coli* (a difficult to treat 'superbug' causing urinary tract infection) involve epidemic human strain types and animal and food types were uncommon. The use of accurate genome sequencing helped to provide the high quality evidence needed to investigate the uncertain role of animal/food sources of infection. Handwashing and good infection control to prevent spread of human strain types is essential to tackle this serious bloodstream disease in people. Infection from food or animals was unlikely though prevention of ESBL- *E. coli* in animals is important to ensure veterinary infections remain treatable and reduce the possibility of future strains becoming adapted to people. The findings were also reported in the media.

A [scientific review was published on LA-MRSA](#) from animals and animal products in the UK. Although the frequency of reports in livestock in the UK remains low, the geographic and species dispersal suggests a widening distribution. The current lack of information suggests the need for systematic surveillance to understand reservoirs and transmission routes.

[Salmonella WGS for AMR prediction in S. Typhimurium](#) was compared against 3 phenotypic tests including disk diffusion, agar dilution and the gold standard broth microdilution representing clinical and veterinary screening environments. Results indicate that with further work to reduce the error rates for specific antimicrobials, WGS could serve as an effective screening tool for the tracking of AMR mechanisms in *S. Typhimurium*.

WGS from >500 *E. coli* has also been tested for AMR prediction against nine antimicrobials using agar dilution. The APHA SeqFinder pipeline was used for testing the WGS data and the minimum inhibitory concentration (MIC) for antimicrobials were interpreted using epidemiological cut-off values. Overall, correlation of WGS with antimicrobial susceptibility indicated WGS gene presence was highly predictive of reduced susceptibility and showed excellent correlation with MIC.

- [Use of whole genome sequencing of commensal \*Escherichia coli\* in pigs for antimicrobial resistance surveillance, United Kingdom, 2018](#)

A harmonized surveillance monitoring scheme for AMR in important veterinary pathogens was devised, following a series of previous workshops held with European colleagues. The monitoring scheme relies on a gold standard method of susceptibility testing (MIC determination by broth microdilution) and is planned for introduction at APHA on a batch testing basis.

WGS was used to investigate unusual patterns of AMR in bacteria detected through surveillance. Analysis of the sequence data informed incident management of possible sources and allowed comparison to human isolates, providing evidence for multi-agency response coordinated through the VMD ResAlert system.

Following reports of the detection of transferable tigecycline resistance genes in *Enterobacteriaceae* in animals and meat in China, examination of sequence data at APHA found that the genes were not detected in the archived sequences of bacteria (*E. coli*, *Salmonella*) recovered from livestock in the UK. This work emphasises the power of WGS to rapidly scan archived isolates for tracking new incursions and inform decisions for outbreak control.

## Networks and influence

APHA (Bacterial Diseases & Food Safety and Advice Services One Health teams) works with a wide range of partners including vets, livestock keepers and the farming industry, other government agencies and universities to protect the health of animals and people. International partnership is vital to reduce the global threat as zoonoses have little regard to national boundaries. We have a close working relationship with similar veterinary institutes across Europe and elsewhere and harmonise our approaches to allow comparison globally.

A great example is the development of harmonised approaches for the detection and response to disease outbreaks through the use of new genome DNA sequencing technology. The goal is to reduce the impact and cost of disease outbreaks worldwide. The [five year EU project](#) has done much to exploit the power of this new technology to transform our understanding of how infectious diseases are spread.

We are also part of a landmark One Health partnership (European Joint Programme) between 38 institutes (veterinary, medical, environment and food) in 19 countries to increase action on

foodborne zoonoses, antibiotic resistance and emerging threats (<https://onehealthjp.eu/>). This will strengthen inter-sector collaboration to improve disease prevention and control.

A number of joint research proposals (JRP) and joint integrative proposal (JIP) that will link and complement with Defra core research were submitted to the One Health EJP and have been successful. The proposals will increase our collaborative network and help gain expertise from other Med and Vet EU national laboratories working in this area strengthening our core capability in this strategically important area.

As members of EFSA's Panel on Biological Hazards (BIOHAZ), APHA experts have contributed to scientific opinions on [Salmonella control in poultry flocks](#) and WGS for [outbreak investigation](#), source attribution and risk assessment of foodborne pathogens. There are recommendations that fit with WGS and sampling sensitivity/epidemiological studies at APHA.

APHA also contributed to the production of revised [technical specifications on harmonised monitoring of AMR](#) in zoonotic and indicator bacteria from food-producing animals and food, which will form the basis for discussions on revisions to current EU legislation on AMR monitoring, planned to come into force in January 2021.

Experts also contributed to updated *Salmonella* and antimicrobial susceptibility testing chapters for the World Organisation for Animal Health (OIE) Manual of Diagnostic Tests and Vaccines for Terrestrial Animals.

APHA hosted a scientist from Romania under the EFSA funded European Food Risk Assessment (EU-FORA) Fellowship work programme '[Livestock, food chain and public health risk assessment](#)'.

## Exotic Bacterial Diseases

We provide a unique national capability focused on assurance of disease freedom, contingency planning and emergency response capability. Research is focused around our International Reference Centre functions and includes development of improved diagnostics, pathogen characterization and international partnerships to sustain skills, and support control efforts in other countries, reducing the global threat.

## Defra Research

APHA has continued to push forward developments in the serodiagnosis of brucellosis and insights help to inform DIVA *Brucella* vaccine development, which in turn informs diagnostics.

An assay for the detection of *Brucella* specific DNA has been audited by the United Kingdom Accreditation Service (UKAS) and is now an ISO 17025:2017 accredited test. Although it is currently only validated for identification of bacterial culture (validation of performance against serum, blood and milk samples is ongoing) this rapid identification tool enables the definitive determination of *Brucella* isolates quicker than before and would be an invaluable tool in the response to an outbreak of disease in the UK. The gold standard means of disease confirmation remains as bacterial culture and phenotypic characterisation.

RT-PCR methods have been developed for *E. hermannii*, *E. coli* O157 and *Y. enterocolitica* O:9 as these are the principle organisms suspected of causing serological cross reaction with

## *Brucella*.

The ability of *Mycoplasma agalactiae* (*Ma*) to survive in a small ruminant farm environment was investigated following the novel recovery of *Ma* in sheep faeces in field studies with collaborators in Sicily, where contagious agalactia is endemic. In previous APHA research *Ma* was also recovered from pooled tick samples from the ears of experimentally infected sheep. The findings from these studies are being used to design field based trials in Sicily to investigate the potential for environmental transmission which is important for informing restocking policies.

## Network and influence

APHA's *Brucella* Reference Laboratory had its status as an FAO Reference Centre for Brucellosis re-designated for a further four years. This helps to maintain our position as a global centre of excellence for brucellosis detection, diagnosis and control and ensures we have effective international collaborations and influence.

The Brucellosis team provided on-location or remote technical support to a number of countries in Africa and Central Asia, supporting implementation of locally adapted, sustainable programs to understand and reduce the prevalence of brucellosis. These activities maintain expertise, contribute to reducing the global disease threat, and provide valuable material for development of APHA diagnostic methods.

APHA was part of an expert group that revised the chapter on 'Biotechnology in the Diagnosis of Infectious Diseases' in the OIE Manual of Diagnostic Tests and Vaccines.

MLVA characterisation by APHA added valuable insight to a study of *Brucella* in dairy cattle in Bangladesh and reported first isolation of *Brucella abortus* biovar 3 from dairy cattle in Bangladesh. We also worked with colleagues in Iran to produce papers reviewing the risk of food in brucellosis transmission and characterising *Brucella* strains isolated from animals and humans in Iran.

The BBSRC/MRC/GCRF funded bacterial vaccine network (BactiVac) involving APHA won the research category of the Antibiotic Guardian Awards in 2019.

As OIE Reference Laboratory for contagious agalactia, APHA prepared an update to Discontools website information for this syndrome.

Relationship with a new partner OIE Reference Laboratory for contagious agalactia in Italy was strengthened through a PhD student spending time at APHA and joint activities on diagnostics.

APHA co-organised a European *Mycoplasma* Conference, hosted by PHE, bringing together human and veterinary *Mycoplasma* experts to discuss issues and latest research.

## 2.3 Bovine Tuberculosis

APHA performs surveillance for bovine tuberculosis (bTB) in order to meet legal obligations, and permit international trade. We support the Government's statutory obligations via reference laboratory activities, official reporting led by the Field Epidemiology Team, expert advice, stakeholder engagement, consultancy and epidemiological analysis, including the development of new tests where necessary.



Under the TB Surveillance Contract funded by the governments of England, Wales and Scotland, APHA conducts the following main activities:

- diagnosis on skin test positive animals and slaughter house cases
- bTB surveillance reports and regular statistics
- contribute to the annual EU co-funding claim report and TB Eradication Strategy
- post mortem capacity to investigate suspect animals, and laboratory capacity for gamma interferon testing of cattle
- advise on the management, supply, and performance of tuberculin
- hold the Marketing Authorisation for BadgerBCG injectable vaccine

APHA maintains a strong and innovative research portfolio on bTB of importance to GB government, in support of policy and in order to maintain competency and up to date knowledge of the disease. This research is predominantly applied, translational and customer focussed around:

- early and accurate detection of infection
- effective deployment of existing diagnostic methods, improving current methodologies and the development of new ones
- the use of mathematical modelling to help identify optimum control options
- data collection to track the spread of disease and to monitor disease control
- epidemiological understanding of the disease from the molecular to the macro level
- development of intervention tools such as vaccines and improved diagnostic tests

## Highlights

- The Animal Test Certificates (ATC) were submitted to VMD for the DIVA skin test and cattle BCG vaccination. Once granted this will lead to a substantial cattle vaccination field trial project.
- Over 330,000 samples have been submitted for gamma testing during 2019, up from 250,000 last year, as more badger control project (BCP) areas become eligible for interferon gamma tests.
- The badger cull in Cumbria was completed in 2018 and results published in 2019, indicating 40 positive badgers out of 363 tested (11% prevalence, and a total of 602 removed). There were only 3 positive badgers outside the Minimum Infected Area (MIA). <https://www.gov.uk/government/publications/bovine-tb-surveillance-in-wildlife-in-england/tb-surveillance-in-badgers-during-year-1-badger-control-operations-in-eastern-cumbria-low-risk-area-2018>. A repeat operation was implemented in 2019 and badger samples are currently being cultured.
- An update on the [effect of badger culling on cattle TB](#) was published and received a lot of press attention. This indicated a reduction in OTF-W incidence rates of 66% in Gloucestershire and 37% for Somerset after four years of culling, and no change in Dorset after two years of culling.

- An [analysis of the Whole Genome Samples from badgers and cattle in and around Woodchester Park](#) was published, which shows that the rate of transmission is greatest within species, but badger to cattle transmission was about 10 times greater than cattle to badger transmission.
- Funding for the badger oral vaccination work has stopped and funds redirected to six other studies, including analysis of aerosol and faecal *M bovis* excretion in cattle.
- [Annual reports on bTB in GB in 2018](#) were published as were [reports for the Edge counties for 2018](#).
- Validation of a PCR test for TB in animal tissue samples continued with testing of 1300 samples in parallel with routine culture. Results were promising with high levels of agreement with culture. An options paper examining the potential uses of PCR in the routine testing programme has been prepared.

## **Epidemiology, Risk Analysis and Data Sciences**

The TB Epidemiology Team completed a complex analysis on the effect of the badger culls on cattle TB (see highlights). This analysis was made more complex due to many of the comparison areas being impacted by the introduction of new BCP control areas, making it unlikely that an exact statistical comparison can be done again. A constructive meeting was held with external experts to lay down the foundations for future statistical analyses.

The various cattle models (TB Modelling Initiative (TBMI), the Bovine Tuberculosis Model for England and Wales (BoTMEW) and the Sand Hutton model) were used to help inform potential field interventions for Defra's response to the Godfray Report. These investigated bovine only skin testing and possible badger cull exit strategies. Work continues to bring the TBMI model into APHA so it can be run for more routine approaches.

WGS is now in routine use for surveillance and research into the control of TB, but is not yet ready to be adopted as a business as usual tool. A WGS Board has been set up to pull together all the strands required to ensure quality assurance for all aspects of this work, but both internal resource limitations and IT funding have delayed implementation for business as usual use. The Field Epidemiology team have an important role implementing WGS as an operational tool in the agency.

## **Emergence of a Cluster of bTB Herd Breakdowns in a Low Risk Area of England**

Continuing substantial effort was focussed on the investigation of the East Cumbria cluster of bTB herd breakdowns, southeast of Penrith led by the Field Epidemiology Team. The introduction of six monthly cattle testing was entering its sixth round, with three cases in 2019, but none under restriction by the end of the year. The cull in 2018 removed over 600 badgers with an 11% prevalence and 37/40 of the positive badgers within the core defined MIA. During 2019 a further cull, over a slightly increased area (to account for the positive badgers not in the MIA) was successfully conducted.

## Laboratory Testing

APHA is the national and OIE Reference Laboratory for bTB. The [OIE annual report for APHA](#) was submitted in January 2019.

Defra has agreed to defer plans to adopt six-monthly testing across the (high risk area) HRA, and a limited roll-out will begin in 2020.

## Cattle Vaccines, Diagnostics and Pathogenesis

### DIVA skin test and BCG vaccination

The DIVA skin test project, developing licensable antigens to detect infected animals amongst BCG vaccinated cattle, generated production, GLP safety and additional efficacy data that was used to populate an Animal Test Certificate (ATC) application submitted to VMD at the end of October. At the same time an ATC application for cattle BCG was also submitted to VMD. A list of questions on further clarifications was received from VMD in December, which are currently being addressed.

Experiments are currently underway at APHA and in partnership with AgResearch (New Zealand) testing the performance of the DIVA skin test in BCG vaccinated cattle experimentally infected with *M. bovis*. The results of these experiments performed in a large number of cattle will provide a greater precision in the estimate of DIVA skin test sensitivity in this target group of animals.

### Participation in the international project to develop a new international standard for bovine tuberculin PPD.

The currently used international standard for bovine tuberculin is more than 30 years old and stock of good quality are low. This standard is however the most critical reagent used to establish the potency of bovine purified protein derivative (PPD) in guinea pig potency assays worldwide. The OIE convened an *ad hoc* group to design and manage the development of a new international standard. Two candidates were established to compare in guinea pig and cattle potency test experiments against the existing international standard. APHA conducted one such experiment using experimentally infected *M. bovis* cattle. The experiment was successfully concluded and that data submitted to the OIE for centralised analysis. The results of the overall project leading to the generation of a new international standard for bovine PPD are expected to be revealed during 2020.

### Development of a defined skin test reagents to overcome the limitations of PPD

Purified Protein Derivatives (PPDs) are largely undefined diagnostic reagents and require a Biocontainment Laboratory (BCL) level 3 production facility as well as BCL3 animal facilities to perform the guinea pig potency assay. Further, their performance can also be impacted negatively by co-infection with other mycobacterial species including infection with or vaccination against *M. avian ssp paratuberculosis*, the causative agent of Johne's Disease. To overcome these limitations, we are developing a molecularly defined skin test reagent to potentially replace PPD to supplement the DIVA skin test (DST) in areas where BCG vaccination is not being considered. Building on the three DST antigens, additional potential

antigens with the appropriate properties of being well recognised in infected animals but not in uninfected cattle were selected, produced as defined proteins or peptides and tested in experimentally or naturally infected cattle and in unvaccinated or animals vaccinated against Johne's Disease. The results demonstrated that this new skin test reagent induced significantly stronger responses than the DST to a level akin to reactions induced after injection of bovine PPD. In contrast, the reagent maintained an identical specificity compared to the DST reagent. This outcome allowed the setting of increased cut-offs for test positivity increasing the robustness of skin testing with defined antigens. Work developing this novel reagent into a licensable product is now underway.

### **Accelerating bovine tuberculosis control in developing countries**

APHA is partner in a large programme funded by the Bill and Melinda Gates Foundation, the Department for International Development (DfID) and the Indian Government's Department of Biotechnology to provide the technical basis to develop novel control strategies targeted at low and middle-income countries (LMIC) where test and slaughter strategies are unaffordable and/or societally not acceptable. The approaches included in this programme consist amongst other elements, testing BCG safety in local cattle and buffalo breeds in India and Ethiopia, and establishing BCG efficacy in natural transmission experiments, as well as the development of fit-for-purpose DIVA tests. Outputs this year include the development of a DIVA skin test format that is compatible with regulatory environments that do not support the use of recombinant proteins as in vivo skin test antigens. In collaboration with Penn State University, APHA developed such a DIVA skin test reagent based on synthetic peptides rather than recombinant proteins. This antigen formulation is now being evaluated both in India and Ethiopia. Other outputs coming from this project include safety data in cattle in India for BCG and the peptide DIVA skin test reagent.

### **New Projects**

Results from the most recent oral BCG vaccination experiment failed to show a statistically significant level of protection against experimental challenge of badgers with *M. bovis*. As a result, Defra and Welsh and Scottish Governments decided to stop funding this work, and 2019 saw the closure of the oral badger vaccination studies. The available funding has been re-directed into six new projects. These are (1) Reducing the uncertainty of the DIVA skin test and OIE bovine tuberculin international standard work (2) Assessing the prevalence of *Mycobacterium bovis* in the faeces of TB reactor cattle (3) Detection of *M. bovis* in cattle aerosol samples (4) Validating serology tests for non-bovines (5) *M. bovis* test development and (6) Optimising and validating the Tuberculosis Order (TBO) disinfection test for use in the Disinfectants Approvals Scheme.

Defra has instigated a new independent advisory group replacing the Vaccines Programme Advisory Group (VPAG), the Microbiology & Immunology Research Advisory Panel (TB MIRAP), which had its inaugural meeting in December with various APHA staff present.

### **Wildlife**

The badger cull area adjacent to the Woodchester Park research station removed a number of marked badgers during 2019. The deployment of numerous GPS/transponder collars has been collecting data on daytime layup, home range use and contact rates between badgers during this time.

The National Wildlife Management Centre (NWMC) wildlife expertise provided further sett surveys in Cumbria when the cull area was extended; and support to Welsh Government operations included the submission of an annual report on last year's farm level interventions, and similar support continued during further interventions this year.

A total of 43 badger cull areas were active in England in 2019.

TB Advice services is a team of scientists and vets embedded in Defra's TB policy team who provide advice on all aspects of TB policy (see section 2.10 for more information on Advice Services generally). In 2019 the team provided advice and support to Defra TB policy which enabled a successful defence of the Supplementary badger cull policy in the court of appeal in 2019 and provided support to the roll-out of badger culling which now covers the majority of the high risk area enabling a key driver of our largest animal health problem to be addressed.

The team advised Defra policy on how best to prioritise and deliver six monthly testing and increased deployment of increased Interferon gamma testing in order to maximise the impact of finite resources.

The team coordinated evidence input to Defra's response to the Godfray review and lead on two of the "themes", including the Research and Development chapter. This report sets out the direction of Defra policy for the next five years and was published on 5<sup>th</sup> March 2020.

We also provided veterinary input to the report on progress of our eradication plan to the EU and also provided veterinary support to problematic cases of non-compliance and breaches of the TB order. This is to ensure that our eradication plan is implemented and the law of the land is enforced.

The Field Epidemiology Team focusses on investigation and reporting of TB breakdowns to inform TB control policy and delivery.

## 2.4 International Development

This report summarises the main activities of the APHA International Development (ID) portfolio. Since the conception of the APHA ID Team in 2017, the principal focus of the team was in preparing for EU Exit Day 1 (D1) readiness and to identify opportunities for international funding.

The ID team has taken an oversight and coordination role for EU Exit D1 readiness that has ensured various parts of the APHA Science Directorate (SD) were fully prepared for EU Exit by working across the agency and liaising with various Defra project boards.

The ID team has combined the preparations for all previous scheduled dates for EU Exit with a forward-looking capability to future proof the sustainability of funding for the agency, particularly for the SD. This has been achieved by maintaining and enhancing the international scientific reputation of APHA as a globally recognised international science centre. An important part of these activities were APHA's contributions to national and international reference laboratories. Consequently, the agency has broadened its scientific engagement thereby protecting the UK from animal and human pathogens and plant pests, and improving the environment whilst supporting international trade and the UK economy. APHA's relationship with Europe will continue, especially as part of European networks. Although APHA no longer holds the status for any European Union Reference Laboratories (EURLs), the agency has continued its



engagement with these and other International Reference Laboratories (IRLs). Additionally, the agency has continued to participate in EU-funded H2020 projects and will optimistically engage with future Horizon Europe projects.

The vision in developing increased science engagement with countries outside the EU now exists, and provides opportunities for APHA to increase its global influence for being a world leader in animal health. This will be achieved by identifying and developing new opportunities, through extending the range of international networks, appointments, partnerships and funding sources. In being involved in these activities, the agency benefits from, and provides a service to, the 'international world'. One of the key advantages is the ability to influence internationally, and to do so in the interest of APHA's main UK customers and the UK as a whole. It is however, important that the benefits and the service are proportionate, and that APHA's international activities follow the right priorities.

## 2.5 Plant and Bee Health

UK plant and bee health services are delivered in an integrated manner using skills from the GB Government policy teams with input from Welsh and Scottish Government. APHA supports this for England and Wales and is supported by FERA's diagnostic laboratories based at Sand Hutton in North Yorkshire. Within APHA delivery comes from the Plant Health & Seeds Inspectorate (PHSI), Plant Varieties & Seeds (PVS) team, the Genetic Modification Inspectorate (GMI) and the National Bee Unit (NBU). In doing so they collectively help protect the country's plants and bees by providing world class inspection, quarantine and certification services. They do this by providing surveillance, testing, training and outreach awareness campaigns for existing, new and emerging EU quarantine pests and diseases and assess GM events and issues as they arise. Further, the PHSI, GMI and NBU collaborate with FERA Science Ltd and others to improve capability of front line staff, using new technologies to provide rapid and effective field identification and to further understand epidemiological and biological aspects of plant and bee pests and disease. The work also helps contingency planning for future outbreaks by raising awareness of biosecurity and communicating science to UK stakeholders, the general public, government and non-government organisations and inspectorate services throughout Europe.

There have been a number of science highlights that plant and bee health have achieved throughout 2019. We responded to further incursions of Asian hornet as well as a widespread introduction of Oak Processionary Moth from continental oak imports. We also enhanced our response preparations for organisms including Small hive beetle, *Xylella fastidiosa*, Tomato Brown Rugose Fruit **Virus** (ToBRFV), and new GM threats. On top of this we assisted in winning another "Gold" at RHS Chelsea and have been involved with multiple successful trade and public events across England and Wales, including the Harrogate Potato show and the National Honey Show.

We have also continued our participation in the Harper Adams Postgraduate courses including helping deliver their new Postgraduate certificate in Plant Health and participation in the Royal Society of Biology Professional Register for Plant Health Professionals.

Over the year more technology has also been established into the NBU, including role-out of their iPad data capture initiative. Both the NBU and PHSI have maintained their ISO 10720

accreditation and also the Heathrow office has been licenced to perform targeted real-time diagnosis.

The EU Smarter Rules for Safer Food (SRSF) regulations came into force on the 14<sup>th</sup> December. This crossed all our work areas and will continue to have major influence on our activities and our client base for many years to come.

Further details on the work carried out over the past year:

## **Plant Health Imports**

PHSI operate at 20 points of entry with some, including Heathrow and Gatwick, having 365 day cover. Most activities are performed to meet EU statutory requirements; however others are to meet wider UK plant health biosecurity threats such as against new and emerging pests and diseases. Strong links were also maintained and developed with other regulators operating at our borders including customs. Extensive preparations were also made for EU exit as well as implementation of new SRSF regulations. This will redefine points of entry to border control posts and the number will increase to approximately 70. Inland requirements also have changed and to support these activities PHSI staff numbers increased to over 220 from 140 in 2018.

Over the last year, PHSI received advanced notification of the landing of 109,047 consignments of controlled goods of which 46,054 were subject to reduced checks. This was almost identical to 2018, despite 5 extra commodities being introduced from 1<sup>st</sup> September including strawberry and grapes. A total of 46,619 Inspections were performed on the regulated material (42,838 in previous 12 months), of these 336 consignments failed as a result of plant health checks (0.7%) and 27 (0.06%) due to the document issues. These failure rates were slightly lower than the previous 12 months. In addition PHSI conducted 4,541 inspections on non-regulated cargo at airports and 1,802 inspections on packages at postal depots.

## **Plant Health Exports**

As part of ensuring the safe international movement of plants, planting material and plant products PHSI issued 9,264 phytosanitary certificates (PCs) for England & Wales (E&W), of which 4,844 certificates were issued for plant products requiring a laboratory examination and 4,420 PCs were issued for plants, bulbs, grain, machinery, potato tubers (seed and ware), seeds and produce, following inspections carried out by PHSI and / or laboratory examination. 973.5 tonnes of bulbs were inspected, of which 773.5 tonnes passed. 701.4 tonnes were exported making up 46 consignments.

## **Plant Passporting**

This EU scheme enables the free movement of regulated plant material around the EU. It is achieved by monitoring specific plant material entering and moving through the scheme. PHSI on behalf of Defra oversee this work for England and Wales.

To the end December 2019 there were 790 clients authorised to issue plant passports for England and Wales. A further 308 clients also joined at the end of December linked to the new regulation and many more are expected in 2020.

Since 2015 the PHSI have been direct emailing authorised plant passporting clients with updates, news and changes to plant passporting. In 2019 APHA emailed out 10 updates throughout the year. These mainly focused on SRSF, but also included information about recent pest additions to the Defra Plant Health Risk Register enabling the trade to make more informed purchasing decisions.

## **Surveillance and Action**

Inland PHSI continued to span a wide range of activities looking for, and dealing with hundreds of regulated pests and diseases which can significantly affect European plant health. The most significant event this year was an unprecedented Oak Processionary Moth (OPM) incident involving all parts of the UK Plant Health Service. This is a UK quarantine pest which causes defoliation of oak trees and hairs on its caterpillars also can cause major health issues to humans and animals. In June, through routine inspection the PHSI detected OPM on recently imported and planted trees from the continent in Southern England. Although this incursion was rapidly and effectively dealt with it quickly became clear that a significant numbers of infected trees had been imported across the UK. Because of the need to quickly trace all imports while their movement information was still fresh and the fact adult moth dispersal would occur from late July there was need to take immediate and decisive action. This led to setting up of an inter-agency UK Plant Health Service (PHS) Incident Management Team (IMT). As part of this APHA took responsibility for tracing investigations (with FC inspecting trees at landscaping locations), inspections at nurseries and on residential property in England and all inspections and action in Wales. This lead to APHA investigating over 2,100 tracing lines stemming from 1,000 consignments and the whole PHS inspecting over 50,000 trees. In total 98 premises in the UK were identified resulting from 156 tracing lines supplied by 28 different Dutch, Belgium and German suppliers.

## **Laboratory diagnostic samples**

Samples taken at UK points of entry and inland from nurseries / garden centres and the wider environment are processed by FERA diagnostic labs. In 2019, 37,447 samples were submitted for processing.

## **Engagement**

### **Public shows**

PHSI exhibited at six key primary shows amongst others, the RHS Cardiff and RHS Chelsea flower show, Chatsworth, Tatton Park, RoseMoor, and the Royal Welsh show. The public show season in the UK begins at Cardiff in mid-April. The messages highlighted the importance of good biosecurity practices, the impact of diseases on trees (in collaboration with the Forestry commission), and a collaborative garden venture at Tatton highlighting *Xylella fastidiosa*. Gold medals were awarded at both RHS Chelsea and Tatton Park show.

## **Conferences**

PHSI have supported numerous nursery and grower group events throughout the regions which included provision of speakers for Palmstead soft landscape, Horticultural Trades Association (HTA) annual meeting, Plant Heritage AGM, [Cofor](#) meeting, seminar at Kew and two tree health events.

The annual APHA plant health conference was organised and delivered, with over 300 people attending the conference this year the theme was “Changes, Challenges and Collaboration”. Numerous presentations/workshops/ask the expert and networking opportunities made this a very successful event.

## **Trade shows**

Supporting industry through exhibiting targeted biosecurity messages is a key aspect of PHSI engagement work and this year we have exhibited at nine events, including Horticultural Trade Association national plant show, the London produce show, FutureScape (a show for landscapers/arboriculturalists), Fruit Focus, Four Oaks, Horticultural Science Live, South West Growers Show, British potato show, AQUA, and GroSouth. In addition we provided handouts relating to the Don't Risk It campaign for attendees at the Discovery Travel Show. Plus Cereals 2018 was attended by staff from plant varieties and seeds team.

## **Plant Health Research projects**

### **Genie project**

Following validation and staff training, a new quarantine facility has been commissioned at APHA's Heathrow office, to help process samples for various listed plant pest and diseases using the Isothermal portable molecular equipment termed a 'Genie'.

### **Unmanned Aerial Vehicle projects (UAV)**

A detailed study was carried out at controlled potato plots at The National Institute of Agriculture Botany (NIAB), Cambridge with the aim to test the use of UAV to detect potato virus in plants to determine whether inspection times can be improved compared to traditional (walking crops) procedures. This study tested three UAV on-board cameras (visible, multi-spectral and hyperspectral) flown over plots of potatoes where the virus infected plants are known. This data was aligned with over 4500 samples that were taken and returned to the laboratory for confirmatory testing. All the spectral data has been processed and compiled into a large database. Statisticians are now analysing the spectral data with the visual and ELISA test information to understand if there are any relationships corresponding to the presence of potato viruses. Preliminary results are looking promising with drone based spectral data picking up more infected plants than visual assessment. Future work will involve more in depth analysis to determine what are the best performing sensors or sensor combinations for classifying between virus and non-virus.

## **Multiplexing for Viruses in solanaceous crops**

PHSI are part of a collaborative project which has just started with Newcastle University, FERA Science Ltd and Mologic Ltd. This is to investigate production of a lateral flow assay to identify a range of solanaceous viruses in a single device. If successfully this will provide a highly usefully and cost effective tool for inspectors, researchers and growers.

## ***Xylella* contingency planning project.**

This study is to assess the feasibility of using ArcGIS to collect field data as part of an outbreak response for the quarantine plant pathogen *Xylella fastidiosa*. Preliminary work has been completed which is now being advanced through a second year of development.

## **Better training for safer foods**

Over the course of last year, 6 PHSI inspectors attended this training around Europe, and included courses such as surveillance and outbreak management and wood packaging materials. Attendees were able to get a better understanding of symptoms of diseases currently not present in the UK for example *Xylella fastidiosa* and to learn from distinguished national experts. A further 8 PHSI inspectors were trained in Brussels in the new IT system for SRSF (TRACES-NT).

## **Phytothreats project**

This project which finished in the summer 2019 aimed to address risks to UK forest and woodland ecosystems from *Phytophthora* by examining the distribution and diversity of different *Phytophthora* in UK plant nurseries. A final report is in the process of being written. Within the project PHSI focussed on development of sampling methodology. Samples taken using these methods by PHSI and other project members were then sent to the James Hutton Institute for processing and metabarcoding analysis. Analysis has proven the sampling and diagnostic methodologies to be robust helping quantify previously unknown *Phytophthora* risks. This in turn has provided the project and nursery owners with quantitative information to better inform biosecurity decisions. In one case 11 *Phytophthora* species were found in a single puddle at one site.

## **Future proofing plant health projects**

The five year future proofing plant health project involving PHSI was completed at the end of this year and final reports are currently being written. Further funding to continue this work has been successful and new projects have been proposed that are currently under review at Defra.

## **Publications**

- Beales P. *et al.* (2019) Raising public awareness of Quarantine and Emerging Pests (PM 3/86) *OEPP/EPPO Bulletin* **49**(3), Wiley. 488-504
- Beales P., Elphinstone J., Fox, A., Lane C., McCann, D., Little J. (2019) *Plant diseases and biosecurity*. Oxford University Press. 208pp



## APHA Genetic Modification Inspectorate

The APHA Genetic Modification Inspectorate (GMI) is responsible for upholding legislation pertaining to the deliberate release to the environment of genetically modified organisms (GMOs) in England, including the marketing of GMOs (other than for food or feed). The GMI's work covers three main areas, as follows:

- 1) A programme of management audits and field inspection visits to ensure persons/ bodies granted consent to release GMOs to the environment have appropriate and effective systems in place to manage their releases in accordance with the conditions and limitations applicable to their respective consent documents;
- 2) A programme of audits of producers and importers of seed of at-risk species to assist companies in appropriately managing the potential for adventitious (accidental or technically unavoidable) GM presence (AGMP) in their seed for sowing; and
- 3) Investigating any cases of the suspected release or marketing of unauthorised GMOs, including taking appropriate action to ensure any such releases are dealt with appropriately and that any risk to the environment and human health is minimised.

### GMI deliberate release inspection programme

In 2019 the GMI conducted management audits in relation to eight consents for the experimental release of GM plants. These comprised two camelina consents (both authorising the release of plants modified to produce omega-3 fatty acids and other potentially beneficial bioactive compounds), one potato consent (with traits including late blight resistance and improved tuber quality), two wheat consents (one for plants with increased iron and one for plants with increased photosynthesis) and one Chinese kale/broccoli consent (for plants altered sulphur metabolism). In addition the GMI conducted management audits in relation to potato and camelina trials that are in the post-trial phase of the release.

The trend observed in recent years for increasingly complex GM trials has continued, with an array of disparate GM events being field tested, either as individual lines or as multi-event lines or stacks. Examples are camelina with altered oil profile, increased oil production, sinapine reduction, and marker genes, and potato with resistance to late-blight, resistance to potato cyst nematodes and improved tuber quality. In addition, two of the consents allowed for the release of lines using CRISPR-Cas9<sup>1</sup> gene editing. This followed a decision in July 2018 by the Court of Justice of the European Union (case C-528/16) that confirmed that organisms created by novel gene editing techniques (such as CRISPR-Cas9 and related methods) are GMOs and fall under the scope of Directive 2001/18/EC as they do not, as yet, have a history of safe use.

GMI management audits seek to ensure that consent holders have fulfilled their duty of care obligation to ensure the organisms for release include only those genetic modifications for which consent has been granted. Gene-edited lines pose a unique challenge in terms of GMI audits, in that techniques such as CRISPR-Cas, whilst capable of making precise changes to the genome of just a few base pairs, can produce unwanted off-target effects. Discussions between the GMI and FERA Science Ltd. (which provides scientific advice and analysis to Defra) confirmed that

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<sup>1</sup> CRISPR: clustered regularly interspaced short palindromic repeats; Cas9: CRISPR-associated protein 9.

detecting undesired changes of just a few base pairs is currently technically unfeasible. A strategy was therefore devised whereby the GMI requested assurance from consent holders on the specificity of the guide RNA, as assessed through (for example) the use of contemporary web-based resources. This approach worked well, as the fidelity of the guide RNA was integral to the development of the GMOs, and details had either been published in scientific journals or were being prepared for publication. Where appropriate the GMI also requested assurance for the absence of vector components in the lines for release.

Field inspection visits were carried out prior to the flowering of the various crops, and it was confirmed that all trials were being managed in accordance with the conditions and limitations of their respective consents.

- [Further information on the GMI deliberate release inspection programme, including reports of GMI field inspection visits](#)

## **GMI seed audit programme**

Following a high-level review of Plant and Bee Health and the GMI, three additional inspectors joined the GMI on a part-time basis towards the end of 2019, making one full-time equivalent. These additions to the team will help increase the resilience of the GMI, allowing more comprehensive coverage of the seed industry with regard to AGMP risk and provide resource for strategic activities, such as contingency planning, horizon scanning and honing risk assessment techniques.

- [Further information on the GMI seed audit programme, including a summary of seed audit findings](#)

## **Fluorescence testing of suspect GM fish**

It is illegal to market unauthorised GMOs in the EU and no genetically modified vertebrates have yet gained marketing authorisation. The GMI usually receives several alerts each year that suspect GM fish have entered the UK. Such alerts come either from members of the public (having seen possible GM fish for sale in pet shops, aquarist shops, or advertised on-line) or, more usually, from APHA colleagues stationed at UK Border Control Posts (BCP).

BCP staff have responsibility for carrying out health-checks on live animals entering the country, and are alert to the possibility of GM fish being present in consignments destined for UK distributors. To date, all such alerts have concerned ornamental fish that have been modified with one or more of a suite of genes that result in fluorescence under ultraviolet light. Observing such fluorescence can, however, be problematic, especially under sub-optimal conditions, and definitive testing would involve destructive and lengthy PCR analysis. To enhance the diagnostic capability of BCPs, and employ rapid and non-destructive analysis, the GMI, in collaboration with FERA Science Ltd., has developed a method for assessing fluorescence of fish at relevant wavelengths under standardised conditions. This assessment method is currently awaiting final sign-off by Policy with a view to being rolled out to BCPs early in 2020.

## **GMI response to alerts of suspected GM presence in seed**

In July the GMI received an alert from the Defra Genetic Resources & GM Policy Team that the French authorities had reported adventitious GM presence (glyphosate tolerance) in soya seed from Italy, sown in experimental trials. The GMI contacted the UK arm of the company whose variety was affected, and was assured that the company had not imported any soya seed into the UK in 2019, and therefore there was a negligible risk of the seed entering the UK.

In August the GMI was contacted by a UK seed company and informed that a seed lot of forage rape, produced in the UK, had returned a positive result for p35S: a promoter element often used in GM crops that is derived from the Cauliflower Mosaic Virus; a virus commonly found in the environment. A significant quantity of the seed had already been marketed and sown.

To ascertain whether the positive finding was due to the native virus or due to adventitious GM presence the company, under the instruction of the GMI, commissioned further PCR testing, which established the presence of the native virus. This, along with the fact that no other GM elements were found during comprehensive PCR testing and a lack of evidence for a source of GM contamination in the seed production area, led the GMI to conclude that the presence of p35S was *on the balance of probabilities* due to presence of the native virus and not AGMP. The GMI therefore informed the seed company that the result should be considered as a false positive and no further action was necessary (see also note under 'other activities' below).

## **Other activities**

In January 2019 a member of the GMI attended the Working Group of the Regulatory Committee for Directive 2001/18/EC (the European Commission's working group on GM seed testing).

In May 2019 a member of the GMI attended the annual meeting of the European Enforcement Project (EEP; a resource whereby knowledge and experience is shared between GM inspectors to help promote best practice in inspection and enforcement). The GMI delivered a presentation on duty of care in CRISPR-edited *Brassica oleracea*. A member of the GMI also sits on the steering committee for this group.

Following discussion with the GM Policy team and Fera Science Ltd., it has recently been agreed that, under funding provided through the Defra/Fera long-term supply agreement, Fera will carry out a project to develop gene-sequencing techniques to 'walk out' from suspect sequences to determine the nature of adjacent DNA in cases where environmental contamination is suspected. If such sequencing 'discovers' the DNA of natural organism, e.g. a virus or bacterium used to provide gene-regulatory sequences for GMOs, this will be conclusive evidence of non-GM environmental contamination. However, if a suspected GM element is adjacent to plant DNA this would indicate that a GMO is present in the sample. It is envisaged that this project will provide greater certainty in cases where currently enforcement decisions are based on the balance of probabilities.

## **Plant Varieties and Seeds**

Plant Variety and Seeds (PVS) Delivery are based in Cambridge and look after the statutory National Listing and Plant Breeders Rights work for the UK. The decisions on National Listing

are made by the National List and Seeds Committee (NLSC) which is chaired by APHA and decisions are made by consensus with the Scottish Agricultural Science Agency (SASA), Agri-Food and Biosciences Institute (AFBI) and the Welsh and Scottish Government. APHA also take the lead in EU representation at the Community Plant Varieties Office (CPVO) for all matters of DUS (Distinctness, Uniformity and Stability) testing in the UK and on the world scale where APHA represent the UK in the Editorial Committee and the Technical Committee of the International Union for the Protection of New Varieties of Plants (UPOV), Geneva.

We also look after the statutory work for England and Wales for seeds certification and the Seed potato certification Scheme and the Fruit Plant certification scheme. APHA also represent England and Wales Seed certification in the European meeting for Seed certification Offices (ESCAA).

APHA are a CPVO Entrusted Office of all our DUS work, which means that we can exchange reports with any other Entrusted Office in Europe for the species in scope. This exchange now stops with EU Exit, we can accept their reports, but they will not accept ours. To counteract this PVS are becoming an EU Exit a world facing stand-alone Plant Breeders Rights Office.

PVS are also continuing with APHA's seeds marketing enforcement work for seed crop quality and are expanding on our International Seed Testing Association (ISTA) sampling training with a view of obtaining Organisation for Economic Co-operation and Development (OECD) 3<sup>rd</sup> country equivalence with the EU on exit so enabling us to export seed to Europe.

## **National Bee Unit**

The National Bee Unit (NBU) delivers bee health programmes on behalf of Defra and Welsh Government (WG) in England & Wales. It has been involved in the management and control of bee pests and diseases, along with training and dissemination of information to beekeepers for over 60 years. It is coordinated by APHA through the central NBU office based at Sand Hutton in North Yorkshire. Here the work of our 53 home-based bee inspectors is coordinated, who in turn are managed by a National Bee Inspector (NBI) and our Regional Bee Inspector (RBI) network. Their work and that of the central team delivers a national apiary inspection programme and provides consultancy and research services and extensive training and advice to Defra, Welsh Government, The Scottish Government, commercial enterprises and beekeepers. They also work with FERA Science Limited who provide our bee health diagnostics at Sand Hutton as well as on various research programmes. Wider research is also performed by the NBU with other universities and institutes both at home and abroad. The NBU's foulbrood inspection programme is ISO 17020 accredited.

## **Imports**

Import inspections are performed to meet EU Statutory requirements but also to manage risks arising from wider Bee Health biosecurity threats. In 2019 bee import consignments increased 17%, the size of consignments also markedly increased over the previous year, with volumes of imported queens increasing 26% to 20,081 and packages of bees up 264% over the previous year to 2,623. This represents a 40% increase over the last 4 year average as 2018 was unusually low year. Most package bees originated from Italy, where Small Hive Beetle is present, resulting in an enhanced inspection rate to reflect the elevated risk profile. The increase in imports during 2019 continues an established trend which has seen a fourfold

increase in queen imports across the last decade and the trade in package bees' rise from almost nothing in 2009 to current levels of c.2500+ units. In 2019, of the 419 import consignments received, 183 were checked by inspectors (43.7%).

## **Surveillance and Action**

In 2019 NBU inspectors completed statutory pest and disease inspections of 6499 apiaries involving checks on 33,598 honey bee colonies. 671 colonies were treated for European Foulbrood and 54 colonies for American Foulbrood. 2019 presented a high level of European Foulbrood, almost double the levels found in the previous year. Most of these foulbrood cases (60%+) were found by inspectors' surveillance rather than discovered by the beekeeper.

The 2019 programme of honey sampling for Residues testing on behalf of the VMD uncovered two positive samples. One involving lead residues believed to be environmental contamination and the other illegal use of antibiotic. The NBU additionally assisted Trading Standards in Dorset in connection with an investigation where Trading Standards had uncovered an operator bulk purchasing supermarket honey for the purposes of illegally rebottled the honey relabelled as local artisan honey for onward sale.

## **Asian Hornet**

The year also saw further incursions of Asian Hornet (*Vespa Velutina*) into the UK. Between July and September the NBU responded to 4 incursions involving this non-native species. Inspectors used track and trace, with the use of hornets trained to bait stations to locate nests. Two of the incidents, New Milton and Tenterton were determined to be incursions of single hornets without an established nest and so did not require a full outbreak response. In contrast Drayton Bassett and Christchurch both involved sightings of multiple hornets, leading to full outbreak response and tracing of hornets to the nests, nest destruction and removal.

## **Engagement**

### **Shows and Trade Events**

NBU exhibited with the Bee Unit trade stand at four major national events across the year, Bee Tradex, the British Bee Keepers Association Spring Convention, the National Honey Show and the Welsh Beekeepers Convention. At most of these events we also contributed either a workshop or a keynote lecture.

### **Beekeeper Training Events**

Beekeeper education, improving beekeeper understanding of bee health, statutory diseases and exotic pests, is a key part of the Bee Health programme. Over the course of the year NBU inspectors have delivered 94 regional or local training events, ranging from countywide Bee Health Days, to Bee Safaris or local Beekeeping Association training events.



## Research Project Participation

In addition to the NBU's ongoing involvement with Fera Science, we have continued involvement with several universities undertaking bee health research. This includes Chronic Bee Paralysis Virus Research (conducted by Newcastle University), Virulence of European Foulbrood (EFB) and the microbes and pesticides associated with the presence of symptomatic EFB in honeybee hives being conducted by (Imperial College London) and working with UK Centre for Ecology & Hydrology to provide reference samples for their National Honey Monitoring Scheme to potentially enable work on refining protocols for detection of pests and pathogens in honey.

The NBU has additionally been part of a consortium brought together by Surrey University to bid for Industrial Strategy Challenge Fund (ISCF) funding for a project to look at the use of Artificial Intelligence and Data for Animal, Bee, and Crop Diseases.

## 2.6 Surveillance Intelligence

Our strategic objectives are:

- To co-ordinate activities enabling the timely detection, investigation, characterisation, assessment, escalation and management of animal-related new and re-emerging threats (NRTs) in livestock and wildlife, providing actionable intelligence for our customers and stakeholders.
- To develop and maintain an integrated and sustainable 'early warning' scanning surveillance system for animal-related NRTs that delivers required outcomes through partnership between government and industry.
- To provide impartial, high quality veterinary scientific advice that supports and informs assessment and decision-making, and adds value to the activities of a wide range of stakeholders within and outwith Government, supported by appropriate levels of expertise.

### Outcomes and Impact during 2019

The work of SIU and all those working in the physical and virtual networks of expertise and delivery that make up the scanning surveillance system in England and Wales resulted in the identification, investigation and characterisation of a wide range of potential NRTs of which 75 were present in GB and 18 were escalated to the Veterinary Risk Group. We have a systematic and standardised method of categorising these potential NRTs for each of the main livestock species and wildlife and this is coordinated by each of the Species Expert Groups (SEGs).

#### Sheep

In 2019, scanning surveillance activities have identified novel viruses including an ovine astrovirus and an ovine picornavirus, both associated with neurological signs in growing lambs. The novel picornavirus was identified in collaboration with SRUC (Scotland's Rural College) in Scotland and institutes in Germany and the USA, and the investigation was prompted following analysis of VIDA data where a diagnosis was not reached. Ovine herpes virus 2 was also found to be the likely agent responsible for sporadic, malignant catarrhal fever-like vascular disease in sheep in cases of "polyarteritis nodosa" or idiopathic systemic necrotizing vasculitis.

The Small Ruminant Expert Group promoted enhanced antimicrobial sensitivity testing of *E. coli* isolates from cases of watery mouth disease, building on APHA's current knowledge of AMR using Whole Genome Sequencing of the *E. coli* isolates. This will help provide additional information including sequence type and the presence, if any, of AMR genes, plasmids and virulence genes to help determine if there is a relationship between the watery mouth disease presentation and specific *E. coli* sequence types or the presence of specific virulence genes. Feedback to stakeholders is raising awareness of better management of neonatal lambs and reducing the dependence on the use of antibiotics.

## Cattle

Livestock owners and field vets in the UK were reminded that the re-emerging BTV-8 strain in northern Europe may cause transplacental transmission and infection of fetuses in cattle, and they should consider BTV-8 as a possible cause of abortion or malformed calves, in addition to Schmallenberg and other viruses such as BVD. The [advice on how to spot the disease](#) has been updated.

A significant reduction in the number of diagnoses of Bovine Neonatal Pancytopenia (BNP) was observed in 2019. This disease has been associated with a BVD vaccine that has now been withdrawn from the marketplace. Cases have continued to be described in the UK in recent years, which may reflect the presence of dams that had historically received the vaccine, but as these animals leave the national herd a decline in BNP cases is likely. However, the APHA and UK scanning surveillance colleagues have also recorded cases of BNP in animals that did not receive this vaccine, which may reflect an underlying low incidence of idiopathic BNP.

A potential new threat, Severe Summer Scour Syndrome affecting young dairy calves at their first grazing, was assessed by the Cattle Expert Group in 2018 and a collaborative investigation protocol was developed and launched across GB and Ireland in the 2019 grazing season. The Cattle Expert Group continues to monitor and evaluate cases.

An investigation into unusually severe milk drop on a midlands dairy farm identified *Salmonella* Typhimurium RDNC 3225. This variant had been previously linked to a significant outbreak of human and animal health disease since 2017 with sheep the primary focus of investigation (see Bacterial Diseases and Food Safety section), and in this case may have arrived via wild birds. The source of the infection was not determined.

## Pigs

Porcine circovirus-3, a virus newly discovered in 2016 and detected in pigs globally, was detected in association with disease characterized by multi-systemic inflammation in stillborn piglets (some with arthrogryposis) in an incident in late 2018, and was also retrospectively identified in stillborn piglets in a similar incident that occurred in 2014.

The value of whole genome sequencing (WGS) of *Brachyspira* isolates was demonstrated. It enabled the detection of *B. hampsonii* in GB pigs with enteric disease by APHA for the first time, and also provided valuable information in relation to antimicrobial resistance in *B. hyodysenteriae* isolates and the investigation of swine dysentery outbreaks. This assists veterinarians in identifying possible links between outbreaks, and in predicting the potential for development of antibiotic resistance.

Another notable finding was an extended disease season of *Klebsiella pneumoniae* (Kp) septicaemia outbreaks compared to the strict summer season occurrence in previous years since the Kp ST 25 strain associated with disease in piglets emerged in 2011.

## Avian

APHA is now formally offering differential diagnosis to poultry owners and their vets following the negation of notifiable avian disease. Previously, following the suspicion and investigation of notifiable avian disease (Avian Influenza and Newcastle Disease), no further, formal

investigation was undertaken if the case was negated. However, poultry owners are now being offered differential testing (at their cost) to help identify the cause of disease. This new approach allows the poultry keeper to put appropriate control measures in place and improves understanding of alternative diseases with similar presenting signs to notifiable diseases, as well as help to identify new and re-emerging threats in poultry as part of APHA's continuing scanning surveillance efforts. Infectious bronchitis virus (IBV) was implicated in two commercial flocks investigated through this new protocol, as well as in numerous routine diagnostic submissions, and appears to have become more problematic in GB poultry despite the widespread use of vaccination.

Focal duodenal necrosis (FDN) was identified in layer chickens at point of lay. The disease has rarely been confirmed in GB and is attributed to clostridial infection, including toxin-producing strains of *C. perfringens*, and can cause reduced egg production and lower egg weights.

Intestinal spirochaetosis was identified in two captive rheas and WGS led to the confirmation of *Brachyspira hyodysenteriae* and *B. hampsonii*. *B. hyodysenteriae* was also identified in archived cases from rheas, and appears different from current *B. hyodysenteriae* strains in British pigs. The *B. hampsonii* detected in one of the rheas was also a different strain from that detected in British pigs. Further investigation of potential sources of *Brachyspira* infection are now planned.

## Wildlife

Two mass mortality incidents in wild rabbits (*Oryctolagus cuniculus*) due to rabbit hemorrhagic disease 2 (RHD2) virus were investigated in the north of England. Circumstantial evidence indicates that this disease, present in Britain since 2010, is likely to be adversely affecting national populations.

There were multiple submissions to the APHA Diseases of Wildlife Scheme (DoWS) to investigate brown hare (*Lepus europeaus*) mortalities, in both 2018 and 2019. This resulted in the discovery for the first time in Britain of RHD2 virus in hares by DoWS and collaborator organisations in 2018. The precise nature of the mortality is still being assessed and there is some evidence from hunting bag returns that hare numbers may be declining nationally.

In wild birds, avian botulism was prevalent in the summer and extended well into September, with approximately 30 submissions to APHA, and many requests for advice about the disease from health authorities, municipal authorities and city park managers.

Mass mortalities of passerine birds at roosting sites cause significant public concern and DoWS investigated two such incidents; in pied wagtails (*Motacilla alba*) at a hospital entrance in the midlands and in starlings (*Sterna vulgaris*) on a road in Wales. In both cases, death was due to trauma.

## Miscellaneous and Exotic Farmed Species

Malignant catarrhal fever outbreaks were reported in Pere David and red deer with contact between affected animals and lambing ewes confirmed in one outbreak. Deer are particularly susceptible to malignant catarrhal fever and avoidance of contact with sheep, which represent the major reservoir of the causative virus, is important in farmed deer husbandry.

A novel adenovirus was identified in diseased respiratory tract tissue of a reindeer (*Rangifer tarandus*). Adenovirus Hemorrhagic Disease is a major disease risk to cervids in North America

but has never been reported in Europe or European species of deer and further investigations are in progress.

Delayed swayback was reported in a red deer (*Cervus elaphus*) fawn, most likely as a result of copper deficiency in the dam as the liver tissue level in the affected fawn was within normal reference range.

## Recognition for our experts

Amanda Carson, Veterinary Lead for the Small Ruminant Expert Group, has been recognised twice this year for her contributions to the sheep sector. She was awarded Associateship of the Royal Agricultural Societies for her outstanding contributions to agricultural and rural progress in the sheep sector, and she has also been elected junior vice-president of the Sheep Veterinary Society.

## Access to our service

The number of hauliers that collect carcasses for scanning surveillance as part of APHA's free-to-farmer carcass collection service was increased from seven to 29 this year. This free service means that farmers, through their vets, can submit carcasses for post mortem examination to APHA's Veterinary Investigation Centres and partner post mortem providers, enhancing coverage across England and Wales. This improved service means that carcasses can be collected more quickly from farms leading to a more efficient service.

## Transforming surveillance information into insights and action

During the year, information from scanning surveillance has been communicated through various channels to a range of different audiences, including:

- [Veterinary Record monthly surveillance reports](#) and focus articles – published in print and online by the Veterinary Record and available toll-free through APHA's GOV.UK pages, making them widely accessible.
- [Quarterly GB Disease Surveillance and Emerging Threats reports](#), by species, available online through a dedicated reports page on the Vet Gateway.
- Other regular reports, including the Chemical Food Safety quarterly report and the annual literature review and horizon scanning report by APHA's Parasitology Group, also available on the Vet Gateway.
- All APHA's [scanning surveillance reports](#) and information notes are available from the dedicated reports webpage.
- The [VIDA Annual Report for 2018](#) was published in an interactive dashboard format on the 'Surveillance and Diagnostics' webpages on Vet Gateway, along with additional analyses and comments by the Species Expert Groups on selected diseases.
- Data and information on swine dysentery from APHA's pig disease surveillance dashboard and the quarterly pig disease surveillance emerging threats report have been widely referenced by others in industry and academia, and the Quarterly Reports are shared on



external websites. This demonstrates the value of APHA's data analysis and expertise to others.

- We have given presentations at various events including BVA species division meetings, other veterinary and scientific conferences and symposia, livestock industry events, sector groups and other agri-food stakeholder conferences and meetings.
- We have also shared information about scanning surveillance at key industry events, including National Sheep Association (NSA) North, Royal Welsh Show, Royal Cheshire Show, Welsh Winter Fair, OV conference and London Vet Show.
- The Avian Expert Group hosted its annual Avian Science Day in May. This was the eighth successive year the event has been held and there were presentations on a range of poultry related topics including Avian Influenza, *Salmonella* and disease surveillance by several speakers from APHA. Attendees included poultry practitioners and industry representatives and provided a good opportunity for delegates to be updated on ongoing APHA poultry-related work.
- APHA has been developing the use of social media and digital platforms, as well as building relationships with key stakeholders, to help promote and disseminate key scanning surveillance outputs, such as reports and publications. This has included the use of blogs to share information about APHA's scanning surveillance, including the role of the Veterinary Investigation Officer on the APHA science blog and the role of APHA in investigating disease threats in a BVA blog to support their surveillance series. Furthermore, APHA is now sharing links in producer newsletters which provides direct links with farmers and enables APHA to share information to wider audiences.

Outputs from the Centre of Expertise for Extensively Managed Livestock included:

- Data on holdings that send their sheep to common land in Wales has been analysed to assess their engagement with scanning surveillance. This reflects feedback from stakeholders that existing data should be used in this way.
- Ongoing involvement in research projects and on-farm studies that involve diseases of concern to extensively managed livestock keepers, including sheep scab and anthelmintic resistance.
- A focus article in the *Veterinary Record* about the development of the centre at APHA Carmarthen.

## 2.7 Enhancing Surveillance and Improving Outbreak Response

This portfolio provides Defra, Welsh Government and Scottish Government with expertise and evidence to enhance surveillance, facilitate and improve outbreak response and inform policy development. Tasks undertaken also help to improve core capabilities and maintain key expertise which may be needed during an animal disease outbreak.

Work is delivered through three multi-disciplinary, outcome based, customer focused work streams:

1. Enhance domestic and international surveillance and inform related policy
2. Facilitate and improve the National Emergency Epidemiology Group (NEEG) outbreak response and inform disease control policy

### 3. Project delivery and quality assurance

#### **Reactive and Flexible to Inform Policy**

To support the Treasury business case for a system that aims to improve on the traceability and timely access to livestock tracing information, a short modelling study was completed. Using Exodis-FMD™ (Foot and mouth disease epidemiological model) the impacts of delays in tracing follow up and success was measured against the size and duration of simulated FMD outbreaks. A quantitative modelling paper entitled “Impact assessment of changes to tracing delays and probability of success on the size and duration of foot and mouth outbreaks in GB” was prepared and presented to CVOs and policy teams from Defra and Welsh and Scottish Governments.

As part of the re-evaluation of post-import testing for Bluetongue Virus (BTV) and to aid in outbreak preparedness planning a risk assessment for infection of UK livestock by Bluetongue Virus (BTV) through the importation of live animals from Northern Europe in 2019 was produced. The results of the assessment suggest the risk of infection of at least one infected animal per month were highest in May but could not be ruled out in other months. The information will help in preparing the NEEG members to make extra time available in the highest risk months.

In addition, the EpiRisk group designed and implemented post vector-season risk based surveillance of cattle herds in South(S)/South East (SE) England, and assessed the risk of airborne introduction of BTV throughout the vector season in collaboration with TPI, Met Office and Defra. This provided confidence regarding the lack of BTV incursions into South and South East England.

In response to an outbreak of fully sensitive *Salmonella* Typhimurium identified in sheep that had links to human illness a risk assessment assessing the length of time that the declaration of *Salmonella* on Food Chain Information forms is necessary was completed in 2019. The results of the risk assessment will directly inform the policy for management of sheep holdings identified as affected by this particular *Salmonella* strain and is likely to be used more widely in the management of future *Salmonella* involving non-poultry livestock.

#### **Enhancing Surveillance**

An epidemiological review of the APHA *B. Melitensis* survey sample selection was undertaken to ensure that potential bias in the sheep and goat survey selection process would not impact the sensitivity of the surveillance. The report highlighted that with the available data there was unlikely to be a significant bias but that discrepancies in the data made analysis extremely difficult. The review was used as evidence to support one aspect of selection was adequate within data limitations, hence 2019 survey continued as normal, but that random selection requires more quantitative investigation, which has been commissioned.

The APHA Surveillance Intelligence Forum held one meeting in 2019, this meeting creates awareness of APHA surveillance activities and surveillance methodologies that could be adopted in the future. Following eight successful internal events the format is being reviewed to involve more external potential data providers, this will allow them to see the importance and impact that their data could play in monitoring the ongoing health of livestock populations.

The Advice Services EpiRisk Team worked with the UK Surveillance Forum (UKSF), Species Expert Group Leads, Veterinary Trade Facilitation and Defra market access teams, to develop c50 Disease Specific Surveillance Profiles in 2019, to support UK disease statuses and trade.

As part of continuous improvements and evaluations of surveillance systems used within APHA a report using specifically developed metrics for evaluating the performance of scanning surveillance was produced for the second successive year. Using similar metrics for successive years allows the system performance across time to be investigated and provides a means of ongoing monitoring and the ability to spot trends that may not be apparent in a single snapshot of information.

A paper entitled “Determining pig holding type from British movement data using analytical and machine learning approaches” has been submitted to Preventative Veterinary Medicine. The machine learning approach was used to automatically determine the type of pig holdings to enable categorisation of pig movement data. The developing machine learning methods may allow epidemiologists to estimate certain characteristics from previously collected data alleviating the need to use questionnaires to gather specific information.

The Livestock Demographic Data Group (LDDG) population density map reports for 2018-19 were published on the [APHA Vet Gateway website](#). This is the 3<sup>rd</sup> year that the reports are available online, making them freely available to stakeholders, researchers and other interested parties. Alongside the updated population maps, the LDDGs are publishing summarised versions of the enhanced demographic reports to share directly with stakeholders. Since publication of the population reports there has been an increasing interest and a number of requests for further information from the LDDGs, including groups within Defra and the Welsh and Scottish Government, as well as universities, species specific veterinary societies and other Government agricultural departments. These have been assessed on a case-by-case basis and indicate the interest in the work and maps developed by the LDDGs.

## **Building Capability for Outbreak Preparedness**

As part of ongoing preparedness for potential highly pathogenic AI outbreaks in the UK a scientific report on the risk of HPAI spread from poultry smallholders to commercial poultry was produced in 2019. The report investigated the possible role of smallholders in the transmission pathway with respect to different species. The report concluded the response to smallholder positives could be scaled down and that there would be little epidemiological benefit in changing the rules for poultry flock registration.

A National Emergency Epidemiology Group (NEEG) workshop looking at producing core standards for sampling strategies before, during and after outbreaks of selected exotic diseases was held. The workshop resulted in drafting of papers detailing surveillance strategies for four major exotic diseases. The papers provide a baseline for sampling to give indicative laboratory and resource requirements, the baseline requirements can be further refined based on the requirements for specific outbreaks.

The NEEG-Lite was stood-up on two occasions during 2019, in response to a positive Equine Viral Arteritis (EVA) result in a stallion and in relation to a complex outbreak of *Salmonella* Enteritidis in poultry. The use of the NEEG-Lite is an important opportunity to introduce staff that are new to NEEG roles to the ways of working and outbreak specific tasks. The full NEEG response was implemented in Dec 2019 in relation to a low pathogenic avian influenza case in a

poultry breeding flock. Responding to different types of disease outbreaks across APHA directorates ensures that methods developed in the NEEG are transferable and highlights where specific bespoke approaches are required depending on the species or pathogen in question.

## Sharing Expertise

The 9<sup>th</sup> APHA Modelling Symposium was held at Weybridge on 7<sup>th</sup> Feb 2019, the title of the symposium was “Global Thinking: Modelling pathogen risk and spread across borders”. Defra CVO Christine Middlemiss opened the symposium and was followed by speakers from Government and academia presenting on the different challenges and successes in epidemiological modelling on a very large scale. The modelling symposium provides an opportunity for academia, APHA and policy colleagues to share best practice and improve their understanding of model requirements, limitations and advantages in the animal health sphere.

Work on developing a model to estimate wild bird abundance on poultry farms was presented at the APHA/SRUC Avian Expert Science Day. The work was particularly relevant to poultry experts where wild birds can present a disease transmission route for notifiable diseases such as AI. The model provides a means of estimating areas where wild bird species may be particularly likely to gather in large numbers and present a disease transmission threat to commercial poultry keepers in the surrounding area.

As part of a program to expand engagement with field staff to improve the relevance of scientific outputs epidemiologists and modellers were invited to the Endemics Operational Delivery Network Meeting to deliver a session introducing epidemiological modelling and the appropriate use of models. Sharing this information with the delivery partners enables them to see the direct impact of their frontline activities such as gathering data and implementing new policies that are used within models. It also helped the modellers to make connections with frontline staff to help in future model developments to ensure they are biologically and operationally plausible.

Members of the Risk Assessment team continue to engage with other risk assessment experts from in Northern Ireland, Republic of Ireland, Defra, Scottish Government and Welsh Government at the Veterinary Risk Assessments Working group meetings that are held twice a year. The group provides critical expertise around the area of using and developing Veterinary Risk Assessment methods in operational situations such as movement licencing.

Expertise in the area of implementing the National Emergency Epidemiology Group during outbreaks of exotic disease was shared through participating in the Chinese Field Veterinary Epidemiology Training Programme that is UN-FAO funded. Experts from APHA presented on the theory and deployment of the NEEG during previous exotic disease outbreaks in GB.

## 2.8 Transmissible Spongiform Encephalopathies (TSE)

The UK TSE National and International Reference Laboratory expertise provided by APHA is currently maintained through Defra, Scottish and Welsh funded combined research and surveillance activities. Following the loss of TSE EURL status, we have re-branded and re-launched our International TSE Reference Laboratory and web pages, as TSEglobalNet and engaged to support the new Italian TSE EURL and the wider EU and OIE laboratory network to retain our leading profile.

The multidisciplinary core TSE team has continued to consolidate around the delivery of statutory and policy advisory work, with our TSE scientific and research capability coordinated through a single Defra commission research project (SE1961). This project complements the existing surveillance contracts, adds scientific value to both existing and completed projects, and facilitates the communication of relevant scientific and policy outcomes. Importantly, this new work underpins policy, maintains the skills of the remaining staff and sustains the specialist and technical core while building the body of knowledge on topics such as tissue distribution, test sensitivity, agent stability/variability, and surveillance sensitivity in the field. The project is delivered through four themed work packages: 'Bioassay and Strain Typing', 'Large Animal and Clinical Studies', 'Molecular Studies', and 'Epidemiology and Risk'. This project aims to address important policy questions about the robustness of the current UK surveillance, effectiveness in the response to disease outbreak, ability to detect new and emerging (or re-emerging) strains and their potential risk to the food chain. Work has continued in each work package this year, and proposals for a further four year funding period have been submitted.

The TSE active surveillance programme requirements are set by the EC regulation 999/2001, to monitor TSE prevalence in the EU, concentrating predominantly upon 'risk' animals (i.e. clinical suspects and fallen stock). During this year, classical and atypical scrapie was detected in sheep, and a case of classical scrapie in a goat. There were no cases of BSE. A continued area of interest in TSE surveillance was the detection of further TSE cases in cervids in Norway. Although these cases have been reported as chronic wasting disease (CWD) they are not related with the CWD cases that are endemic in North America. In this sense the term CWD should be used only as an operational term when referring to the European cervid TSE cases. Our continued preparedness for detection of TSE in cervids was tested periodically through the year, however disease was not confirmed in any of the submitted cases. Following reports of TSE in camelids, and squirrel brain, we have sourced reference material via our international collaborations, initiated risk assessment and investigation of test methodology to ensure that our Reference laboratory techniques are appropriate.

The UK timescale for BSE negligible risk status is unchanged. Being able to export beef and other products to countries outside the EU is a one of the main priorities of Ministers and the UK industry, with the potential value of certain markets being over a hundred million pounds a year. The UK is currently classified as 'controlled BSE risk' by the OIE, and we are increasingly invited to present to international trade delegations seeking the scientific reassurance that would enable them to confidently recommence the importation of beef and sheep from UK. This year has again seen an increase in visiting delegations from China and Japan, and Taiwan as discussions over EU exit progressed. We have continued to publish in peer reviewed journals, participate and present at international TSE conferences (Prion 2019, Iberian Prion Congress 2019), and continue to provide specialist expertise for EFSA and ACDP as panel members or ad hoc advisors to advise on epizootic issues, decontamination and assess the impact of policy changes to disease controls.

As part of our ongoing IRL/OIE reference laboratory activities we have reviewed OIE manual TSE chapters, provided proficiency test schemes, referral advice, and reference and training material through TSE-globalNet. Significant support has also been given to TSE EURL Italy throughout the year and our annual review as TSE and ABP NRLs presented at EURL meetings. We continue to offer comprehensive isolate characterisation using transgenic mouse bioassay, both through our leading role in the EU strain typing expert group and also for third countries within our OIE remit.



There have been significant resource pressures and specialist staff retention issues in the last year, with loss of experienced epidemiologists and veterinary pathologists as well as scientists.

## Scientific highlights

A range of transmission studies have been carried out to inform on the ability of TSE agents to cross species and to describe the clinical signs and pathology of the resulting disease, which will provide information on the risks that these TSE strains present through the food chain. These studies also assess the ability of the currently used post-mortem tests to diagnose various TSEs and potentially novel prion diseases created by these transmission studies, and also provide control material for our TSE Reference laboratories.

Two index cases of classical scrapie were diagnosed this year, one in a goat and one in sheep. The outbreak in sheep occurred in susceptible genotypes and highlights that there is still a risk of scrapie infection in this country as susceptible genotypes still remain in the UK sheep population, following stopping the National Scrapie Plan and routine genotyping. The flock was culled, which provided the opportunity to obtain a more accurate estimate of disease and genotype prevalence.

A classical scrapie case was confirmed in a classical scrapie-affected goat farm that had been scrapie-free for 2 years and was about to be lifted of all restrictions. This farm is part of an ongoing study to eradicate classical scrapie by breeding for resistance and so far all cases, including the new case, have occurred in goats of susceptible genotypes born prior to enrolling into the study.

We culled two VRQ/VRQ BSE-inoculated sheep, which had a considerably longer incubation period than a previous group. This replicated findings in transgenic mice where challenge with VRQ/VRQ sheep BSE can produce two disease phenotypes with different incubation periods. The last remaining atypical-BSE inoculated steer was culled with signs of BSE (confirmed by postmortem tests); a vast range of tissues has been collected from all animals, which is now available for further investigations to determine distribution of prions in atypical BSE cases.

We continued to work on studies to assess efficacy of TSE Cleansing and Decontamination (C&D) in preventing further scrapie outbreaks. For goats, we completed examination of 280 goats culled from an affected farm that had been depopulated and restocked without any further scrapie monitoring for 7 years. There was no evidence of re-infection, at least to a level known during the outbreak (1% scrapie prevalence). By contrast, TSE C&D of a barn that had housed scrapie-affected sheep did not prevent re-occurrence of scrapie in susceptible sheep, with one of 25 sheep being infected. Dust samples collected from the barn tested negative for prions by Protein Misfolding Cyclic Amplification (PMCA). This confirms that the sheep bioassay is more sensitive than PMCA to detect environmental contamination.

We determined that the sensitivity of the rapid TSE test (Bio-Rad ELISA) currently used in the UK for active surveillance is considerably lower in goats compared to confirmatory tests, such as immunohistochemistry or Western immunoblot. This implied that scrapie cases might be missed in goats, particularly those in the pre-clinical stage. The findings were presented at the Iberian Prion Congress in October 2019 and a manuscript submitted for publication.

We invested in RT-QuIC technology and worked collaboratively with colleagues from Italy (ISZTO Turin), Rocky Mountains Laboratory (Colorado, USA) and APHA Bacteriology to enable



successful in-house production of the recombinant PrP (rPrP) required for RT-QuIC which will be used for research activities as well as adjunct testing capability to support our national and international reference laboratory functions.

We demonstrated that heat treatment (used for bacterial decontamination of an inoculum for bioassay) of an L-type atypical BSE inoculum, negatively affects PMCA results. These findings support our current bioassay approach, whereby inocula are only heat treated if contaminated, rather than always heat-treating prior to bioassay, as this would negatively affect its sensitivity.

A summary of the potential impact that changing sheep aging methods could have on scrapie surveillance was written, and work was initiated to review literature on BSE decontamination at farm, lab and abattoir sites which will inform risk assessments and protocols for future land use. Following reports of a suspected case of laboratory acquired CJD infection in France, we reviewed risk assessments and procedures in our laboratory and animal facilities.

## 2.9 Wildlife

The role of the NWMC, as a recognised centre of scientific & technical expertise on wildlife disease and management, is to provide evidence, impartial advice and services, primarily to the Defra and the Welsh and Scottish governments, to resolve human-wildlife conflicts. Our teams of experts on wildlife disease, wildlife management, animal ecology, invasive non-native species, population modelling, and animal welfare are based in Sand Hutton and Woodchester Park.

Our work is closely integrated with that of other portfolios: (a) Animal and Zoonotic Viral Diseases Portfolio (e.g. on rabies- enhancing diagnostic capabilities, outbreak preparedness and modelling of mammalian vectors); (b) TB Portfolio (e.g. bovine TB epidemiology, badger ecology and modelling); (c) Plant and Bee Health Portfolio (e.g. Asian hornet control).

In February, NWMC received a clean bill of health from our external management auditor who assessed the compliance of our management system against ISO 9001:2015. We were very pleased to note that Defra's former Minister of State George Eustice mentioned two pieces of work delivered by NWMC in his goodbye address in March. NWMC's important work was further recognised at this year's APHA Awards: the badger control policy team - a multi-disciplinary team operating across directorates- received a team award, the Lead Scientist picked up an individual award, and another two members of staff were highly commended.

## Diseases

During 2019, NWMC's Woodchester Park unit again provided a range of wildlife-related policy-support services for Defra's TB team. We undertook expert field-surveys and provided policy implementation support in selected areas for Defra, including liaising effectively and sensitively with the farming industry and individual landowners. Through working with partners to secure host sites, the team delivered 10 lay vaccinator training courses. Clients included trainees from Wildlife Trusts, several different badger or wildlife groups, Welsh Government and the Ministry of Justice. Thirty nine new lay vaccinators were approved with high praise from clients for the quality of instruction from the APHA wildlife team. Another 2 day symposium was organised to provide much valued training on 'TB in wildlife' issues for another batch of APHA TB field vets and visits by over 40 University students were hosted as part of their studies. A full report was

published on 2018 delivery and results of the Welsh Government's 'TB in wildlife' policy and 2019 interventions were supported, working effectively with Weybridge lab staff and Service Delivery staff in Wales.

The team continues to collect uniquely valuable data on population movement response to disease control and is now also involved at the cutting edge of developing methods for using whole genome sequence data to understand the epidemiology of *M. bovis* in badgers and cattle. We completed a large piece of TB modelling work for Defra (looking at the different impacts of culling, selective culling or vaccinating badgers) which represented a significant part of the evidence used by Northern Ireland to decide on the approach it will take in the coming years for control of TB in wildlife. Our modellers also contributed to the Badger TB Surveillance (BTBS) interim report for Defra TB Policy on the evaluation of Idexx testing on badger blood samples collected by industry contractors. Their analyses suggested that the test has not performed as well as anticipated and the BTBS team is working together in 19/20 to test whether a refinement of the methodology could lead to a satisfactory improvement in test performance.

The National Reference Laboratory (NRL) for *Trichinella* and *Echinococcus*, run from Sand Hutton, continued to submit data, via EFSA, to the European Commission as supportive evidence to allow the UK to retain its *Echinococcus*-free listing. In 2019, 445 fox faecal samples were processed, all negative for *E. multilocularis*. The NRL, through a memorandum of understanding with the FSA, also tested wild boar supplied by wild game hunters for *Trichinella* species. A total of 760 wild boar meat samples were analysed in 2019, all of which tested negative for *Trichinella*.

The UK wild boar population model completed in 2018 was used to investigate African swine fever (ASF) spread potential to aid Defra policy teams and inform contingency planning (e.g. zones of potential infection...). Our modelling team also delivered the latest round of work on the European Food Safety Authority (EFSA)-funded [ENETWild project](#) (Wild boar distributions in Europe). This includes the launch of a citizen science mammal recording app – [iMammalia](#).

We produced a draft contingency response plan for Defra Wildlife in readiness for an outbreak of *Batrachochytrium salamandrivorans* (Bsal). This new form of chytridiomycosis has proven highly pathogenic to salamanders and newts and has been responsible for mass mortalities in amphibians in northern Europe.

Regarding our ability to provide a rapid response, we now have a total of 10 staff who hold CW70 permits (giving them authorisation to use APHA firearms). Three CW70 holders attended a wild boar management course in autumn 2019. This aims to ensure we have sufficient staff able to assist with wild boar control in the event of an outbreak of ASF or other epidemic. In addition, three members of staff attended Exercise Old Spot in December 2019, a contingency planning exercise for ASF, organised by Defra Animal Health.

The EpiRisk Team within Adice Services have worked with science and wildlife experts to establish a protocol to deal with suspect cases of swine fever in feral wild boar, to provide confidence of ASF disease freedom in the UK.

## **Wildlife management and invasive species actions**

We are now in the third year of the [UK Squirrel Accord](#) (UKSA)-funded grey squirrel fertility control project. The project aims to move the existing fertility control science to the point that a

strategy for the British grey squirrel is available and an oral contraceptive product is ready for the registration process. Our work has expanded this year to explore and test novel candidate contraceptives which have recently become available through the work of other research groups. Thanks to our established captive breeding colony of grey squirrels, we developed non-invasive methods to monitor reproduction (cycling and pregnancy) in these animals. We refined and tested grey squirrel-specific methods to deliver a putative oral contraceptive. We designed a food hopper that could monitor patterns of bait uptake by individual squirrels and we employed the bait marker Rhodamine B to quantify the proportion of squirrels ingesting baits in captive and field trials at different times of the year, with different densities of squirrels and bait hoppers. NWMC hosted senior members of the UKSA in December to provide an update on our work. Lord Kinnoull who attended the meeting personally sent his praise after the meeting "The depth and quality of the thinking in the whole team is a testament to APHA."

Work on the invasive Egyptian Geese in 2019 involved piloting licensed shooting to remove free-living Egyptian geese from a contiguous defined Control Area; largely involving the shooting of breeding pairs on nesting territories (February-March). The pilot study has shown that Egyptian geese can be consistently targeted and killed over a designated contiguous Control Area using sound-moderated rifles. The 190 geese removed being equivalent to ~2% of the estimated 2018 GB population (9,611 geese). Preparations for a further pilot study (scheduled for February-March 2020), using traps, were undertaken in the year. These pilot studies will help inform future decisions on the potential larger-scale management of Egyptian Geese in the future.

For monk parakeets, control of eggs in the one remaining known colony on the Isle of Dogs was undertaken during the 2019 breeding season. A novel nest-trap was developed and field tested – successfully capturing a breeding female and youngster. Two adult female ruddy ducks were culled by NWMC, leaving around 12 individuals left scattered across the UK. To date there is no evidence of breeding in 2019, and the species is eliminated as a breeding bird in most areas.

The [RAPID \(Reducing And Preventing IAS Dispersal\) LIFE](#) project has continued at a good pace throughout 2019. This three year EU-funded project (in partnership with Natural England and Bristol Zoo) aims to pilot a coordinated, strategic and evidence-based approach to Invasive Alien Species (IAS) management in freshwater aquatic, riparian and coastal environments across England, whilst demonstrating the efficacy of this approach for replication across Europe. An IAS toolkit was completed in 2019 which is freely available to download online. There is a variety of resources available in this toolkit, from user-group specific biosecurity videos, to good practice management guidance for 15 different IAS. Five practical management projects were conducted to demonstrate strategic management of IAS at a catchment level using best practice methodologies (e.g. biological control work on Japanese knotweed and Himalayan balsam at a number of sites across England). A series of workshops on biosecurity and priority IAS species were also delivered.

NWMC staff have also been heavily involved in discussions with the National Bee Unit around suitable alternatives to the pesticide currently used to destroy Asian Hornet nests. This has been removed from the list of pesticides approved by the Health and Safety Executive for outdoor use and alternatives have been discussed and agreed upon. In terms of practical delivery, three Asian Hornet nests were successfully destroyed at two separate locations in autumn 2019. Finally, NWMC staff were involved in a rapid response to the escape/release of up to 20 raccoon dogs in autumn 2019.

Following the revocation of Natural England's General Licences for control of avian pests in April 2019, support has been provided to Defra in respect to a review of the evidence base to support the development of revised licences. NWMC provided ornithological expertise alongside other response team members from Defra Evidence, Policy and Legal. NWMC staff contributed significantly to the response team's production of monographs for the 16 listed pest species summarising evidence for impacts under each of the General License purposes. In addition, providing a review of information on alternative non-lethal methods of avian control. The information assisted in the development of temporary revised General Licences. NWMC staff were also members of the General Licensing Core Plus team (from August 2019) assisting in shaping the technical direction of a subsequent further review of General Licensing. This subsequent review is ongoing, involving reviews of species-purpose, alternative non-lethal means of control and a survey of stakeholder views.

## **Non-native Species Secretariat (NNSS)**

The NNSS continues to coordinate non-native species work and support policy teams in England, Scotland and Wales, as well as helping to improve biosecurity in the UK Overseas Territories (OTs). Throughout the summer and autumn the NNSS was instrumental in preparing for the Environmental Audit Committee enquiry into invasive non-native species and gave oral evidence to the Committee in a two hour session, alongside the Biosecurity Minister and Chief Plant Health Officer. The NNSS is also supporting the [response to the Committee's report](#), published in November, and as part of this work is exploring the potential role of a dedicated invasive species inspectorate.

The NNSS continues to lead the GB risk analysis mechanism, providing risk assessments and risk management information to support decision making. It has also drafted and finalised generic contingency plans for the majority of non-native species that threaten England, Scotland and Wales and saw these plans implemented in response to several incursions of raccoon dog and sacred ibis. This year the NNSS delivered on the UK's obligation under EU law to prioritise pathways of invasive species introduction to the UK and continues to lead the development of pathway action plans for the angling and recreational boating sectors. It has also led for the UK on its legal responsibility to report progress towards implementing the EU Invasive Alien Species regulation.

In the OTs the NNSS has completed horizon scanning and pathway action planning to help prepare the territories for future invasive species threats. Work continues in the OTs to implement pathway actions, prioritise management and seek resources to deliver a wider range of biosecurity improvements and species management.

## **Network and Influence**

NWMC hosted four representatives from the Ministry of Municipalities and Environment in Qatar. The visit from the Qatari delegation to APHA was part of the UK's Ministerial brief to increase the UK's international profile and focused on Qatar's ambition to increase their food production, food security, disease prevention and animal welfare.

Our wildlife experts continue to sit on a number of scientific journal editorial boards, national and international committees and steering groups. In 2019, one of our experts was invited to join the Wild Pig Management Advisory Group (Agriculture, Fisheries and Conservation Department,

Hong Kong) as an advisory member for a two-year term from May 2019- May 2021. Expertise on wild boar management is in high demand at present and talks reviewing wild boar population trends in Europe and different approaches to population management were given to [Eurogroup for Animals](#) in Belgium (May), the “Pathways: Human Dimension of Wildlife Conference” conference in the USA (September) and at a 3 days workshop in Israel(November).

Our head of NRL has been approved as a member of the [International Commission on Trichinellosis](#). Throughout the year, she has successfully engaged with her EURL for parasites counterparts to discuss how APHA/the NRL will keep working with the EURL post EU-exit.

A number of our staff continue to be involved with teaching at several academic institutions, most notably the MSc in Wildlife Management at the University of Newcastle. Another of our researchers gained associate lecturer status at the Centre for Wildlife Management, University of Newcastle.

Two NWMC scientists were invited speakers at a workshop on the cultural/social/technical issues around wildlife research at POLEs (Places Other than Licensed Establishments) hosted by [Animal Research Nexus](#) in Oxford. This led to one of them being invited to become a member of the [British Ornithological Trust's](#) special methods and technical panel.

NWMC contributed to a proposal presenting how the International Union for Conservation of Nature (IUCN), working closely with the APHA, European Association of Zoos and Aquaria, Eurogroup for Animals, European Alliance of Rescue Centres and Sanctuaries, Newcastle University, the IUCN Species Survival Commission Invasive Species Specialist Group and a number of scientists and organisations, will provide comprehensive and timely technical support to the European Commission for the identification, assessment, sharing and dissemination of best practices for the humane management of invasive alien species.

We continue to have a very fruitful collaboration with EFSA and the ENETWILD consortium, providing us with many valuable opportunities to closely work with national and international stakeholders.

On 13-17 May the NNSS led its 5th Invasive Species Week across the UK, Ireland and the Channel Isles. It was launched by the Minister for Biosecurity and Scottish Environment Minister and included over 320 organisations working together to raise awareness of invasive non-native species and biosecurity. The NNSS also led discussions with counterparts in Belgium, Netherlands and France to reduce the risk of aquatic invasive non-native species entering the UK and spreading to Ireland. At an EU level the NNSS continues to represent the UK at Scientific Forum meetings where risk assessments to support listing are reviewed, attends Committee meetings at which votes are taken, and attends the European and Mediterranean Plant Protection Organization (EPPO) Invasive Plant Panel as an invited expert. The NNSS is also represented at the UK Biological Security Strategy Working Group and Cross Government Risk Assessment Network.

Building on networks with French stakeholders that have been developed during RAPID LIFE, two international conferences on IAS have been hosted by the RAPID team in 2019, one in France in May and one in Brussels in December. The knowledge-sharing and relationship building at these events has been extremely useful and has encouraged further collaboration, such as some French stakeholders taking on the Check, Clean, Dry campaign in France – to raise awareness about biosecurity and the spread of invasive species. We hope that having laid some foundations through these networking events that we can continue to encourage



international collaboration into the five year “After-LIFE” phase after that the RAPID LIFE Project and hopefully beyond.

## 2.10 Advice Services

Advice Services collates expertise from across the APHA portfolios and disciplines and beyond into properly informed and evidenced advice to Animal Health and Welfare policy makers allowing well informed policy intent to be turned into deliverable plans via the APHA Operational Manual Instructions and specific guidance to other Government bodies and to stakeholders. Support and advice is also provided to teams delivering those policies, considering research commissioning etc. The team contribute to Parliamentary Questions, Freedom of Information requests, Ministerial and Corporate correspondence.

It works with a range of others within APHA including Science Directorate, other teams in Service Delivery Directorate, comms etc. Elsewhere in Government the team works closely with Defra, Scottish Government, Welsh Government, Department of Agriculture, Environment and Rural Affairs Northern Ireland (DAERA), PHE, FSA, Food Standards Scotland (FSS), VMD, AHDB, TPI, Gov’t Science and Engineering Profession, Met Office, EPIC, UK Border Force, Local Authorities, Science Advisory Council for Exotic Disease (SAC-ED) and the Cross Government Risk Assessment Network. Beyond Government, Advice Services work with external suppliers listed on the Animal (and Plant) Health Modelling Framework, with representative bodies such as the NFU, assurance scheme operators (such as Red Tractor and the British Egg Industry Council (Lion Code eggs), the Royal College of Veterinary Surgeons, British Veterinary Association (and its specialist divisions) and industry organisations such as the Pet Food Manufacturers Association and sector groups such as the National Pig Association.

AS comprises of seven teams each led by a vet and comprising vets, scientists and technical leads supported by a co-ordination unit that also manages the APHA contribution to inward missions from the Health and Food Audit and Analysis team of the European Commission (formerly known as the Food and Veterinary Office (FVO)) and 3rd countries.

Five of the teams are policy specific:

1. Exotics and Welfare
2. One Health
3. TB: Policy facing
4. TB: Delivery facing
5. Veterinary Trade Facilitation

Whilst both the EpiRisk and the Field Epidemiology teams support multiple policy areas (Field Epidemiologists provide operational support and advice to the Service Delivery Directorate).

Most of the work covered by Advices Services has been detailed within the individual portfolio and disciplines sections within this report. Other work is detailed below:



## Publications

AS contributes to and co-ordinates many publications in peer reviewed journals as well as publishing their own reports to inform colleagues, the public, farmers and veterinarians of current threats and progress on disease management.

### Internal government reports include

- Monthly reports across APHA
- VRG monthly reports to all policy admins, CVOs and animal health agencies
- Quarterly Risk ID reports (inc VRG, IDM, D2R2)
- Disease investigation reports e.g. East Cumbria TB

### Externally published reports include

- Exotic disease outbreak epidemiology reports e.g. AIV 2019-01
- Vet Record Reports
- [POAs](#) –37 published in 2019
- The [monthly publication of the Official Statistics](#) of incidence and prevalence of bTB in cattle were released for year ending July 2019
- Annual TB reports including England Surveillance, Low Risk and edge Areas reports
- [HSA technical note](#) - Animal Welfare Advice for Small-scale and/or Seasonal Processors on the Electrical Stunning and Bleeding of Poultry LDDG livestock population and indicator reports produced are published on the [Vet Gateway](#)
- Risk Assessments published by HAIRS
- Reports by the Advisory Committee on the Microbiological safety of Food (ACMSF)
- UK zoonoses annual report (aka Trends and Sources report) published by the European Food Safety Authority (EFSA)

## Key work areas

### Trade

Our team negotiates bilateral certification with 3<sup>rd</sup> countries, assists to salvage trade during disease outbreaks and recover lost trade after disease outbreaks. Our expertise provides the essential advice in support to current and future UK trading arrangements with 3<sup>rd</sup> countries and negotiation to future trade relationship with the EU. This will become more important post EU Exit to enable continuation of existing trade agreements between 3<sup>rd</sup> countries, so they continue to apply to the UK after December 2020, as well as negotiation of new free trade agreements with 3<sup>rd</sup> countries and negotiation of sanitary and phytosanitary (SPS) issues with the EU.

The team have also contributed to the Borders Intelligence Group on Products of Animal Origin (POAO) risk management, and contributed highlights from our quarterly UK Border Force (UKBF) report.

## **Animal Welfare**

Veterinary advice enabled production of the Code of Practice for the Welfare of Pigs, and was central to informing The Wild Animals in Circuses Act 2019. Advice is provided on farmed animals, gamebirds, the welfare of farmed fish, welfare in transport and at the time of killing including altered atmosphere and religious slaughter, and development of a technical note for seasonal poultry slaughter ([HSA technical note](#)).

Advice and evidence provision supported a review of sentience including crustaceans and similarly of the welfare of companion, sporting and performing animals, microchip implantation, and the Animal Welfare (Licensing of Activities Involving Animals) Regulations with a particular focus on guidance and preventative health care. Welfare aspects of future farming subsidies and grant proposals has been provided with advice for enhanced standards.

Veterinary and science advice is also central to the UK international animal welfare influence, driving animal welfare improvements through the OIE and other channels.

## **Exotic Notifiable Animal Diseases**

Veterinary and science evidence and advice is provided to inform policy decision making in determining national controls to protect from exotic notifiable diseases. Advice is developed using national and international evidence, working with National Reference Laboratory experts and consulting with a wide range of industry organisations.

Veterinary risk assessments and licence conditions, to allow specified activities in notifiable disease outbreaks, such as an incursion of Foot and Mouth Disease, have been re-evaluated and developed, enabling quick and safe deployment.

Veterinary and science advice has been provided to industry to facilitate understanding and compliance with requirements on practical measures for secondary cleansing and disinfection utilising an industry-funded risk assessment.

Working with policy, disease consultants and APHA field delivery enhanced capability in investigating suspect Swine Fevers in wild boar and feral pigs has been developed in the face of the heightened threat from abroad.

Veterinary advice in controlling an outbreak of Equine Viral Arteritis, was provided to ensure a proportionate and secure response while protecting the wider equine industry.

Veterinary and science advice is provided to support all investigations of suspect exotic notifiable disease. [Total investigations for 2019](#)

## **Epidemiology Risk**

Veterinary Risk Group (EpiRisk) managed the cycle of monthly meetings and reporting to CVOs throughout 2019, and all teams across AS contributed. 11 threats and 45 points for information were reported to VRG in 2019. VRG provides a coordinated process that ensures systematic and timely assessment of animal health and welfare related threats and vulnerabilities, across UK directorates and administrations.

EpiRisk led the re-tender of the animal (and plant health) modelling framework with experts, to develop engagement between policy makers and external modelling community and to enhance UK's internal modelling capability. Undertook pre-engagement activities with SAC-ED, external modelling groups, and policy customers to develop requirements and approaches for the new 'Invitation To Tender' for this framework.

Ongoing work with policy teams to ensure a definitive list of all finalised licences, categorised by disease, administration covered, and licence type; matched with a supporting generic Veterinary RA, to aid efficiency of licensing during outbreaks.

## 3. Science Disciplines

### 3.1 Bacteriology

As planned the APHA bacterial archive was successfully moved from Bury St Edmunds to Weybridge in the summer 2019 following the closure of the Bury laboratory facilities. A review of the activities in the first six months post-transfer is underway to identify any potential changes in approach that may allow better use of the archive for both internal science and surveillance, and as a potential resource for external partners.

Some elements of plans to rationalise bacteriology estate to enable more efficient working and co-locate teams are progressing. Renovation of a new facility to house high containment surveillance, diagnostic and research work on exotic *Mycoplasma* is underway as is renovation of laboratories to co-locate the *Salmonella* serotyping team, fulfilling important statutory functions, with other *Salmonella* surveillance and research work.

The discipline was successful in a significant number of proposals submitted to the One Health European Joint Programme which will complement Defra funded research enabling maintenance of international linkages and helping support core capability.

A Centre of Excellence Project has continued to develop activities in characterising novel and/or emerging bacteria of potential veterinary significance.

- A novel bacterial species isolated repeatedly from alpaca in the UK was formally described as *Actinobacillus vicugnae* (<https://doi.org/10.1099/ijsem.0.003607>). Further, working with SRUC colleagues, five isolates from normally sterile sites in sheep have been characterised as a new bacterial species (*Streptococcus caledonicus*) with potential veterinary impact.
- Diagnostic assays to better understand the significance and impact of veterinary pathogens previously identified as emerging in the UK, notably *Campylobacter hepaticus* (a newly described bacteria associated with spotty liver disease in poultry) and *Avibacterium paragallinarum* (causing infectious coryza in poultry) have been validated and are moving towards routine implementation.
- Further work with SRUC recovered *Neisseria animaloris* from bite wounds on pectoral fins and tailstocks, and from lungs and other internal organs, of eight harbour porpoises. *N. animaloris* is considered a commensal of the canine and feline oral cavities but is able to cause systemic infections in animals as well as humans, usually after a biting trauma has occurred. Gross and histopathological evidence suggest that fatal disseminated *N. animaloris* infections had occurred due to traumatic injury from grey seals. This work suggested that *N. animaloris* should be added to the list of potential zoonotic bacteria following interactions with seals, as the finding of systemic transfer to the tissues of the harbour porpoises may suggest a potential to do likewise in humans (<https://dx.doi.org/10.1038/s41598-019-50979-3>).
- Work exploring the potential of metagenomics approaches in bacterial veterinary diagnostics has been delayed due to cost-savings but will be explored in the future.

Challenges for the future include the impact of moving towards routine implementation of WGS for surveillance of key pathogens such as *Mycobacterium bovis* and *Salmonella* – challenges

remain around IT and data storage resource and infrastructure and around recruiting and retaining staff with appropriate expertise. More widely recruitment and retention policies for the discipline need to balance an ongoing need for flexibility with scope to develop the deep expertise needed in disease experts of the future.

## 3.2 Biomathematics

Modelling teams from the Biomaths and Risk Research (BRR) Workgroup and from the NWMC have worked together on modelling the impact on bovine TB occurrence in cattle of control options outlined in the Godfray review of TB control in GB. Three different models that have been developed within the agency were applied to specific sampling strategies for detection of TB in cattle farms. Each model differs in scope and complexity, including a model recently developed in collaboration with Edinburgh (the TB modelling initiative model). This is a good example of working between different parts of APHA, and the production of results from multiple models adds additional confidence in the findings.

The APHA Data Science strategy is nearly complete, has drawn on expertise across APHA, and identified a number of key development areas and proposed approaches. This work moves forward the important biomathematics objectives around IT infrastructure availability, quality assurance, and the application of state of the art approaches to analysis of complex data sets. Defra's Digital, Data and Technology Services (DDTS) are developing their vision for a Data Science cloud platform and talking to potential suppliers. The Science Computing Environment (SCE) management team are refining the SCE strategy to focus on services likely to complement capability gaps; largely around high-end bespoke applications requiring server-level flexibility and administrative rights, leaving DDTS to providing more tightly managed analytical software platforms which fulfil the bulk of standard analytical tasks. Efforts are underway to engage DDTS on this hybrid IT model.

Staff from the BRR workgroup at Weybridge were part of the G-RAID consortium that organised a one-day international symposium held in Amsterdam. The symposium brought together European experience and expertise in generic risk assessment modelling for animal diseases to investigate the potential for standardization of input data and algorithms, to explore options for validation of generic Risk Analysis tools and to discuss how results of generic risk assessments can be communicated. The workshop was targeted at risk managers, attendees included the UK CVO. The symposium highlighted the importance of getting the initial risk question right, understanding how the necessary assumptions and data gaps impact the results and effective two way communication between science and policy. With regards to APHA biomathematics capability our involvement in the symposium has improved our understanding of how to communicate complex quantitative models to non-specialist staff, such as policy colleagues and risk managers, both through formal written presentations and informal discussions. Our involvement in the wider consortium has increased our technical capability through getting to understand in more detail the different methods and issues of the tools developed by the other international G-RAID consortium members.

With rising concerns around African Swine Fever (ASF), NWMC's Epidemiology and Modelling team have been engaging with policy, and developed modelling to look the potential spread and possible control options for ASF in the feral wild boar population in the Forest of Dean. This work has proven a good example of working with different areas of APHA and the wider DEFRA group, and merging our wildlife modelling capability with our international expertise on Wild Boar

ecology in order to proactively engage with policy issues, and help develop our outbreak readiness.

NWMC's epidemiology and modelling group have also contributed to a range of other work areas across APHA- for example using model outputs and data analysis to assist with contingency operations for the continued control of Asian Hornet (*Vespa velutina*). The team have provided outputs to help plan resourcing levels during contingency operations, and have also provided analysis to DEFRA Bee Health policy to help inform the current control strategy employed in the UK (the modelling was used to simulate different invasion scenarios, and understand the point at which successful eradication becomes highly unlikely). The modelling output used in this work now forms a key piece of evidence in our ongoing efforts to control *V. velutina*.

The EpiRisk Team within Advice Services are leading work with others in Advice Services and APHA to pull together a Risk Assessment Hub; to inform future risk assessments and improve efficiency in risk assessment drafting, and have drafted a number of risk assessments to inform policy advice, including:

- Ticks on pets – ongoing
- *Salmonella* decay on sheep farms for to help better understand the potential duration of the threat and to help affected farmers be clear on what they must report via Food Chain Information (FCI) when sending their stock to abattoir
- BTV8 import risk assessment with monthly updates
- Echinococcus in returned dogs after Brexit
- TRAdE Control and Expert System (TRACES) risk assessment based on ASF
- Raw pet food risk assessment, which has in turn helped inform the industry-produced code of practice to help minimise the disease transmission risks relating to raw pet food, of significance for the health of both pets and their owners.
- Rift Valley fever outbreak in Mayotte, France
- HPAI game bird release in HRAs

### 3.3 Epidemiology

The joint proposal to become an OIE Collaborating Centre in Risk Analysis and Modelling submitted by APHA and the Royal Veterinary College (RVC) was successful and ratified at the OIE General Session in May 2019. Work has been underway to consider where best to focus activities including the development of a regional skills and interests survey to understand training needs for each of the work streams in the centre's remit: risk analysis, epidemiological modelling, mathematical modelling, economics and data

Outbreak response is a key part of the Agency's activities. This year, the National Emergency Epidemiology Group (NEEG) which includes epidemiology colleagues from across APHA was stood up to respond to unusual outbreaks of equine viral arteritis and *Salmonella* as well as a case of low pathogenic AI. A wide range of outbreak preparedness activities were also undertaken including input to a number of laboratory response contingency planning exercises,



with recent work on surveillance sampling and exotic disease exercise scenarios has been used to inform the future development planning of the APHA Weybridge site

Based on the NEEG structure, a new dedicated National TB Epidemiology Group has been established. This group brings together specialists from analytical and field epidemiology, data science, statistics, geographical information systems, modelling and policy advice to tackle specific bovine TB issues, provide policy advice and a platform for knowledge sharing. In the area of bovine TB, work on WGS and planning for wider roll out has continued with a triage system finalised for the selection of cases for more in depth analysis. An analysis assessing the effects of badger culling on TB incidence in cattle has been completed and published in the Scientific Reports journal. Further activities are described under the TB portfolio.

Within the area of food safety and zoonoses, epidemiological input has been provided to surveillance design and reporting as well as investigation of new cases. Epidemiological input has also contributed to scanning surveillance activities for emerging and endemic diseases including analysis of laboratory submission data and the investigation of future methods to aggregate outputs from diverse data sources. Linked to this, the identification and assessment of new and emerging diseases continues to be reviewed through monthly cross-administration UK Veterinary Risk Group meetings co-ordinated by the epidemiology policy advice team. A significant work area at this time are the analyses and reviews required for the new livestock movement information systems being established in England, Scotland and Wales.

Epidemiological training and support has been provided within APHA and more widely. This includes delivery of teaching on the RVC Masters in Veterinary Epidemiology course as well as supervision of PhD and Masters projects in Great Britain. On an international scale, the epidemiology team has provided training and shared information on our epidemiological practices to colleagues from a range of countries including China, South Korea, Japan, Qatar, Romania and the Republic of Ireland. APHA have also taught animal health and food safety risk assessment as part of the EFSA EU-FORA risk analysis fellowship programme. The APHA are also a hosting institute for an EU-FORA fellow.

The delivery of high quality research continues to be a focus. This year, the Horizon 2020 EU-funded project COMPARE concluded. Risk analysis and epidemiologists from the Agency were a key contributor to this project. In this project a generic risk assessment model was developed and epidemiological and statistical tools were applied to WGS data. APHA highlights from the five year project were presented at a final meeting at Weybridge. Epidemiologists, risk analysts and modellers continue to be involved in the H2020 EU-funded One Health European Joint Programme (EJP) project and were successful in their applications for the latest round of projects. Finally, APHA's first ever plant health risk assessment was performed within the Department of Epidemiological Sciences for Defra. The quantitative risk assessment considered the effectiveness of the current and alternative surveillance regimes at detecting the introduction of potato brown rot disease to England & Wales via import of seed potatoes.

Epidemiological research has been showcased at a number of international conferences including Safepork and the Society of Veterinary Epidemiology and Preventive Medicine (SVEPM) with APHA epidemiologists being invited speakers at the Bundesinstitut für Risikobewertung (BfR) in Germany and the Federation of Infection Society conferences.

Finally the Epidemiology Oversight Group has been re-established. The aim of this APHA group is to enable an integrated approach to training, skills development and resourcing in order to provide the best quality epidemiological evidence, investigation and advice. Areas of focus this

year have included staff retention, cross-team working and knowledge sharing. Planning for the coming year is currently underway.

### 3.4 Molecular Biology

Demand for high throughput sequencing has continued to increase over the past year. In response, APHA have invested in more instrumentation to facilitate the rapid turnaround required. This includes WGS of AI Virus, *Salmonella*, and Lyssaviruses from various positive samples and outbreak situations in addition to routine surveillance. APHA have also been providing this service on a commercial basis for a number of external customers; primarily focussing on provision of raw data microbial community analysis and bacterial WGS. However, through the EU Horizon2020 funded European Virus Archive global project APHA have provided viral genome sequencing for a number of overseas organizations.

Developing and implementing automated pipelines for the analysis of high throughput sequence data was a key activity in 2019. The analysis of *Mycobacterium bovis* WGS is fully automated and is currently running in parallel with traditional genotyping. This will move into business as usual when the appropriate IT infrastructure is operational. Developments for data processing of *Salmonella* and AI Virus are following the same route. The Field Epidemiology Team has contributed significantly to the development and implementation of WGS as an operational tool in the agency.

APHA are closely involved in a Wellcome Trust funded project to develop a cross government bioinformatics platform (Scalable Pathogen Pipeline Platform; SP3) to facilitate rapid data sharing and outbreak detection. Working with the project teams from Universities of Oxford and Cardiff, and representatives from Public Health organisations from across the UK, the platform is being designed to unify analytical approaches and fit user specifications.

Defra has established a Centre of Excellence for DNA methods and APHA are key partners. The aim is to share best practice across the Defra group and drive efficiency by working together to develop validated protocols for all aspects of molecular biology from sampling and analytical procedures to data analysis and long term curation of outputs.

During the year APHA hosted a six-week visit of a member of staff from the EU Bovine TB reference laboratory (VISA-VET, Madrid) to share our expertise on the laboratory and data analysis aspects of WGS of *M. bovis*.

### 3.5 Parasitology

APHA is now an approved member of the International Commission on Trichinellosis (ICT). This will allow us to continue to exchange knowledge on trichinellosis in humans and animals and collaborate with international organizations such as the WHO to aid in control of *Trichinella*.

The National Reference Laboratory for *Trichinella* and *Echinococcus* in APHA Sand Hutton has, in addition to carrying out annual surveillance of these two parasites, been also carrying out commercial work for their detection for academic and governmental institutions worldwide.

Collaborations have continued with various parasitology groups within the UK and further afield. This has assisted research and emphasised the importance of surveillance for new and

emerging pathogens as well as endemic parasitic diseases. APHA has also been working closely with PHE on surveillance and documentation of the range and abundance of indigenous ticks, important tick borne diseases and monitoring for the introduction of exotic species. Effective partnerships were also created between APHA and other UK government departments such as the Food Standards Agency through disease investigation.

Working together with the Small Ruminant Expert Group on investigating and publicising new and emerging diseases through diagnostic scanning surveillance, has led to further research. APHA together with the Moredun Research Institute were successful in a three year VMD research call on anthelmintic resistance and looking at the role of animal movements and wildlife in resistance dissemination. This will involve a PhD studentship.

Work also continues in the VMD research project into sustainable control of sheep scab in the light of emerging resistance APHA's diagnostic data (going back to 1995) as well as our expertise is an essential component of this project.

Resistance in sheep gastro-intestinal parasites to a newer class of anthelmintic, monepantel, was also investigated and reported.

APHA continues to be represented on the European Veterinary Parasitology College (EVPC) committee and involvement in the EU Cost action group on anthelmintic resistance (COMBAR) has continued to ensure good European collaboration and also training opportunities.

The second year training of an APHA Veterinary Investigation Officer has been completed and approved as part of the process for EVPC diplomate status.

APHA's parasitology discipline champion successfully revalidated her diplomate status of the European college of small ruminant health and production (ECSRHM) for the next five years. For this you have to prove to have carried out sufficient CPD, written publications and presentations to disseminate your knowledge in this area.

Peer and non-peer reviewed publications this year have been diverse in the parasite content. The first detection in the UK of anthelmintic resistance in a pig parasite, multiple resistance detection to macrocyclic lactones in the sheep scab mite *Psoroptes ovis*, and monepantel resistance in sheep as well as the equine piroplasmosis status in the UK and *Hyalomma rufipes* (an exotic tick) on an untraveled horse. The horizon scanning report by APHA's Parasitology Group has also been published and disseminated to industry.

APHA continues to have representation on important industry bodies, the Sustainable Control of Parasites (SCOPS) and Control of Worms Sustainably (COWS) groups (promoting sustainable control of parasites in ruminants) and the Welsh herd and flock health and welfare group.

Numerous presentations were given throughout the year to government representatives, state and private veterinary surgeons and the farming industry on various parasitology topics.

## 3.6 Pathology and Animal Sciences

The Pathology and Animal Sciences Department has continued to focus on improving integration between the specialist veterinary, technical and science teams, building flexibility

and resilience and consolidating expertise to maximise the benefits of merging Pathology and Animal Sciences disciplines into a single department.

In Pathology, We have continued to build and strengthen our specialist veterinary pathology capability and impact within the Agency, gaining further integration within the research portfolios, surveillance teams and influence in Defra policy. The depth of knowledge of the veterinary pathologists recruited and trained over the last few years has improved, resulting in an increase in outputs and publications led by veterinary pathologists. This is reflected within the science portfolios, in ad hoc reports of pathology investigations, and in fostering new collaborations, consolidating previous ones and in grant applications.

The increased dependency on our high disease biocontainment post mortem facilities for handling high risk carcasses, particularly for TB, and greater deployment of our specialist expertise in exotic and zoonotic diseases has increased our visibility within Defra and externally. Cross training between the pathology and animal sciences teams has increased technical resilience and enabled a sustainable response to annual TB control programmes in badgers and livestock. We continue to support exotic and notifiable disease response investigations (e.g. influenza, Glanders, EIA and TSE) and provide clinicopathological and test consultancy.

Our links with the Surveillance Intelligence Unit and the Veterinary Investigation Centre network have been strengthened via provision of the surveillance histopathology service and increased representation in the species expert groups. Our lead avian and mammalian surveillance pathologists have provided gross pathology training for VIOs, Veterinary Officers (VO) and Private Veterinary Surgeons and the use of a contracted pathology supplier (Finn Pathologists) is now mainly for contingency or surge cover rather than quality assurance and second opinion. Expertise within the team has increased to consultancy level, and we continue to train junior veterinary pathologists in partnership with The Royal Veterinary College. One pathologist achieved FRCPath part 1 this year and Weybridge and Lasswade teams are now recognised as an important hub of enthusiastic learning and critical expertise in the veterinary pathology sector.

Key issues in Pathology continue to be development, maintenance and retention of specialists. We require pathologists and scientists with a depth of knowledge across the breadth of responsibilities, and it takes several years to gain the level of knowledge needed. This year, although there has been greater focus on pathology training for permanent staff, it has not improved retention; we have again faced significant difficulties in recruitment – with loss of several pathologists and research scientists and resultant limited resilience within the Pathology team.

In Animal Sciences, whilst continuing to comply with the Animal (Scientific Procedures) Act 1986 our Animal Sciences capability has been reduced and fragmented over recent years due to the ageing infrastructure of our biocontainment and livestock facilities. This has resulted in unavailability of a large number of buildings which has compromised timely delivery of a number of studies. These issues are currently being addressed via capital expenditure focussing on critical buildings, and the APHA Weybridge Masterplan funding bid to Treasury for a complete redevelopment which prioritises *in Vivo* facilities.

We have focussed on the highest priority work and maximising the use of the available facilities. Following completion of the animal study phases and subsequent closure of the badger TB oral bait programme, we have transferred our remaining badger colony and specialist knowledge to the Wildlife team at Sand Hutton, and repurposed the biocontainment facility for poultry studies.

We also continue to work in partnership with them to deliver commercial contract poultry work and maintain critical expertise.

After previously increasing the number of Named Veterinary Surgeons (NVS), this year we strengthened the numbers of Senior Named Animal Care and Welfare Officers (NACWO) with appointments of Senior Animal Scientists and Technologists. This has enabled us to continue to consolidate expertise and build flexibility, resilience and specialist knowledge in our veterinary and animal technician teams, whilst developing clear career pathways and improving critical mass. As part of this, the management of the biocontainment post-mortem facility now bridges the in-vivo and vitro work of the department.

Maintaining critical mass and deep specialist knowledge for in-vivo work across the breadth of species and experimental models and zoonotic pathogens continues to be an issue across the Science Division and will take several years to improve. As part of our commitment to the 3Rs (replacement, reduction and refinement) assessment and investment in modern image analysis (infrared thermography/ video tracking software) for the continual development of welfare assessment and the ongoing development of enrichment techniques still remain at the forefront of development in our animal science. A presentation on the use of infrared thermography in large animal studies was given at the Laboratory Animal Science Association Annual Conference on 28 November 2019.

We have continued to increase our leadership, profile as a centre of excellence and influence in Animal Sciences and ethics, with greater publication and contribution to national and international committees, participation in biocontainment groups and as reviewers of book chapters. In anticipation of gaining ACDP level 4 biocontainment facilities as part of the Weybridge site redevelopment we have increased specialist expertise in large animal biocontainment at ACDP level 4, and associated biocontainment animal transportation, tracking and disposal via international collaboration. We also contributed to research on the compliance with the ARRIVE (Animal Research: Reporting of In Vivo Experiments) guidelines, which was published in 2019

- APHA is joint Animal Welfare and Ethical Review Body (AWERB) Hub chair with TPI. The hub has been recognised a leading hub nationally
- A member of APHA Named Veterinary staff is on the Laboratory Animal Veterinary Associated (LAVA) Council membership and through this, membership of AWERB UK.
- Our Science Director and establishment licence (PEL) holder has become a committee member of the PEL Holders' Forum.
- A member of the APHA Named Veterinary staff is member of the Animal Welfare Research Network, which includes veterinarians and scientists involved in animal welfare from various institutions and universities in the UK and other countries. Membership has been instrumental in exploring collaborations with other institutes and sharing expertise and knowledge. Animal welfare assessments of pigs, cattle, sheep and goats in collaboration with the University of Bristol concluded this year and analysis is in progress.

Our Animal Sciences lead vet is the task leader on best practice for Ethics Committee and work-package leader for co-ordination of best practice (biosafety) under the VetBioNet project. VetBioNet is an EU Horizon 2020 project involving the coordination of all the farm animal high disease biocontainment facilities in Europe. One of the activities under this project is that APHA undertakes transnational accesses for researchers outside the UK. In 2019 testing genetically



modified vaccine candidates against Nipah Virus was undertaken for University of Palma and in 2020 an experiment to compare African Swine Fever in wild boar and pigs is scheduled for the Swedish National Veterinary Institute (SVA).

For APHA to achieve its mission to “safeguard animal and plant health for the benefit of people, the environment and the economy” it is necessary to do scientific research into diseases that affect this.

As well as using in-vitro and material collected as part of its surveillance function, it also undertakes research involving the use of animals. To do this, APHA complies with the [Animals \(Scientific Procedures\) Act 1986](#). It also has a code of practice, working procedures and training programmes to define and enforce the high standards the agency must have for this type of work.

APHA has its own Ethics Committee which must review and approve all experiments involving the use of animals for a scientific purpose before they begin. The committee members include vets, animal care staff, a biostatistician, scientists and non-scientists from across the agency. There are also external lay members of the committee, recruited from the local community, who bring an independent view to the proceedings.

### 3.7 Virology

The skills of our workforce within the virology discipline have been expanded in numerous areas, but particularly addressing core resilience underpinning outbreak and emergency response by ensuring staff across the discipline have an underpinning competence that means they can be deployed and respond to emerging threats. Staff from other departments with appropriately maintained competencies can also be drafted in (SLSD and Pathology). APHA have continued to flex our test portfolio to address improvements in diagnostics including addressing emerging threats, ensuring our ability to respond to UK disease incursion, but also to include the expansion of existing capabilities to support UK trade. Capability and capacity updates for 2019, highly successful third party audits which raised a minimal number of findings resulting in the recommendation that Virology retains both its ISO17025 accreditation and ISO9001 certification. Successful addition of sheep semen to the Schmallenberg RT-PCR ISO17025 accreditation by flexible scope (previously Schmallenberg RT-PCR only accredited for Bovine semen). Further expansion to our accredited testing portfolio; WNV ELISA's, N5, N6, N7, N8 and N9 AI real time PCR's added to scope. Successful implementation of the MXAria PCR analysis platforms for Notifiable Avian Disease, CSF/ ASF multiplex PCR and Schmallenberg analysis by PCR. Additionally, a series of endemic pathogen tests have been made ready for BREXIT / third country trade requirements: Equine Encephalitides, Duck Viral Hepatitis and Enteritis, Goose Parvovirus and Aujeszky's.

We have continued to develop and maintain our international programme and have been successful in attracting money from the National Institute for Health, the Defence Threat Reduction Agency and Clinical Research Disease Fellowships; all from the Americas. This has supported the expansion of our global programme particularly in the area of influenza, which is strategically being developed in order to proactively compensate for the loss of EU reference laboratories for AI and ND (transition handover completed December 2018). However, we have continued to proactively engage with the European science community across our broad portfolio in order to secure strong scientific partnership in the years ahead. Explicitly we have



worked on a follow on project (EVA-Global, successful commencing 2020) to continue cooperation on the successful completed European Virus Archive Global (EVAg) project that APHA play a key role in. The COMPARE project has also completed and some elements continue in VEO now up and running. New proposals are in preparation; SFS-10-2020: Epidemiology of non-regulated contagious animal diseases and International Coordination of Research on Infectious Animal Diseases ICRAD-ERAnet.

Staff turnover has remained moderately high (around 15 per cent per annum) and we have mitigated staff losses by flexing key expertise in critical areas. Virology have been moderately successful in filling vacancies, after quarters 1 and 2 (calendar) this has been more challenging in 2019, current active vacancies (December 19) sit at 10/90 FTEs. Rapid cross-cutting training programmes continue to be implemented including BREXIT contingency staff, although these challenges continue to threaten sustainable delivery of core and impact on discipline succession planning. Despite resource pressure constraints the discipline (SEV/Virology) has continued to produce a high output of scientific publications (83 publications between January and December 2019), some of them through international partnership and with high impact. Continuing professional development of our staff in the department and the discipline has been strongly maintained and we have been proactive in securing committee and international positions. Representation and visibility at key National and International (240 person days) conferences, project meetings and delivering training. Examples: Options X Influenza International Symposium, EPIZONE (including Young Epizone and Scientific Committee), Rabies in the Americas, European Others Viral Zoonoses, International Meeting on Arboviruses and their Vectors. High profile 'One Health' events – OIE/EJP Paris and at Defra.

The Virology Department has continued our collaborations with several UK universities, which includes the provision of training opportunities for undergraduate and postgraduate students. These training opportunities include BSc/MSc sandwich/placements (3) as well as a PhD training that is also open to staff (10 on going). The department of Virology has representation on the APHA Academic Board.

The Virology Department has continued to provide scientific leverage through a relatively new programme of research work on African swine fever the discipline has responded to changing global events. To develop our capability further in the area of vector borne disease APHA have proactively tracked and monitored significant developments in Europe and maintained a close dialogue with policy customers.

The portfolio has seen a substantial increase in social media visibility via formal and informal routes (Twitter, Facebook, LinkedIn) topics have included; EHV, HEV, One Health, APHA-EPIZONE, resulting in an increase in portfolio and discipline awareness.

APHA have continued to maintain a strong multidisciplinary programme across science, particularly involving epidemiology, risk and pathology and also have been working closely with the molecular biology discipline champion to support strategic growth in the use of bioinformatics underpinning our science; Defra, UKRI, H2020 integrated approaches and evolution of technologies and their implementation, critical future investment is required for the 'Big Data' elements of this field of investigation. A notable achievement working both across Science and Operations Directorates with the support of industry, was the development of protocols to achieve effective cleansing and disinfection following disease outbreaks in poultry premises. Procedures based on science evidence have now been practically developed and will be applied operationally in the field when required.

## 4. APHA Scientific

APHA provides most of its wider markets commercial work under the brand [APHA Scientific](#). The

Agency framework document permits exploitation of core capabilities and facilities in wider markets (including international) to help achieve its strategic aims and to maximise the efficiency and effectiveness of its activities for UK governments.

### Main Areas of Work and Approximate Annual Income

#### Laboratory services

This provides testing services to a range of customers:

- International trade export testing in support of export certification. £1.4m (static). This is a non-statutory monopoly service and is provided at cost.
- Disease surveillance testing. £1.5m (static). This is a discretionary service carried out as part of APHA's scanning surveillance for new and re-emerging animal diseases. The provision of a diagnostic service facilitates engagement with private vets and information on the diseases they are seeing on a day to day basis. Most individual tests are charged at around the full economic cost (FEC).
- 'True' commercial testing for non-UK governments, private industry and academia in the UK, and international customers. £1.7m (increasing due to growth of income from DNA sequencing work).

#### Vaccine development and testing

A range of research and development, extraneous agent testing and other services are provided.

#### Reagent sales

APHA produces biological reagents for its own use and is also able to sell these to an international customer base. Many are unique and are used for international trade testing by the customer laboratories. A growing network of international distributors facilitates 50% of these sales. During the last year we have appointed 5 new distributors to cover territory in Asia, South America and Eastern Europe. The reagents catalogue is being refreshed with new offerings including expecting to boost sales including Mareks and glanders reagents.

#### Proficiency Testing

This is a service to provide assurance to veterinary laboratories that their test results are accurate by sending them blind panels of samples for testing.

The commercial service grew out of the need to provide proficiency testing for APHA labs but has expanded so fast (10% per annum) that now approximately 90% of the work is commercial and 10% is for internal customers. The work is done under the brand [VETQAS](#) and around 850

laboratories from 65 countries participate. VETQAS is the world leader in veterinary proficiency testing. Some schemes are provided in collaboration with TPI and Cefas. The development of proficiency testing schemes for WGS based tests is underway with colleagues across the EU and part funded by the European Joint Program.

## **Intellectual Property (IP) exploitation**

This involves licencing IP developed by APHA (often with partners) to international diagnostic and pharmaceutical companies. This is mostly in the veterinary field but also for human medicine where appropriate. The activity ensures that important scientific discoveries have impact in the real world. APHA has eight current granted or applied-for patents and 33 active licences, although several of these are not yet earning royalty income. Most activity is in diagnostics, TB and Brucella. We are currently in discussion with a multinational technology company for the sale of the Amplite platform. Amplite is a lateral flow molecular diagnostics device designed for the pen-side detection of veterinary disease.

## **5. Quality**

### **ISO 17025 Quality System**

#### **UKAS assessment visits**

UKAS audits against ISO17025 have been completed as follows:

Department of Bacteriology 12th June 2019, Starcross 16<sup>th</sup> July 2019, Shrewsbury 23<sup>rd</sup> July 2019, Newcastle 6<sup>th</sup> August 2019, Laboratory Services Weybridge 3<sup>rd</sup> September 2019, Central Sequencing Unit (CSU) 5<sup>th</sup> September 2019, Pathology 2<sup>nd</sup> September 2019 and Carmarthen 9<sup>th</sup> October 2019.

The feedback from the UKAS assessors was again that there is a clear commitment to deliver a very high level of service supported by a well embedded management system. The assessments confirmed the quality system is well established and continues to be maintained to a very high standard. No significant actions raised at any of the visits and all the minor non-conformances cleared within the agreed timescale

#### **Group Audits**

All group audits for 2019 are now complete. The following group sites were included:

- 9 January: Thirsk
- 6 March: Quality Services
- 4 April: Bury

- 14 May: Lasswade

The audit schedule is now produced using a risk based approach, resulting in a more selective Group audit plan with a reduction in the audit burden across the laboratories.

## **Transition to the new ISO 17025:2017 Standard**

The 2017 version of ISO 17025 Standard has been published by ISO and APHA is in the process of moving over to the new Standard. This has involved a very intensive assessment by Quality Services staff of the impact of the new Standard and the establishment of systems of work to ensure there are no gaps in our compliance with it. APHA's compliance with the new Standard was assessed by UKAS in parallel with the surveillance visit and specific non-conformances raised relating to compliance issues highlighted. In total, nine issues were raised in terms of compliance and these have been addressed. New quality system documentation has been produced covering Test Management (AP056) and Uncertainty of Measurement and these have now been issued. The way test results are reported to customers has also needed to be updated and revised to ensure all aspects of the new Standard are covered. It is expected that APHA will transition over to the new Standard on the 31<sup>st</sup> January 2020.

## **ISO 9001 Quality System - LRQA surveillance visits**

The ISO 9001 compliance covering the research activities of APHA was set up to underpin our compliance with the Defra/FSA Joint Code of Practice for Research and continues to have this critical assurance role for the scientific research work being carried out.

## 6. Health and Safety

### Health and Safety Executive Inspections

APHA and the Health and Safety Executive (HSE) met in July 2019 to review inspection and performance scores over the past 12 months.

No reportable incidences have occurred.

HSE considers APHA strengths as:

- Increased evidence of effective engagement with Defra and Facilities Management (FM) provider at all levels
- Evidence of team works – Safety Health and Wellbeing (SHaW), Scientists, FM and Defra
- Available expertise and resources – science, safety, engineering
- Investment and commitment in raising standards – Human Factors, Risk Assessment, Alarm Management, Risk Registers, Training
- Evidence of raising maintenance standards – testing engineering controls, documentation, communications
- Leadership commitment and engagement
- Engagement with HSE and wider sector

HSE perspective on current/future challenges for APHA are as follows:

- Balancing investment on existing ageing facilities and new build plans
- Managing multiple work streams, projects and priorities e.g. balancing biosafety risks with other risks/priorities
- Building resilience e.g. biocontainment engineering expertise, outbreak response, change in research trends

HSE will be introducing intervention planning approach for Profiling Targeting Strategy for CL4 operators in subsequent years.

### Accidents and Incidents

No biological reportable incidents have been reported to HSE and no serious incidents, exposure or loss of containment have occurred.

### Leadership

APHA are among founding members of the Biological Sector Strategic Leadership Group, which aims to promote good practice and co-operation in this sector.

## Other Matters

SHaW have been proactive in completing the planned assurance and audit programme and producing lessons learnt.

Biosafety courses including high containment courses have been planned and delivered for the year.

## 7. Learning and Development

APHA offers an extensive learning and development programme ranging from specialist training to meet legislative and accreditation requirements through to technical and specialist training to upskill our scientists generally. In 2019 we held six different scientific bespoke closed courses plus eleven different quality courses and five different Home Office courses. In addition we sent individuals on various other courses such as driver and trailer towing, sheep shearing, wild boar training, carriage of goods by air various epidemiological data analysis courses as well as on and off-site health and safety training including The Institution of Occupational Safety and Health (IOSH) and wellbeing courses.

We have continued with our apprenticeship programme – offering level 3 laboratory technician apprenticeships with Brooklands College, Weybridge as well as level 3 and 5 Leadership, level 6 Data Scientist and level 2 Animal Technician with The Institute of Animal Technicians (IAT). We continue to investigate other appropriate apprenticeships such as level 7 Research Scientist apprenticeship.

We also held twelve leadership and management courses including strategic writing, success profiles and conducting high quality conversations.

Currently, twenty-three staff from APHA or studentships linked with APHA are undertaking PhDs, nineteen had already registered before 2019 and four new PhDs were registered in 2019. In addition, twenty staff are undertaking MScs including four registered in 2019.



**Table: A summary of qualifications (Science Directorate) achieved in 2019**

<b>Name</b>	<b>Qualification</b>	<b>Awarding Body</b>
Andrea Buckle	BTEC National Diploma in Applied Science	BTEC- Pearson
Claire McKenna	BTEC National Diploma in Applied Science	BTEC- Pearson
Daniel Earl	BTEC National Diploma in Applied Science	BTEC- Pearson
Jasmine Dorsett	BTEC National Diploma in Applied Science	BTEC- Pearson
Mark Travers-Tauss	BTEC National Diploma in Applied Science	BTEC- Pearson
Jasmine Dorsett	Level 3 - Laboratory Technician Apprenticeship	SIAS
Mark Travers-Tauss	Level 3 - Laboratory Technician Apprenticeship	SIAS
Amanda Gage	Agile Project Management Foundation	Civil Service Learning
Anna La Rocca	Agile Project Management Foundation	Civil Service Learning
Ayesha Fowler	Agile Project Management Foundation	Civil Service Learning
Becky Bateman	Agile Project Management Foundation	Civil Service Learning
Christopher Finnegan	Agile Project Management Foundation	Civil Service Learning
Hannah Marriott	Agile Project Management Foundation	Civil Service Learning
Kimberley Homer-Theodore	Agile Project Management Foundation	Civil Service Learning
Robert Dewar	Agile Project Management Foundation	Civil Service Learning
Sally Everest	Agile Project Management Foundation	Civil Service Learning
Vidhya Narayanan	Agile Project Management Foundation	Civil Service Learning
Zoe Pembery	Agile Project Management Foundation	Civil Service Learning
Alexia Fish	Prince2 Practitioner	Civil Service Learning
Hannah Marriott	Prince2 Practitioner	Civil Service Learning
Lucia Biffar	Prince2 Practitioner	Civil Service Learning
Dipesh Dave	Level 3 in Leadership & Management apprenticeship	Institute for Apprenticeships & Technical Education
Gareth Williams	Level 3 in Leadership & Management apprenticeship	Institute for Apprenticeships & Technical Education
Jean-Pierre Frossard	Level 3 in Leadership & Management apprenticeship	Institute for Apprenticeships & Technical Education
Dipesh Dave	CMI Level 3 in First Line Management apprenticeship	Chartered management Institute
Gareth Williams	CMI Level 3 in First Line Management apprenticeship	Chartered management Institute
Jean-Pierre Frossard	CMI Level 3 in First Line Management apprenticeship	Chartered management Institute
Olaf Booy	PhD	Newcastle University

<b>Name</b>	<b>Qualification</b>	<b>Awarding Body</b>
Rachel Poynter	MSc in Molecular Biology	Staffordshire University
Daisy Jennings	MSc in Genomic Medicine	Imperial College London
Meenakshi Khatri	MSc in Veterinary Microbiology	University of Surrey
Nicola Fletcher	FRC Path Part 1	Royal College of Veterinary Pathologists
Sian Mitchell	Diplomate status of the European college of small ruminant health and production	ECSRHM
Therese Carson	CMI level 3 Diploma in First Line Management	QA Ltd. (CSL)
Rachael Collins	MSc in Veterinary Microbiology	University of Surrey
Nicola Fletcher	FRC Path Part 1	Royal College of Veterinary Pathologists
Janice Dent	IAT Level 2 Diploma in Laboratory Animal Science and Technology	Institute of Animal Technology
Lee Gofford	IAT Level 2 Diploma in Laboratory Animal Science and Technology	Institute of Animal Technology
Davina Sharp	IAT Level 2 Diploma in Laboratory Animal Science and Technology	Institute of Animal Technology
Caroline Warren	CPD scheme required for CSI	Royal Society of Biology
Sharon Brookes	FRSB - fellowship	Royal Society of Biology
Felicity Wynne	PhD (wildlife Diseases & Species Conversation)	University of Plymouth
Aga Wojciechowska	BSc (Hons) Criminology and Psychological Studies	Open University
Rowena Hill	BSc- BioVeterinary Science	Hull University
Deanna Dalley	NEBOSH National General Certificate in Occupational Health & Safety	CSL

## 8. Publications and Representation

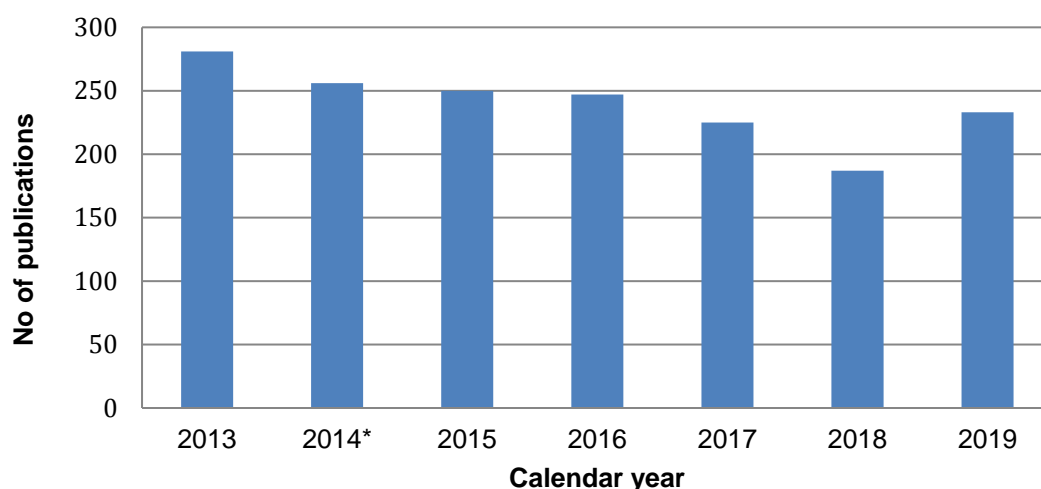
### Publications

Publishing in scientific journals is a key objective for APHA scientists and is almost always an important objective in any research project we work on. Whilst we aim to publish in top scientific journals wherever possible we are also mindful that APHA's science is predominantly applied, translational and customer focused. This means that some of our work will be published in trade journals or as information booklets etc. – essentially somewhere that is accessible to our wide range of stakeholders.

In terms of peer reviewed publications, we have maintained a strong publication rate during 2019 with the publication of 233 papers across all our science portfolios. This number is a 25% increase from 2018. Of the 233 we were lead author on 45%. A full list of publications is [published on GOV.UK](#).

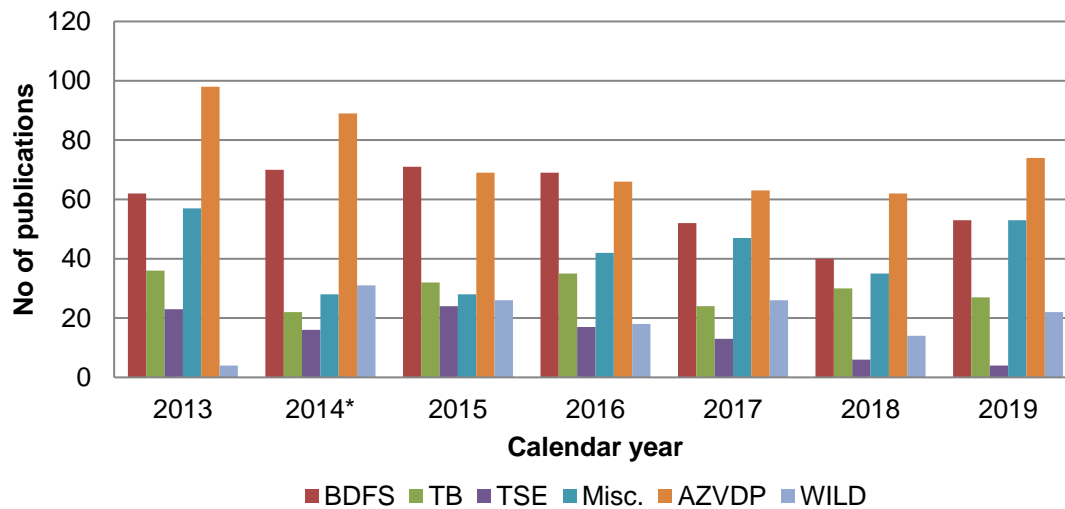
Breakdown by science portfolio	
Animal and Zoonotic Viral Diseases (AZVDP)	74
Bacterial diseases and food safety (BDFS)	53
Bovine tuberculosis (TB)	27
Miscellaneous	53
Transmissible spongiform encephalopathy (TSE)	4
Wildlife	22

#### AHVLA/APHA peer-reviewed publications: 2013-2019



\* Includes Wildlife from 2014 onward

## AHVLA/APHA peer-reviewed publications (by portfolio): 2013-2019



\* Includes Wildlife from 2014 onward

## Representation

We continue to develop our representation on appropriate national committees (235 representatives on 147 committees) and international committees (137 representatives on 125 committees) demonstrating the strong scientific reputation of APHA and our scientists. Appropriate representation and influence at international level is increasingly important particularly in the face of EU exit.