Avian influenza in wild birds in Australia

Fact Sheet

February 2025

Key points

- Avian influenza (AI), also known as bird flu, is an infectious disease of birds caused by strains of Influenza A virus.
- Avian influenza virus (AIV) strains are classified as 'low pathogenicity' (LPAI) and 'high pathogenicity' (HPAI) based on their clinical effect on poultry.
- Outbreaks of HPAI in Australia have affected poultry but not wild birds.
- Since 2021, a new strain of HPAI (known as HPAI H5 clade 2.3.4.4b or H5 bird flu) has resulted in severe and widespread HPAI outbreaks in poultry, wild birds, farmed mammals and wild mammals globally. This strain has **not** yet reached Oceania (Australia and New Zealand).
- LPAI viruses are considered part of the natural viral community in wild birds in Australia.
- Infection with Influenza A viruses in birds is a **nationally notifiable disease** (see *Surveillance and management*); you must notify animal health authorities if you suspect a bird is infected with an Influenza A virus.

Aetiology

Influenza A viruses are RNA viruses belonging to the family *Orthomyxoviridae*. Influenza A viruses are classified according to the serological subtypes of their surface glycoproteins, haemagglutinin (HA) and neuraminidase (NA) [1]. To date, 17 HA and 9 NA subtypes are recognised in birds and are found in different combinations [2].

Influenza A viruses are further designated as high pathogenicity avian influenza (HPAI) or low pathogenicity avian influenza (LPAI), based on their ability to cause disease in poultry. Avian influenza virus (AIV) subtypes H5 and H7 have the capacity to mutate from LPAI into HPAI forms when they are introduced to and subsequently mutate in poultry [3, 4].

Avian influenza viruses constantly evolve, resulting in the ongoing emergence of new lineages and strains that are classified based on sequence analysis and distribution of the viruses in hosts, geographic locations and time. The dominant strain currently circulating globally is HPAI H5 clade 2.3.4.4b, with more than one NA subtype identified.

One Health implications

Wildlife and the environment: HPAI H5 clade 2.3.4.4b (commonly referred to as H5 bird flu) can cause mass mortalities in many species of wild birds, as well as other terrestrial and marine mammal

species, and may represent a population level threat to some wildlife hosts, impacting biodiversity. Other strains of HPAI are less likely to cause disease in wild birds and mammals.

Low pathogenicity AI strains are unlikely to cause disease in wild birds or other wildlife species but are important due to the potential of LPAI H5 and H7 subtypes to mutate into HPAI forms when introduced to poultry.

Domestic animals: a range of domestic species are susceptible to AIVs including poultry, swine, horses, cattle, dogs and cats. To reduce the risk of AIV infection, domestic animals should not be allowed to have direct or indirect contact with wild birds.

Humans: AIVs do not normally infect humans, however some subtypes (of both low and high pathogenicity strains) have been associated with disease in humans, ranging from mild illness to severe respiratory disease and death, with over 460 reported human deaths worldwide due to HPAI H5 (at 16 Feb 2024) [5].

Some humans have become infected with LPAI. Most illness and deaths associated with AIV in humans occur after **close contact with infected poultry** or with objects contaminated by their faeces. Deaths have also been attributed to close contact with infected wild swans [6]. A summary of confirmed H5N1 human cases can be accessed at www.who.int/teams/global-influenza-programme/avian-influenza. See also 'Avian influenza in humans CDNA National guidelines for public health units' www.health.gov.au/resources/publications/avian-influenza-in-humans-cdna-national-guidelines-for-public-health-units.

Natural and other hosts

Anseriformes (waterfowl: ducks, swans, geese) and Charadriiformes (gulls, terns and shorebirds) are considered the main natural reservoirs for all avian influenza A viruses [7]. There is a need for more detailed understanding of the natural history of AIVs, including wild reservoirs and host species worldwide. Studies indicate that host species and population ecology are important in AIV maintenance, transmission, and possibly, long-distance movement [8].

Influenza A viruses (including the current circulating strains of HPAI H5) can infect a variety of animals, including wild and domestic birds and mammals. The FAO website (www.fao.org/animal-health/situation-updates/global-aiv-with-zoonotic-potential/en) reports species affected in recent HPAI H5 outbreaks [9]. A referenced list of species in which H5N1 has been reported (to 2010) can be accessed via the USGS website www.usgs.gov/media/files/list-species-affected-h5n1-avian-influenza [10].

While previous outbreaks of HPAI overseas have resulted in deaths and mass mortality events in numerous avian species, the **recent global circulation of HPAI H5 clade 2.3.4.4b poses unprecedented risks to wildlife.**

In birds, HPAI H5 infection and associated illness or death has been reported in most major bird orders, with over 300 species newly affected since 2021. HPAI H5 infection, illness and (in some cases) death have been reported in humans and over 80 mammal species (see the https://www.fao.org/animal-health/situation-updates/global-aiv-with-zoonotic-potential/bird-species-affected-by-h5nx-hpai/en). Affected mammals are mostly species that predate or scavenge

on infected birds (e.g. foxes, bears) or live in close proximity to infected birds (e.g. marine mammals) [1, 9, 11, 12].

Mass mortality events in wildlife due to HPAI H5 clade 2.3.4.4b have occurred worldwide [13-15]. Examples include:

- 2020, Germany: 3000 red knots
- 2021-22, Israel: 8000 Eurasian cranes
- 2022, Peru: over 100,000 wild birds
- 2022, Chile: over 4,000 sea lions.

For more information on the current global outbreak of HPAI H5, see the WHA HPAI technical update (https://wildlifehealthaustralia.com.au/Portals/0/Incidents/HPAI_Technical_Update.pdf) and other resources on the WHA Incident Information page (https://wildlifehealthaustralia.com.au/Incidents/Incident-Information/high-pathogenicity-avian-influenza-information).

World distribution

Avian influenza viruses have a global distribution and have been isolated from all continents, including Antarctica [2, 10, 16-19]. The current global outbreak of HPAI H5 has spread through Asia, Africa, Europe, North and South America and into the Antarctic mainland and islands. Only Oceania (which includes Australia and New Zealand) remains unaffected.

Since 2020, there has been an increase in frequency and geographic spread of HPAI outbreaks in poultry and wild birds associated with HPAI H5 clade 2.3.4.4b strains. For a global map of AI viruses with zoonotic potential, see www.fao.org/animal-health/situation-updates/global-aiv-with-zoonotic-potential/en.

Occurrences in Australia

High pathogenicity AI H5 viruses (including H5 clade 2.3.4.4b strains) have not been detected in animals in Australia.

In Australian poultry enterprises, 12 outbreaks of HPAI H7 strains have occurred between 1976 and 2025 [20-26]. HPAI has never been detected in free-ranging Australian wild birds. However, during a 1985 HPAI outbreak, HPAI H7 was detected in a feral Eurasian starling (*Sterna vulgaris*) trapped inside an affected poultry shed [27-30] .

Low pathogenicity AIVs have been detected in wild birds in Australia, however mortality due to AIVs has not been reported in wild birds (either native or feral) in Australia [28, 31, 32].

Almost all LPAI subtypes (H1-16, excluding H14 and H19) have been detected in Australian wild birds. LPAI viruses have been identified in Australian Gruiformes, Pelecaniformes, Procellariiformes, Anseriformes and Charadriiformes [27, 33-39].

With the emergence of the HPAI H5 clade 2.3.4.4b strain, the likelihood of introduction to Australia via wild bird movements has increased compared to previous years [40-42].

Epidemiology

The incubation period for AIV varies with bird species, virus subtype and virulence [43]. High pathogenicity AIV incubation in wild birds can range from a few hours to 7 days.

In wild ducks, viral replication occurs primarily in the gastrointestinal tract with high loads of virus being shed in faeces [44]. Faecal-oral transmission is thought to be the main means of AIV spread in wild bird populations. Recent isolates of HPAI H5 have also been found in tracheal samples, suggesting the method of transmission may be species dependent, and airborne transmission may be important in some species, when in close contact [43].

The duration of virus shedding appears to vary with host species. Virus can be shed in poultry and wild bird faeces for 30 days or longer [45]. Virus survival outside the host is affected by environmental conditions. Avian influenza viruses can persist for extended periods in water and faeces, depending on ambient temperatures, pH and salinity [43].

The epidemiology of AIVs is likely to be different in Australia compared to other regions of the world. Much of the current understanding of AIV ecology, molecular phylogenetics and spread is derived from studies in Asia, Europe or North America and may not be relevant to the Australian situation [27, 46]. Recent studies support the hypothesis that within the Australian context, the drivers for emergence of AIV are likely to be different to those in the northern hemisphere. Both long- and medium-term rainfall patterns, as well as variation in population size within wild duck species, have been linked to AIV prevalence in wild duck species in south-east Australia. In the Australian context, rainfall events strongly influence breeding opportunities in wild duck species, which can in turn determine age-structures and percentage of immunologically naïve individuals within the flock [47]. Furthermore, Anseriformes species found in Australia are not migratory (they do not travel to the northern hemisphere), although they are nomadic within the Australo-Papuan region [48, 49].

Although shorebirds are exposed to HPAI viruses along the migratory route between Asia and Australia, there is no evidence that migratory birds have carried infectious HPAI H5 clade 2.3.4.4 into Australia in samples collected up to and including the 2022 migratory season [31, 32, 50-52]. National AIV wild bird surveillance data (see *Surveillance and management* below) indicates that migratory shorebirds do not commonly carry AIVs into Australia from other regions of the world [39, 53] and analysis of AIVs present in Australia demonstrates limited evidence of viral introductions to date [50, 54-56].

Clinical signs

Wild birds infected with LPAI viruses usually show no clinical signs. However, reduced foraging and altered migration have been reported in infected swans in one overseas study [57].

High pathogenicity AI viruses, including HPAI H5 virus strains, can result in up to 100% mortality in chickens [58]. High pathogenicity AI H5 strains (including clade 2.3.4.4b) have caused significant mortality events in a variety of wild bird species and wild mammal species overseas (see *Natural and other hosts*) [9, 10, 59].

Infected **wild birds** may have neurological signs (ataxia, paralysis, seizures, tremors, abnormal posture), respiratory signs (conjunctivitis, increased nasal secretions, oedema of the head,

dyspnoea), gastrointestinal signs (diarrhoea) or sudden death without prior signs [2], similar to the signs seen in infected poultry. **Wild mammals** may show neurological or respiratory signs (as above) or die suddenly without signs.

Diagnosis

A diagnosis of AIV infection must be confirmed by PCR and/or virus isolation. In Australia, samples are tested for influenza A using PCR. All Influenza A positive samples are then tested using a specific PCR for influenza A subtypes H5 and H7. Positive H5 and H7 samples are sent to the CSIRO Australian Centre for Disease Preparedness, Geelong, for viral culture and sequencing to determine pathogenicity. Serum can be tested for antibodies to the influenza A virus using ELISA. This test has been shown to be valid in a number of Australian wild bird species [60, 61].

Laboratory diagnostic specimens and procedures

Both live and dead birds (or other species) may be sampled. Swabs (cloacal, oropharyngeal) and environmental (faecal) samples are collected for viral testing and serum is collected to test for evidence of exposure to AIVs. Collection procedures are in accordance with the 'Sick and Dead Bird Health Surveillance: sample collection protocol' [62]. In dead birds, samples should include alimentary tract tissues (proventriculus, pancreas, intestine, caecal tonsils), respiratory tract tissues (trachea, lung) and brain. Samples from live birds should include oropharyngeal and cloacal swabs and/or fresh faeces, and serum for antibody studies [45].

Clinical pathology and pathology

There is little reported information on clinical pathology of wild birds infected with AIVs. Changes in domestic ducks included anaemia, reduced plasma protein and increase in a range of biochemical parameters in serum [63].

There are no pathognomonic lesions for avian influenza in birds [2]. Severity and distribution of lesions are dependent on the pathogenicity of the virus and host factors (e.g. species, age, immunity). In LPAI virus infections, there may be no pathological changes, or mild to moderate respiratory lesions may be present. Similarly, in HPAI infections, findings can range from no visible pathology to severe multi-organ involvement with necrosis, inflammation and haemorrhage [2].

Differential diagnoses

Differential diagnoses may include any cause of sudden death or acute onset of illness (e.g. acute poisoning, botulism, chlamydiosis, avian paramyxovirus, *E. coli* infection, heat stress) [45].

Treatment, prevention and control

Treatment of HPAI is not feasible in free-ranging wild birds. Prevention and control measures based on **risk mitigation** are therefore the mainstay of HPAI management for free-ranging wild birds.

In captive wild birds, treatment of HPAI H5 clade 2.3.4.4b infection with off-label antiviral medications has recently been attempted in a small number of species in zoological collections in

the USA. Early anecdotal evidence suggests that rapid intervention and daily oral medication is required for treatment to be effective.

Although prevention and control of AIV in wild birds (and mammals) may be challenging, various steps have been recommended, including:

- Practicing good baseline biosecurity in all situations involving wild animals (see *National Wildlife Biosecurity Guidelines* https://wildlifehealthaustralia.com.au/Portals/0/ResourceCentre/BiosecurityMgmt/National_Wildlife_Biosecurity_Guidelines.pdf)
- Good surveillance and data collection including reporting and investigation of all unusual sickness and deaths in domestic and wild birds, and wild mammals (see also WHA "*HPAI advice for veterinarians and wildlife health professionals*" https://wildlifehealthaustralia.com.au/Portals/0/Incidents/HPAI_Advice_for_veterinarians_and_animal_health_professionals.pdf).
- Practicing intensified surveillance and biosecurity measures in high-risk situations [14].
- Removal of wild animal carcasses during an outbreak may reduce environmental sources of the virus but also introduces new risks and challenges such as animal disturbance, contributing to disease spread and exposure of humans to infection [64] The advice from joint CMS and FAO's Scientific Task Force on Avian Influenza and Wild Birds is that decisions around the removal of carcasses should be determined based on a risk assessment [14].

See the **WHA risk mitigation toolboxes** (https://wildlifehealthaustralia.com.au/Incidents/Incident-Information/wha-hpai-risk-mitigation-toolboxes) for more information.

The practices of **culling, containing or dispersing** wild animals and the destruction or modification of habitat (e.g. use of disinfectants) have been deemed as ineffective measures for AIV control by global advisory organisations [45, 65] and should be strongly discouraged.

Vaccination of valuable captive birds (e.g. in zoos and breeding centers) and threatened species of wild birds may be considered in the event of a HPAI outbreak in Australia, and has been included in national AUSVETPLAN guidance documents [66]. See https://animalhealthaustralia.com.au/ausvetplan.

Supporting the general resilience of wild bird populations (e.g. through habitat conservation, predator control and managing human interactions) is an important strategy for promoting overall health and the ability of populations to recover more rapidly from the impacts of newly emerging strains of HPAI.

Prevention of infection in farmed birds relies on appropriate biosecurity. See AUSVETPLAN and National Farm Biosecurity Manual for Poultry Production https://www.agriculture.gov.au/sites/default/files/sitecollectiondocuments/animal-plant/pests-diseases/biosecurity/poultry-bio-manual/poultry-biosecurity-manual.pdf.

Research

There are a broad range of endemic AIV subtypes in wild birds in Australia. Key research recommendations for the Australian situation include:

- More detailed understanding of the natural history of AIVs, including wild reservoirs and host species across the globe
- Exploring environmental and species-specific variables in virus susceptibility
- Exploring spatial and temporal trends, and climatic and rainfall zone
- Further analysis of AIV phylogeny and gene flow of subtypes, ecology and epidemiology
- Further analysis of the pathogenicity, for poultry, of AIV subtypes found in wild birds, in particular the ability of LPAI H5 and H7 subtypes to mutate to HPAI.
- Further analysis of the susceptibility, pathogenicity and transmission dynamics of LPAI and HPAI viruses in Australian wild bird species.

WHA analysis supports continued use of faecal environmental samples for wild bird surveillance due to the relative low cost and logistical ease of collecting these compared to other samples [27].

Surveillance and management

The National Avian Influenza Wild Bird Surveillance Program coordinates information to inform the national picture on AIV. The Program includes surveillance for AIV via sampling of healthy, live and hunter-shot wild birds; and investigation of significant, unexplained morbidity and mortality events in wild birds [27]. During the 18 years of the Program, thousands of Australian wild bird samples have been screened, with no HPAI viruses detected [32].

Further information can be found on the WHA website: https://wildlifehealthaustralia.com.au/Our-Work/Surveillance/Wild-Bird-Surveillance.

Passive surveillance in wild bird mortality events excluded AI as the cause of death in over 2,500 wild bird mortality events since 2005 [67] [eWHIS data, contact admin@wildlifehealthaustralia.com.au].

AI outbreaks in Australia (including wild birds) are managed under the 'Disease Strategy: Avian influenza (version 5.2), AUSVETPLAN 2023' [45]. Infection with Influenza A viruses in birds is a **nationally notifiable disease** (see www.agriculture.gov.au/biosecurity-trade/pests-diseases-weeds/animal/notifiable). By law you **must** notify animal health authorities in your jurisdiction if you know or suspect that an animal has a notifiable pest or disease. Refer to advice in your jurisdiction (https://www.agriculture.gov.au/biosecurity-trade/pests-diseases-weeds/animal/state-notifiable) and outbreak.gov.au on how to report.

Wildlife Health Australia administers Australia's general wildlife health surveillance system, in partnership with government and non-government agencies. Wildlife health data is collected into a national database, the electronic Wildlife Health Information System (eWHIS). Information is reported by a variety of sources including government agencies, zoo-based wildlife hospitals, sentinel veterinary clinics, universities, wildlife rehabilitators, and a range of other organisations and individuals. Targeted surveillance data is also collected by WHA. See the WHA website for more information https://wildlifehealthaustralia.com.au/Our-Work/Surveillance and https://wildlifehealthaustralia.com.au/Our-Work/Surveillance/eWHIS-Wildlife-Health-Information-System.

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References

1. Webster RG, Bean WJ et al. (1992) Evolution and ecology of influenza A viruses. *Microbiological Reviews*, **56**(1): 152-179
2. Stallknecht D, Nagy E et al. (2007) Avian influenza. In 'Infectious diseases of wild birds.' (Eds N.J. Thomas, D.B. Hunter and C.T. Atkinson) pp. 108–130. (Blackwell: Ames, Iowa)
3. Alexander DJ (2007) An overview of the epidemiology of avian influenza. *Vaccine*, **25**(30): 5637-5644
4. Feare CJ (2007) The role of wild birds in the spread of HPAI H5N1. *Avian diseases*, **51**(s1): 440-447
5. WHO (2024) Cumulative number of confirmed human cases of avian influenza A/(H5N1) reported to WHO. 16 Feb 2024 [cited 2024 14 March]; Available from: https://www.who.int/teams/global-influenza-programme/avian-influenza
6. Gilsdorf A, Boxall N et al. (2006) Two clusters of human infection with influenza A/H5N1 virus in the Republic of Azerbaijan, February–March 2006. *Eurosurveillance*, **11**(5): 3-4
7. Olsen B, Munster VJ et al. (2006) Global patterns of influenza A virus in wild birds. *Science*, **312**(5772): 384-388
8. Stallknecht D and Brown JD (2007) Wild birds and the epidemiology of avian influenza. *Journal of Wildlife Diseases*, **43**(3): S15-S20
9. FAO (2023) Global avian influenza viruses with zoonotic potential situation update. [cited 2023 3 Nov]; Available from: https://www.fao.org/animal-health/situation-updates/global-aiv-with-zoonotic-potential/en
10. USGS (2010) List of species affected by H5N1 (Avian influenza), referenced reports of highly pathogenic avian influenza H5N1 in wildlife and domestic animals. [cited 2023 3 Nov]; Available from: https://www.usgs.gov/media/files/list-species-affected-h5n1-avian-influenza
11. WOAH (2023) Avian Influenza. [cited 2023; Available from: https://www.woah.org/en/disease/avian-influenza
12. ProMED (2023) Avian influenza (69): Americas (Chile) dolphin, HPAI H5N1 [cited 2023 27th April];
13. ProMed (2022) PRO/AH/EDR> Avian influenza (09): Europe (UK) wild bird, HPAI, conservation concern. 2022 Jan 07; Available from: www.promedmail.org/post/8700696

14. CMS & FAO (2022) H5N1 highly pathogenic avian influenza in poultry and wild birds: Winter of 2021/2022 with focus on mass mortality of wild birds in UK and Israel. Available from: https://www.cms.int/sites/default/files/uploads/avian_influenza_0.pdf

15. OFFLU (2023) OFFLU call to discuss Avian Influenza events in mammals. 2 Mar 2023; Available from: https://www.offlu.org/wp-content/uploads/2023/03/OFFLU-call-AI-mammals-Mar2023.pdf

16. Nestorowicz A, Kawaoka Y et al. (1987) Molecular analysis of the hemagglutinin genes of Australian H7N7 influenza viruses: role of passerine birds in maintenance or transmission? *Virology*, **160**(2): 411-418

17. Hurt A, Su YC et al. (2016) Evidence for the introduction, reassortment and persistence of diverse influenza A viruses in Antarctica. *Journal of Virology*: 01404-16

18. British Antarctic Survey (2023) First confirmed cases of avian influenza in the Antarctic region. 23 Oct 2023; Available from: https://www.bas.ac.uk/media-post/first-confirmed-cases-of-avian-influenza-in-the-antarctic-region

19. WOAH (2024) Wildlife under threat as avian influenza reaches Antarctica. Available from: https://www.woah.org/en/wildlife-under-threat-as-avian-influenza-reaches-antarctica/

20. Selleck P, Arzey G et al. (2003) An outbreak of highly pathogenic avian influenza in Australia in 1997 caused by an H7N4 virus. *Avian Diseases*, **47**(s3): 806-811

21. Westbury H (1997) History of highly pathogenic avian influenza in Australia. In 'Fourth International Symposium on Avian Influenza'. US Animal Health Association: Richmond, VA

22. DAFF (2021) Avian Influenza or Bird Flu. Available from: https://www.agriculture.gov.au/biosecurity-trade/pests-diseases-weeds/animal/avian-influenza#has-h5n1-highly-pathogenic-avian-influenza-ever-occurred-in-australia

23. Agriculture Victoria (2023) Avian influenza (bird flu). Available from: https://agriculture.vic.gov.au/biosecurity/animal-diseases/poultry-diseases/avian-influenza-bird-flu

24. Agriculture Victoria (2024) Avian influenza (bird flu). 23 May 2024 [cited 2024 24 May 2024]; Available from: https://agriculture.vic.gov.au/biosecurity/animal-diseases/poultry-diseases/avian-influenza-bird-flu#h2-0

25. NSW DPI (2024) Avian influenza. [cited 2024 20 June]; Available from: https://www.dpi.nsw.gov.au/animals-and-livestock/poultry-and-birds/health-disease/avian-influenza

26. Agriculture Victoria (2025) High pathogenicity avian influenza (HPAI). [cited 2025 13 February]; Available from: https://agriculture.vic.gov.au/biosecurity/animal-diseases/vetsource/current-biosecurity-alerts/high-pathogenicity-avian-influenza-hpai

27. Grillo T, Arzey KE et al. (2015) Avian influenza in Australia: a summary of 5 years of wild bird surveillance. *Australian Veterinary Journal*, **93**(11): 387-393

28. Arzey G (2004) The role of wild aquatic birds in the epidemiology of avian influenza in Australia. *Australian Veterinary Journal*, **82**(6): 377-378

29. Westbury H (2003) History of highly pathogenic avian influenza in Australia. *Avian Diseases*: 23-30

30. Bunn C, Coman H et al. (1987) Wildlife aspects of the fowl plague outbreak June 1985, in Wildlife Disease Association Annual Meeting WDA: Flinders Ranges, South Australia. 20-31

31. Wille M and Klaassen M (2023) No evidence for HPAI H5N1 2.3. 4.4 b incursion into Australia in 2022. *Influenza and Other Respiratory Viruses*, **17**(3)

32. Wildlife Health Australia (2023) National Avian Influenza Wild Bird Surveillance Program. [cited 2023 30 Oct]; Available from: https://wildlifehealthaustralia.com.au/Our-Work/Surveillance/Wild-Bird-Surveillance

33. Hurt A, Hansbro PM et al. (2006) Isolation of avian influenza viruses from two different transhemispheric migratory shorebird species in Australia. *Archives of Virology*, **151**(11): 2301-9

34. MacKenzie J, Edwards EC et al. (1984) Isolation of ortho- and paramyxoviruses from wild birds in Western Australia, and the characterization of novel influenza A viruses. *Australian Journal of Experimental Biology & Medical Science*, **62 (Pt 1)**: 89-99

35. Peroulis I and O'Riley K (2004) Detection of avian paramyxoviruses and influenza viruses amongst wild bird populations in Victoria. *Australian Veterinary Journal*, **82**(1-2): 79-82

36. Downie J, Hinshaw V et al. (1977) The ecology of influenza. Isolation of type 'A' influenza viruses from Australian pelagic birds. *Australian Journal of Experimental Biology and Medical Science*, **55**(6): 635-643

37. MacKenzie J, Britten D et al. (1985) Isolation of avian influenza and paramyxoviruses from wild birds in Western Australia. In 'Veterinary viral diseases: Their significance in South-east Asia and the Western Pacific.' (Ed A. Della-Porta) pp. 336-339. (Academic Press: Orlando, FL)

38. Haynes L, Arzey E et al. (2009) Australian surveillance for avian influenza viruses in wild birds between July 2005 and June 2007. *Australia Veterinary Journal*, **87**(7): 266-72

39. Hansbro PM, Warner S et al. (2010) Surveillance and analysis of avian influenza viruses, Australia. *Emerging Infectious Diseases*, **16**(12): 1896-904

40. Curran JM (2012) The surveillance and risk assessment of wild birds in northern Australia for highly pathogenic avian influenza H5N1 virus. PhD thesis School of Veterinary and Biomedical Sciences, Faculty of Health Sciences, Murdoch University

41. East IJ, Hamilton SA et al. (2008) Identifying areas of Australia at risk for H5N1 avian influenza infection from exposure to nomadic waterfowl moving throughout the Australo-Papuan region. *Geospatial Health*, **3**(1): 17-27

42. Wildlife Health Australia (2023) Technical Issue Update - Global High Pathogenicity Avian Influenza Events Available from: https://wildlifehealthaustralia.com.au/Portals/0/Incidents/HPAI_Technical_Issues_Update_V3Sept23.pdf

43. Swayne DE (2009) Epidemiology of avian influenza in agricultural and other man-made systems. In 'Avian Influenza.' (Ed D.E. Swayne). (John Wiley & Sons)

44. Webster RG, Yakhno M et al. (1978) Intestinal influenza: replication and characterization of influenza viruses in ducks. *Virology*, **84**(2): 268-278

45. Animal Health Australia (2023) Disease strategy: Avian influenza (Version 5.2). In 'Australian Veterinary Emergency Plan (AUSVETPLAN), Edition 5.2.' (Standing Council on Primary Industries: Canberra, ACT)

46. Klaassen M, Hoye B et al. (2011) Identifying crucial gaps in our knowledge of the life-history of avian influenza viruses: an Australian perspective. *Emu*, **111**: 103-112

47. Ferenczi M, Beckmann C et al. (2016) Avian influenza infection dynamics under variable climatic conditions, viral prevalence is rainfall driven in waterfowl from temperate, south-east Australia. *Veterinary Research*, **47**(1): 23

48. Roshier DA, Robertson AI et al. (2002) Responses of waterbirds to flooding in an arid region of Australia and implications for conservation. *Biological Conservation* **106**: 399-411

49. Tracey JP, Woods R et al. (2004) The role of wild birds in the transmission of avian influenza for Australia: an ecological perspective. *Emu*, **104**(2): 109

50. Wille M, Grillo V et al. (2022) Australia as a global sink for the genetic diversity of avian influenza A virus. *PLoS Pathogens*, **18**(5): e1010150

51. Wille M, Lisovski S et al. (2019) Serologic evidence of exposure to highly pathogenic avian influenza H5 viruses in migratory shorebirds, Australia. *Emerging Infectious Diseases*, **25**(10): 1903

52. Wille M, Atkinson R et al. (2024) Long-distance avian migrants fail to bring 2.3. 4.4 b HPAI H5N1 into Australia for a second year in a row. *Influenza and Other Respiratory Viruses*, **18**(4): e13281

53. Curran JM, Ellis TM et al. (2013) Surveillance of Charadriiformes in northern Australia shows species variations in exposure to avian influenza virus and suggests negligible virus prevalence. *Avian Diseases*, **58**(2): 199-204

54. Kishida N, Sakoda Y et al. (2008) H2N5 influenza virus isolates from terns in Australia: genetic reassortants between those of the Eurasian and American lineages. *Virus Genes*, **37**(1): 16-21

55. Vijaykrishna D, Deng YM et al. (2013) The recent establishment of North American H10 lineage influenza viruses in Australian wild waterfowl and the evolution of Australian avian influenza viruses. *Journal of Virology*, **87**(18): 10182-9

56. Bhatta TR, Chamings A et al. (2020) Detection of a reassortant H9N2 avian influenza virus with intercontinental gene segments in a resident Australian Chestnut Teal. *Viruses*, **12**(1): 88

57. Van Gils JA, Munster VJ et al. (2007) Hampered foraging and migratory performance in swans infected with low-pathogenic avian influenza A virus. *PloS ONE*, **2**(1): e184

58. Alexander DJ (2000) A review of avian influenza in different bird species. *Veterinary Microbiology*, **74**(1): 3-13

59. Bevins SN, Dusek RJ et al. (2016) Widespread detection of highly pathogenic H5 influenza viruses in wild birds from the Pacific Flyway of the United States. *Scientific Reports*, **6**: 28980

60. Hoque A (2011) Risk of spill-over of diseases (in particular avian influenza) from wild aquatic birds in north Queensland. PhD thesis School of Veterinary and Biomedical Sciences & School of Public Health, Tropical Medicine and Rehabilitation Sciences, James Cook University: Townsville

61. Curran JM, Robertson ID et al. (2013) Evaluation of avian influenza serologic and virologic diagnostic methods in wild anseriformes and charadriiformes. *Avian Diseases*, **58**(1): 53-59

62. Rose K (2005) 'Sick and Dead Bird Health Surveillance Sample Collection Protocol.' ed. ARWH. (Zoological Parks Board of NSW: Sydney, NSW) https://arwh.org/wp-content/uploads/2021/05/SickDead-Bird-Surveillance_with-images.pdf

63. Mahmoud EA (2015) Hemato-biochemical and pathological changes on avian influenza in naturally infected domestic ducks in Egypt. *Veterinary World*, **8**(10): 1177-1182

64. OFFLU (2023) Southward expansion of high pathogenicity avian influenza H5 in wildlife in South America: estimated impact on wildlife populations, and risk of incursion into Antarctica. Available from: https://www.offlu.org/wp-content/uploads/2023/08/OFFLU-statement-HPAI-wildlife-South-America-20230823.pdf

65. FAO (2004) Joint FAO/OIE Emergency Regional Meeting on Avian Influenza Control in Animals in Asia, 26-28 February 2004. 2004 [cited 2023 3 November]; Available from: https://www.fao.org/3/y5537e/y5537e0b.htm

66. Animal Health Australia (2021) Guidance Document: Risk-based assessment of disease control options for rare and valuable animals, Available from: https://animalhealthaustralia.com.au//wp-content/uploads/dlm_uploads/2021/11/AVP_GD_Rare-and-valuable_V5_1.pdf

67. Grillo T, Cox-Witton K et al. (2016) Wildlife Health Australia. *Animal Health Surveillance Quarterly Report*, **21, 1**(1): 6-8

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