Avian influenza: epidemiology and surveillance in New Zealand

Avian influenza epidemiology

Avian influenza (AI) refers to infection of birds with avian influenza A viruses of the family Orthomyxoviridae. These RNA viruses are widespread, highly contagious and extremely variable. AI viruses are most frequently recorded in waterfowl (defined for this paper as members of the order Anseriformes – ducks, geese, and swans), which are considered to be the biological and genetic reservoirs of all AI viruses and the primordial reservoir of all influenza viruses for birds and mammals (Webster et al. 1992; Stallknecht 1998; Perdue et al. 2000). Carriage of AI is also seen to a lesser extent among two families within the order Charadriiformes: the Laridae (gulls and terns), and Scolopacidae (waders). The Charadriiformes are considered of secondary importance, given that AI viruses are only detected seasonally and at low prevalence when compared to the Anseriformes (Olsen et al. 2006; Munster et al. 2007; Whitworth et al. 2007). Wild birds, particularly migratory waterfowl, may play a major role in the initial introduction of AI viruses into commercial poultry (Halvorson et al. 1985; Hinshaw et al. 1986).

However, once AI becomes established in commercial poultry, wild birds have very little or no role in secondary dissemination (Nettles et al. 1985). The influenza A virus is subtyped based on serologic reactions to the haemagglutinin (HA) and neuraminidase (NA) surface glycoproteins (WHO Expert Committee 1980). Sixteen subtypes of HA and nine subtypes of NA are recognised. The distribution of virus subtypes varies by year, geographic location and host species (Swayne & Halvorson 2008). The surface glycoproteins are the major targets of the host immune response. There is little or no cross-protection between different HA or NA types (Anon 2014; Swayne et al. 2008).

New Zealand official status

New Zealand is free from high-pathogenicity avian influenza (HPAI) and has never had a case of low-pathogenicity avian influenza (LPAI) in poultry. New Zealand’s claim of freedom from HPAI is based on the historical freedom provisions of Article 1.4.6a of the OIE Terrestrial Animal Health Code (Anon 2015). Addressing the specific requirements detailed in Article 1.4.6a:

• New Zealand has never had an occurrence of HPAI;
• HPAI has been notifiable for at least the last 10 years;
• an early detection system is in place for all susceptible species;
• measures to prevent the introduction of HPAI are in place;
• no vaccination against HPAI has been carried out; and
• infection with HPAI is not established among wild birds in New Zealand.

There has never been a case of HPAI in wildlife, although LPAI has been detected sporadically in wild waterfowl (Stanislawek et al. 2002; Stanislawek et al. 2016).

Figure 1: The nine major migratory bird flyways of the world

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as two viruses that share a subtype may be only distantly related. Some of this variability results from a process known as antigenic drift – the gradual accumulation of mutations. As a consequence of this, the viral HA or NA surface glycoproteins may change sufficiently for the immune responses generated against these glycoproteins to no longer be effective. A more rapid change can occur through a process known as genetic reassortment, which occurs when two different influenza viruses infect the same cell. In this situation, gene segments from both viruses may be packaged into a single novel viron. If genetic reassortment results in the acquisition of new HA or NA glycoproteins, this can cause an antigenic shift among the viruses circulating in a species. This may be sufficient for the reassortant virus to evade existing immunity or to significantly change its virulence for birds or mammals. (Anon 2014; Swayne et al. 2008).

There are two well-recognised lineages of avian influenza viruses: Eurasian and North American. The amount of reassortment between these lineages differs between regions, with very few reassortant viruses detected in some areas or among some wild bird populations, but significant reassortment where there is overlap between migratory flyways, such as in Alaska (Figure 1). Viruses in wild birds are more likely to be transferred between hemispheres in the latter regions (Anon. 2014)

**OIE definitions**

The OIE defines AI as an infection of poultry caused by any influenza A virus of the H5 or H7 subtypes, or by any influenza A virus with an intravenous pathogenicity index (IVPVI) greater than 1.2 (or alternatively, at least 75 percent mortality), as described below. These viruses are further divided into two categories: HPAI and LPAI viruses.

**HPAI viruses**

These are influenza A viruses that have an IVPI in six-week-old chickens greater than 1.2; or alternatively, that cause at least 75 percent mortality in four- to eight-week-old chickens infected intravenously. H5 and H7 viruses that do not have an IVPI of greater than 1.2 or cause less than 75 percent mortality in an intravenous lethality test should be sequenced to determine whether multiple basic amino acids are present at the cleavage site of the haemagglutinin molecule (HA0). If the amino-acid motif is similar to that observed for other high-pathogenicity avian influenza isolates, the isolate being tested should be considered as HPAI virus.

**LPAI viruses**

These are all influenza A viruses of H5 and H7 subtypes that are not high-pathogenicity avian influenza viruses (Anon. 2015).

For international reporting purposes the OIE requires reporting of cases of LPAI and HPAI (as defined above) in poultry, and infection with HPAI in birds other than poultry (including wild birds). The OIE defines poultry as “all domesticated birds, including backyard poultry, used for the production of meat or eggs for consumption, for the production of other commercial products, for restocking supplies of game, or for breeding these categories of birds, as well as fighting cocks used for any purpose” (Anon. 2015).

LPAI infection of domestic poultry can result in mild to severe respiratory signs including coughing, sneezing, rales, rattles and excessive lacrimation. Generalised clinical signs such as huddling, ruffled feathers, depression, lethargy and occasionally diarrhoea have also been described. Layers may show decreased egg production. High morbidity and low mortality are normal for LPAI infections (Swayne & Halvorson 2008). Intratracheal inoculation of poultry with LPAI can result in localised infection of the upper and lower respiratory tract (tracheitis, bronchitis, airsacculitis and pneumonia), with histological lesions and viral antigen distribution restricted to the lungs and trachea, although pancreatic necrosis is also reported (Swayne et al. 1992; Shalaby et al. 1994; Mo et al. 1997; Capua et al. 2000). Intravenous inoculation of poultry with LPAI results in swollen and mottled kidneys, with necrosis of the renal tubules and interstitial nephritis noted on histopathology and high viral titres in kidney tissues (Slemons & Swayne 1990; Swayne & Slemons 1990; Slemons & Swayne 1992; Swayne & Slemons 1992; Shalaby et al. 1994; Swayne & Alexander 1994; Swayne et al. 1994; Swayne & Slemons 1995). However, this renal tropism is strain-specific and is most consistently associated with experimental intravenous inoculation studies (Swayne & Halvorson 2008), though Alexander & Gough (1986) did report the recovery of H10N4 LPAI from the kidneys of hens presenting with nephropathy and visceral gout. Salpingitis associated with a non-pathogenic H7N2 virus was described by Zielger et al. (1999).

In contrast, most cases of HPAI infection of domestic poultry are associated with severe disease, with some birds being found dead before clinical signs are noticed. Clinical signs such as tremors, torticollis and opisthotonus may be seen for three to seven days before death. Precipitous drops in egg production in breeders and layers are reported. Morbidity and mortality are usually very high (Swayne & Halvorson 2008). HPAI of poultry results in necrosis and inflammation of multiple organs including the cloacal bursa, thymus, spleen, heart, pancreas, kidney, brain, trachea, lung, adrenal glands and skeletal muscle (Mo et al. 1997; Swayne 1997; Perkins & Swayne 2001). Histopathological lesions described include diffuse nonsuppurative encephalitis, necrotising pancreatitis and necrotising myositis of skeletal muscles (Acland et al. 1984). Viral infection of the vascular endothelium is suggested as the mechanism for the pathogenesis of HPAI infections in poultry, especially the CNS lesions (Kobayashi et al. 1996a; Kobayashi et al. 1996b). Viral antigen can be detected in multiple organs, most commonly the heart, lung, kidney, brain and pancreas (Mo et al. 1997).

**Epidemiology of AI in New Zealand**

New Zealand lies at the southeastern extremity of the East Asian-Australasian Flyway (Figures 1 and 2), which is an important consideration regarding the likelihood of introduction of any new AI viruses into the country. Because of this geographical isolation, relatively few migratory birds reach the country. In total, about 200 000 birds of 47 species arrive as annual migrants, but more than 90 percent of these are just two species of wader (Scolopacidae): bar-tailed godwits (Limosa laponica) and red (lessar) knots (Calidris canutus) (Williams et al. 2006). Most godwits are believed to fly here directly from Alaska, while red knots have stopovers along the Asian coast as they migrate from the Siberian...
Arctic. Additionally, small numbers of other waders such as the Pacific golden plover (*Pluvialis fulva*) and red-necked stint (*Calidris ruficollis*) migrate to New Zealand via a number of stops in the Pacific. These birds share summer breeding grounds in the Arctic regions of Siberia and Alaska with species from Eurasia and the Americas (Figure 2) (Bulach et al. 2010).

In contrast to the Americas and Europe, where regular migrations of waterfowl are established, New Zealand is not on any waterfowl migration pathway, so our populations are isolated from all others except occasional Australian vagrants (Williams et al. 2006). When considering the movement of avian influenza viruses around the world this is important, as previous studies have suggested that members of the order Anseriformes, and particularly the family Anatidae, play an important role as the natural reservoirs of AI virus (Gilbert et al. 2006, Hars et al. 2008, Bulach et al. 2010).

Further minor migration links include those of pelagic (ocean-ranging) seabirds such as petrels and albatrosses, which breed on and around the New Zealand coast during the southern hemisphere summer. These birds migrate to maritime regions of the northern Pacific associated with Japan, Russia, and Alaska, with some travelling as far as the west coasts of North and South America (Bulach et al. 2010).

Some trans-Tasman migration of seabirds between New Zealand and Australia also takes place. For example, the Australasian
gannet (Morus serrator) and white-fronted tern (Sterna striata) breed in New Zealand, then migrate to Australian coastal areas for their adolescence or during the non-breeding season (Marchant & Higgins 1990). On their return to New Zealand, they associate at roosts or nesting sites on beaches, headlands and small offshore islands, mingling with adult gannets and terns that have overwintered in New Zealand waters (Williams et al. 2006).

With respect to the importance of the migratory species reaching New Zealand as a source of new AI viruses, Bulach et al. (2010) speculated that the pelagic seabirds and waders that often migrate into North America do not play a role in the movement of influenza viruses to Australia and New Zealand. This conclusion was based on the closer relationship of the Australian and New Zealand H7 isolates to Eurasian AI virus isolates than to North American isolates, despite the flyways that link the Australia, New Zealand and North America regions. Further support for this conclusion has come from surveys carried out by the Ministry for Primary Industries (MPI) National Animal Health Laboratory during the first six years of the avian influenza surveillance programme (2004–2010). These surveys targeted migratory birds, in particular the bar-tailed godwit and red (lesser) knot. No AI virus was isolated, indicating that migratory birds pose a very low risk for the introduction of AI to New Zealand (Stanislawek et al. 2015). This conclusion is supported by findings from surveillance of migratory birds in Australia (Curran et al. 2014).

Phylogenetic analysis of the HA gene of the New Zealand H5 viruses shows that these cluster together and appear to be genetically closer to the low-pathogenic North American H5 wild bird viruses than to H5 wild bird viruses from Eurasian lineage (Stanislawek, unpublished data). While this does not fully support the theory developed for New Zealand H7 viruses by Bulach et al. (2010), the genetic differences in the relationship of the H5 and H7 viruses in New Zealand could be explained by the early introduction of mallard ducks (Anas platyrhynchos) that were most likely already infected with AI viruses, from Europe in the 1860s and from North America in the 1930s and 1940s (Heather & Robertson 1996). In conclusion, New Zealand is geographically isolated from the migratory species that are influential in the spread of avian influenza viruses around the world. In contrast to the situation in North America, Asia and Europe, the circulating subtype H5 and H7 avian influenza viruses in New Zealand appear to have undergone an extended period of genetic isolation. This is supported by the work undertaken by Bulach et al. (2010) and Stanislawek (unpublished data).

**MPI AI surveillance**

New Zealand’s AI surveillance programme is multi-faceted, incorporating active surveillance of resident wild birds, and enhanced passive surveillance. New Zealand has never had a case of HPAI in wild birds or poultry, or a case of LPAI in poultry.

**Wild bird surveillance**

From 2004 to 2015, MPI, in conjunction with the New Zealand Fish and Game Councils, the Department of Conservation and other stakeholders, carried out surveillance for AI on targeted migratory and resident birds (Table 1). The first six years of surveillance focused on migratory birds, in particular the bar-tailed godwit, and red (lesser) knots, on their arrival from late September to November, at Miranda,

<table>
<thead>
<tr>
<th>Year</th>
<th>Species sampled</th>
<th>Cloacal samples tested</th>
<th>Oropharyngeal samples tested</th>
<th>RT/PCR positive</th>
<th>Confirmed H5 or H7 isolates</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>Mallard duck, red knot, bar-tailed godwit</td>
<td>469</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2005</td>
<td>Mallard duck, paradise duck, red knot, bar-tailed godwit</td>
<td>1 089</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2006</td>
<td>Mallard duck, red knot, bar-tailed godwit, ruddy turnstone</td>
<td>826</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2007</td>
<td>Mallard duck, paradise duck, grey teal, red knot, bar-tailed godwit</td>
<td>950</td>
<td>174</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>2008</td>
<td>Mallard duck, paradise duck, red knot, bar-tailed godwit</td>
<td>1 484</td>
<td>343</td>
<td>37</td>
<td>0</td>
</tr>
<tr>
<td>2009</td>
<td>Mallard duck, red knot, bar-tailed godwit, black-billed gull, black-backed gull</td>
<td>1 480</td>
<td>1 480</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>2010</td>
<td>Mallard duck, black-billed gull, black-backed gull, wrybill, little blue penguin, yellow-eyed penguin, sooty shearwater</td>
<td>1 991</td>
<td>1 991</td>
<td>5</td>
<td>17</td>
</tr>
<tr>
<td>2011</td>
<td>Mallard duck</td>
<td>790</td>
<td>790</td>
<td>25</td>
<td>0</td>
</tr>
<tr>
<td>2012</td>
<td>Mallard duck</td>
<td>790</td>
<td>790</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>2013</td>
<td>Mallard duck</td>
<td>960</td>
<td>960</td>
<td>49</td>
<td>0</td>
</tr>
<tr>
<td>2014</td>
<td>Mallard duck</td>
<td>880</td>
<td>880</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>2015</td>
<td>Mallard duck</td>
<td>1 065</td>
<td>1 065</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>12 774</td>
<td>8 473</td>
<td>138</td>
<td>26</td>
</tr>
</tbody>
</table>

* All H5 and H7 detections were low-pathogenicity avian influenza. All detections were in resident waterfowl.
their main North Island arrival site. Findings from surveillance undertaken from 2004 to 2010 indicate that migratory birds pose a very low risk for the introduction of AI to New Zealand, as no AI virus was isolated. These birds were targeted because of their migration pathway, along which AI viruses may be present: directly from the Arctic regions of Asia and North America in the case of the godwit, and from Arctic regions via the Pacific coast of Asia in the case of the knot. Subsequently, from 2010 to 2015 surveillance focused on resident birds, mainly waterfowl (Stanislawek et al. 2012) (Figure 3).

New Zealand is not on a migration pathway for waterfowl as observed in the northern hemisphere, although vagrant waterfowl from Australia are occasionally encountered. Nevertheless, since 2004, non-migratory waterfowl (predominantly mallard ducks) have also been sampled in the summer months throughout New Zealand, with a particular focus on coastal areas close to migratory shorebird habitats (Stanislawek et al. 2015) (Figure 4). This surveillance programme is ongoing.

Enhanced passive surveillance
MPI operates a 24/7 toll-free exotic pest and disease emergency hotline and receives calls regarding sick and dead wild and domestic birds from members of the public, veterinarians, regional laboratory pathologists and others (Tana 2014; Stanislawek et al. 2015). Where reports relate to native birds, they are handled collaboratively with the Department of Conservation (DOC).

Figure 3: Locations of active surveillance for H5 and H7 subtypes of AI in wild birds, 2004–2015

Figure 4: Samples being collected from wild ducks in the Hauraki Plains area (left) and the mouth of the Kaituna River (right).
A risk assessment determines whether there is a need to investigate the report further. Key information used in the assessment includes:

- history of the event (numbers affected and timeline of events);
- presenting syndrome in dying birds;
- species of bird(s) affected;
- availability of fresh samples (where unavailable, follow-up is instigated);
- location; and
- epidemiological trends over space and time.

Based on the risk assessment, the report is either stood down or investigated further for a potential exotic or emerging disease aetiology (Stanislawek et al. 2015).

A rapid field service is in place for sample collection and submission of unexplained bird deaths (Rawdon et al. 2007; van Andel et al. 2010), using MPI-approved suppliers. A standardised investigation protocol, co-ordinated by the MPI Investigation and Diagnostic Centre at Wallaceville, is applied to submissions. The investigation protocol includes necropsy and sample collection for histology, bacteriology and virology. The presence of AI is assessed using influenza A real-time RT-PCR TaqMan (Spackman et al. 2003), with follow-up using real-time H5 and H7 RT/PCR TaqMan assays to exclude H5 and H7 subtypes (Slomka et al. 2007; Sidoti et al. 2010). Virus isolation is performed on samples that are positive in PCR assays (Stanislawek et al. 2002).

Reports on avian disease and mortality investigations are published quarterly in Surveillance as part of the IDC report of suspect exotic disease investigations.

Mortalities of threatened or critically endangered native birds are also monitored. Necropsies are performed by veterinary wildlife pathologists contracted to DOC and where required further diagnostic testing is undertaken to help make a definitive diagnosis. MPI also collects data from approved veterinary diagnostic labs in New Zealand.

Based on imminent disease risk, additional data is collected from diagnostic labs, veterinarians and farmers. Data is also collated and presented each year for reporting purposes. The number of submissions to the surveillance system is reported each year in the Annual Report for the passive surveillance system. Annual reports for the MPI AI surveillance programme can be found at the NZVA Sciquest site http://www.sciquest.org.nz/surveillance.

### Industry surveillance

Surveillance for AI within the New Zealand poultry industry is multifaceted and supports the MPI passive surveillance system.

Previous work undertaken has included serological surveillance (2006–2007) and virological surveillance (2008–2009) for AI virus H5 and H7 subtypes in commercial poultry. This surveillance work was conducted by the then MAF Biosecurity New Zealand (now MPI), with the support of the Poultry Industry Association of New Zealand (PIANZ) and the Egg Producers Federation (EPF). The survey was designed using the 2005 OIE guidelines for AI surveillance.

The serological survey used a cross-sectional two-stage stratified design to ensure representative sampling of all poultry sectors and proportional regional representation of poultry farms. Production sectors included initially were broiler, caged/barn layer, free-range layer, pullet rearer and turkey breeder farms (Rawdon et al. 2010). Active surveillance was extended in 2008–2009 to ducks, quail, pheasants, partridges and guinea fowl produced for meat, eggs, or release in game reserves (Frazer et al. 2009; Frazer et al. 2010). This survey found no evidence of active infection with either H5 or H7 AI subtypes, and provided evidence of absence at a between-farm prevalence of 5 percent (95 percent confidence).

At present surveillance is conducted to meet the requirements of an MPI import health standard (IHS). Breeder birds in donor flocks are tested as per the IHS before hatching eggs are imported. Further testing is conducted where any mortalities occur (as required by the IHS) and a sample of live chicks born in quarantine is also tested. AI surveillance is also undertaken to meet the trading partner’s requirements for the export of table eggs, hatching eggs and day-old chicks. This aspect of industry surveillance is reported each year in the Surveillance Annual Report, http://www.sciquest.org.nz/node/123576). Neither LPAI nor HPAI has ever been detected in the New Zealand commercial poultry flock as a result of these surveillance activities.

Commercial poultry companies employ veterinarians to develop health plans for the flocks they are responsible for. These plans include the establishment, supervision and interpretation of routine testing for flock health and also the investigation of poor performance in a flock. Where exotic diseases such as AI are suspected, MPI is also notified via the exotic pest and disease hotline (see Enhanced passive surveillance, above) and, under the direction of MPI Incursion Investigators, further diagnostics may be carried out.

Poultry veterinarians are supported by two specialist poultry pathology laboratories that conduct avian lab tests for the commercial poultry industry and are audited to the NZS ISO/IEC standard 17025:2005 “General

### Table 2: Avian submissions to the MPI Passive Surveillance System, 2004–2015

<table>
<thead>
<tr>
<th>Year</th>
<th>Submissions from approved veterinary diagnostic labs</th>
<th>Wildlife submissions</th>
<th>MPI pest and disease hotline notifications</th>
<th>MPI investigations</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>116</td>
<td>–</td>
<td>30</td>
<td>8</td>
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<tr>
<td>2005</td>
<td>340</td>
<td>–</td>
<td>85</td>
<td>8</td>
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<tr>
<td>2006</td>
<td>360</td>
<td>–</td>
<td>154</td>
<td>24</td>
</tr>
<tr>
<td>2007</td>
<td>33</td>
<td>–</td>
<td>60</td>
<td>14</td>
</tr>
<tr>
<td>2008</td>
<td>120</td>
<td>–</td>
<td>37</td>
<td>10</td>
</tr>
<tr>
<td>2009</td>
<td>163</td>
<td>–</td>
<td>*151</td>
<td>7</td>
</tr>
<tr>
<td>2010</td>
<td>174</td>
<td>–</td>
<td>25</td>
<td>7</td>
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<tr>
<td>2011</td>
<td>142</td>
<td>–</td>
<td>19</td>
<td>7</td>
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<tr>
<td>2012</td>
<td>290</td>
<td>16</td>
<td>19</td>
<td>8</td>
</tr>
<tr>
<td>2013</td>
<td>664</td>
<td>178</td>
<td>19</td>
<td>6</td>
</tr>
<tr>
<td>2014</td>
<td>385</td>
<td>141</td>
<td>30</td>
<td>13</td>
</tr>
<tr>
<td>2015</td>
<td>503</td>
<td>95</td>
<td>45</td>
<td>14</td>
</tr>
</tbody>
</table>

*The greatly elevated number of bird mortality reports in 2009 was due to a toxicity event in August of that year caused by grey side-gilled sea slugs (Pleurobranchaea maculata) in the Auckland region. This event created considerable media interest and increased the number of calls to MPI’s hotline from the public.
requirements for the competence of testing and calibration laboratories” by
International Accreditation New Zealand (IANZ) (http://www.ianz.govt.nz/).
Both laboratories are also Recognised Laboratories under the MPI Export
Laboratory Programme (https://mpi.govt.nz/exporting/overview/general-
requirements/export-laboratory-programme/). Poultry veterinarians can also use the private veterinary laboratory
network for disease investigation
To further enhance the passive surveillance system, PIANZ and the EPF
provide all their commercial poultry farmer members (who produce about 95 percent of all commercial poultry
in New Zealand) with AI information posters for their poultry sheds (Figure 5).
The objective is to raise awareness and provide information regarding early
warning signs and the requirement to call the MPI exotic pest and disease hotline whenever there is a suspicion of AI (or
other exotic diseases).

Import health standards
Import risk analysis (IRA) is a scientific discipline that transparently
accommodates known facts, knowledge gaps and uncertainty (Vose, 2008; World
Organisation for Animal Health 2010). MPI uses IRA to identify pre-border
hazards such as pathogens that may be associated with imported animals, and to
assess the likelihood and consequences of introducing those hazards. IRA also
informs control measures to manage the identified risks, and helps communicate
the risks to others (Cobb & MacDiarmid, 2014).
An early study revealed that AI virus persisted in refrigerated muscle tissue for
287 days, although feeding meat or blood from a viraemic bird to a susceptible bird
did not transmit infection (Purchase 1931). More recently, Swayne & Beck
(2005) confirmed this when they demonstrated that LPAI virus could not
be found in the blood, bone marrow, breast or thigh meat of experimentally
infected poultry, and that feeding breast or thigh meat to a susceptible bird
did not transmit infection. However, experimental infection of poultry with
HPAI resulted in detectable virus in blood, bone marrow and breast and
thigh meat. A H5N2 isolate was found to achieve only low viral titres in muscle
tissue (10^{2.2–3.2} EID50 virus/g), and feeding this meat to susceptible birds did
not transmit infection, whereas an H5N1 isolate achieved a much higher titre in
muscle tissue (10^{7.3} EID50 virus/g), which was sufficient to achieve transmission
in a feeding trial. This study also demonstrated that AI virus vaccination
prevented HPAI virus replication in muscle tissue. The authors concluded
that the potential for LPAI virus to appear in the meat of infected chickens
was negligible, while the potential for having HPAI virus in meat from infected
chickens was high; but proper use of vaccines could prevent HPAI from being
present in meat.
LPAI cannot be transmitted to susceptible birds by feeding meat from an
infected bird. Following natural infection, LPAI virus replication is limited mainly
to the respiratory tract tissues, although some infectivity may be associated with
the pancreas, kidneys and reproductive tract. HPAI viruses replicate in a wide
range of tissues, and studies have shown that feeding meat from an HPAI-
infected bird can transmit the virus to a susceptible bird.
AI virus has been isolated from the internal contents of eggs from naturally

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**Symptoms of Avian Influenza (AI) in poultry**

**Clinical signs of AI are highly variable.**
They may be influenced by the strain of the virus, the age and species
of bird affected, and the presence or absence of other diseases and
prevailing environmental conditions. The main symptoms include:
* sudden and unexplained deaths
* a rapid spread of the disease throughout the flock
* depression and loss of appetite
* a drop in egg production
* nervous signs
* facial swelling
* coughing, sneezing and diarrhoea

Although the symptoms of AI can be similar to those of other common
poultry diseases, if you suspect your poultry are infected with AI then you must call:
* your vet, or your technical advisor, or
* the MPI Exotic Pest and Disease Hotline on 0800 80 99 66
An experienced exotic disease investigator with access to poultry
specialists will answer your call.

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Figure 5: The AI information poster produced by PIANZ and EPF for poultry farmers
infected layer and breeder flocks with clinical disease, and from an infected layer flock with no clinical signs (Cappucci et al. 1985). Unpublished work by Brugh (cited by Swayne & Beck 2004) identified HPAI virus in 85–100 percent of eggs laid on days 3 and 4 following experimental inoculation. Although no reports of transmission of infection to chicks via infected eggs have been located, movement of egg trays and associated fomites was a significant risk factor in the spread of AI infection during an epidemic in the Netherlands in 2003 (Thomas et al. 2005).

New Zealand's import health standards for poultry products include sanitary measures for HPAI in poultry meat and all strains of avian influenza in poultry hatching eggs. For example, poultry meat or meat products must be derived from birds kept in a country, zone or compartment free from HPAI since hatching, or for 21 days before slaughter for export, with current OIE Code surveillance requirements being met to claim freedom from HPAI. Otherwise they must be cooked in accordance with the Code recommendations for inactivation of avian influenza virus in meat.

**Conclusion**

New Zealand is free from HPAI and has never had a case of LPAI in poultry. Internationally, waterfowl play a pivotal role in the epidemiology of AI and are responsible for its movement globally via overlapping migratory flyways. New Zealand is not on a migratory pathway for waterfowl, with only occasional vagrants arriving from Australia. Import health standards are in place to effectively manage the risks associated with live birds and poultry products. Active surveillance is undertaken in wild birds, enabling characterisation of the endemic viruses (Stanislawek et al. 2015) and the passive surveillance system allows for rapid detection of HPAI should it ever occur (Tana 2014).

**References**


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