A simulation based evaluation of the time to detect EA/NA H5N2 HPAI virus infection in commercial turkey flocks under various active surveillance testing protocols

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Overview

• Current active surveillance protocol
  – Test 1 pool of 5 oropharyngeal swabs taken from dead birds randomly selected from the available mortality from each house using rRT-PCR

• Sampling protocol options under consideration
  – Increase the number of oropharyngeal swabs in a test pool from 5-swabs to 11 swabs
  – Swab 8 bell-drinker water-pans per-house and test 2 pools of 4 swabs
  – Take an oropharyngeal swab and a cloacal swab from the same dead bird and test 1 pool of 11 oropharyngeal swabs and 1 pool of 11 cloacal swabs
Performance Measures

• Time to HPAI detection
  – The average time from HPAI introduction to detection in the flock
  – An estimate of the time that flocks are infectious (shedding) and are a hazard to other flocks
  – Goal: The shortest time to detection to reduce risk of transmission through local area spread

• HPAI Detection probability
  – The proportion of outbreaks (houses) detected (or not detected)
  – An estimate of the chances of missed detections that might result in spread through product movements
  – Goal: The highest detection probability to reduce the risk of spread through higher risk product movements (e.g., live birds)
Surveillance Protocols Evaluated

• Time to HPAI detection
  – Daily testing for surveillance in the HPAI Control Area
  – Indiana H7N8 drinker sampling protocol proposed by the University of Minnesota
    • 2 pools of 4 swabs (8 bell-jar drinkers/ 4 each side of house)
    – Targeted dead bird surveillance
      • 2 pools of 11 oropharyngeal swabs per-house
      • 1 pool of 5 oropharyngeal swabs per-house
  • HPAI detection probability
    – Testing on two consecutive days prior to product movement
    – Targeted dead bird surveillance
      • 1 pool of 5 oropharyngeal swabs per-house on 2 days
      • 1 pool of 11 oropharyngeal swabs per-house on 2 days
      • 1 pool of 11 oropharyngeal + 1 pool of 11 cloacal swabs from the same dead birds on 2 days (handled in separate tubes)
Surveillance Objective
Earliest Detection

• Targeted dead-bird surveillance
  – Detect the **first occurrence** of a HPAI infected dead bird among all the dead birds in the dead-bird pool from a house

• Drinker sampling
  – Detect the **first occurrence** of a HPAI contaminated bell-jar drinker contaminated by the first infectious bird in a house
HPAI Virus Strain Variation
Time to Death (Days) Mean (95% P.I.)

Empirical distributions fit to data:

- **A/NorthernPintail/WA/2014 H5N2**
  Mean 4.90 (3.59 to 6.37)

- **A/chicken/IA/2015 H5N2**
  Mean 5.18 (2.23 to 9.11)

- **A/turkey/MN/2015 H5N2**
  Mean 5.51 (2.79 to 8.99)

- **A/ostrich/Italy/2000 H7N1**
  Mean 1.88 (0.75 to 3.25)

(Only the mean is shown)

Spackman et al., ARS SEPRL
Saenz et al., (2001)
Simulation Modelling Study

6000 simulated outbreaks

• Within-flock HPAI disease transmission model

\[ P_{inf} = 1 - \exp(-\beta \left( \frac{I}{N} \Delta t \right) ) \]

  – Variability in Mean Death Time for HPAI virus strains

  – Uncertainty and variability in the rate of HPAI spread (\( \beta \))

• Models of active surveillance protocols

  – Variability in house size for tom turkeys

  – Variability in normal daily mortality patterns

  – Uncertainty in RRT-PCR test characteristics
Drinker Sampling Evaluation

• Key model parameters
  – 150 birds per bell-drinker per-house
  – Sip-rate (mean 16 sips per-day)
  – 2 Sips for bell-drinker to become HPAI positive

• Key assumptions
  – Birds don’t have a preference for a drinker
    » i.e., they can drink from any drinker
  – No decay of HPAI virus titer over time in water
    » Biofilm provides a stable media for virus survival
    » No titer dilution with water replacement
  – Sick birds drink at the same rate as healthy birds
Results: HPAI Detection Probability
Testing on 2 Consecutive Days Prior to Movement

Predicted detection percent

Day of movement post exposure of the house

1 pool each of 11 swabs (oropharyngeal & cloaca)
1 pool of 11 swabs (oropharyngeal)
1 pool of 5 swabs (oropharyngeal)
Drinker Sampling Evaluation: 6000 simulated outbreaks

H5N2 HPAI virus (Turkey MN 2015)
On Average
1 Dead
22 Infectious

H7N1 HPAI virus (Italy 2000)
On Average
1 Dead
9 Infectious
# Results: Time to HPAI Detection
(Mean Days with 95% P.I.)

<table>
<thead>
<tr>
<th>Daily testing protocol (per house)</th>
<th>H5N2 HPAI Turkey MN 2015</th>
<th>H7N1 HPAI Italy 2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drinker</td>
<td>2 pools of 4 swabs</td>
<td>3.4 (1 to 6)</td>
</tr>
<tr>
<td>Dead birds</td>
<td>2 pools of 11 swabs</td>
<td>5 (3 to 7)</td>
</tr>
<tr>
<td>Dead birds</td>
<td>1 pool of 5 swabs</td>
<td>5.6 (3 to 8)</td>
</tr>
</tbody>
</table>
## Sensitivity Analysis

**Time to HPAI Detection**

Mean Days (95% P.I.)

<table>
<thead>
<tr>
<th>Sips per bell-drinker per-day</th>
<th>Sips</th>
<th>10</th>
<th>16</th>
<th>22</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sips</td>
<td>3.7 (2-6)</td>
<td>3.4 (1-6)</td>
<td>3.1 (1-5)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sips required to get an HPAI positive drinker pan</th>
<th>Sips</th>
<th>2</th>
<th>5</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>3.4 (1-6)</td>
<td>4.6 (2-7)</td>
<td>4.9 (3-7)</td>
<td></td>
</tr>
</tbody>
</table>
Risk Management Considerations

• Performance of drinker sampling is HPAI strain dependent
  – Drinker sampling may result in a gain of a day or more which could shorten the time to depopulation or enhanced biosecurity
  – Strong potential for LPAI surveillance
  – Further research on key parameters is needed

• Risk of spread by surveillance crews or flock-service personnel should be considered
  – Barrel surveillance (dead birds) used in past outbreaks

• Drinker sampling results are useful as a screening test but are preliminary
  – Could be useful as an early warning but ramifications of a false positive have to be considered
  – Confirmation takes additional time
Questions?