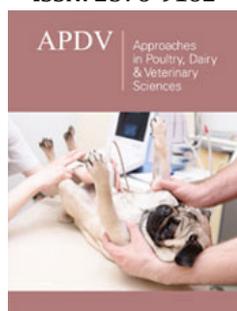


Risk-Based Avian Influenza Surveillance System for Poultry: Response to H5 Virus Detection in Wild Birds in the Republic of Korea

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Mini Review

The Avian Influenza Virus (AIV) belongs to the Alphainfluenzavirus genus of Orthomyxoviridae and infects vertebrates such as mammals and birds. AIVs are classified into various subtypes based on the combination of surface proteins, Hemagglutinin (HA) and Neuraminidase (NA). So far, 16 HA and 9 NA subtypes have been detected; therefore, the combination of HA and NA theoretically results in 144 subtypes [1]. Considering this, cases of highly pathogenic infections have been confirmed for H5 and H7 virus subtypes. Thus, when either of these two AIV types is detected, a response must be promptly implemented to the highly pathogenic infection. In the Republic of Korea, winter management of Highly Pathogenic Avian Influenza (HPAI) is strengthened by setting special control period from late autumn in October to early spring in February, often extending to March. During this period, specimens from wild birds (e.g., feces, dead bodies, and captures) are collected and actively surveilled by testing for AIVs [2]. The present study compares the winters of 2019/2020 and 2020/2021 for livestock vehicles and farms, which were epidemiologically linked to the detection of H5 AIV in wild birds. In 2020, starting with the first detection on October 10, 23 cases of H5 viruses were detected in wild birds from 17 regions (cities and counties), but HPAI was not confirmed. Meanwhile, in the winter of 2020/2021, a total of 297 cases of H5 or H7 AIV were detected. Of these, 234 cases detected in 65 regions were confirmed to be the H5N8 HPAI virus. The first detection was confirmed on October 21, 2020. In addition, HPAI was confirmed in 109 poultry farms from 48 regions. Moreover, in 25 regions, HPAI was confirmed in both wild birds and poultry.

The number of H5 AIVs detected in wild birds was eight (34.8%) each in October and November; three (13.0%) in December, and two (8.7%) each in January and March 2019/2020. Considering that the highest H5 AIV detection was recorded in October and November, during which majority of winter birds move into Korea, the detection of H5 AIV might decrease from December, if viral transmission is minimized in the wild bird population. However, a different pattern of detection was observed for the H5N8 HPAI virus. The number of detections of this virus in wild birds was two (0.9%) in October 13 (5.6%) in November, 46 (19.7%) in December, 121 (51.7%) in January, 42 (17.9%) in February, and ten (4.3%) in March. The combination

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of favorable environmental conditions for virus survival (i.e., the lowest annual temperature in January) and the spread within the wild bird population possibly resulted in the highest number of HPAI viruses being detected in January. The number of HPAI outbreaks in poultry was also the highest in December and January with 41 (37.6%) each. In addition, one (0.9%) outbreak each in November and April, 20 (18.3%) in February (18.3%), and five (4.6%) in March were confirmed. A risk assessment system was developed to provide information on the risk of HPAI in poultry farms following the detection of H5/H7 AIV in wild birds. From the day before the collection of specimens with H5 AIV to the day of confirming the detection through laboratory test, livestock vehicles within a radius of 3 km from the sampling point were selected, and their visits to poultry farms were tracked. In this system, data on the trajectory of movement sourced from GPS devices attached to livestock vehicles were used [3]. As soon as H5 AIV detection was confirmed in wild bird specimens, the risk of HPAI was assessed for each region where poultry farms visited by these livestock vehicles were located. The regions were classified into four risk groups. In this risk assessment, deep learning techniques for farm level estimation, Gaussian mixture model for classification at region level, and K-means method for clustering were sequentially applied [4]. Risk was calculated for 151 regions in relation to 23 detections of H5 AIV in 2019/2020 and for 163 regions in relation to 234 detections of H5N8 HPAI in 2020/2021. The regions in 2020/2021 included all 48 regions where HPAI outbreaks were confirmed on poultry farms. The median number of regions that were linked to an AIV detection in wild birds through livestock vehicles was as follows: 53 (minimum–maximum: 3–15) in 2019/2020 and 46 (1–145) in 2020/2021. Most regions linked with the AIV detection points were in the central part of the country, including the southern part of Gyeonggi-do, northern Chungcheongnam-do, and northern Chungcheongbuk-do, which have considerable traffic. Several regions were linked when AIV was detected in Anseong (Gyeonggi-do), Asan and Cheonan (Chungcheongnam-do), and Cheongju (Chungcheongbuk-do) in 2019/2020. Similarly, in 2020/2021, the regions that were linked were Cheonan, Icheon (Gyeonggi-do), and Cheongju. Since the risk at regional level was independently assessed for every detection of AIV, a specific region might have been estimated several times. Regions for which the risk of HPAI were estimated most frequently were Cheongyang (Chungcheongnam-do, 17 times), Gongju (Chungcheongnam-do, 16 times), and Sangju (Gyeongsangbuk-do, 16 times) in 2019/2020. In 2020/2021, the regions were Pocheon (Gyeonggi-do, 141 times), Cheonan (133 times), and Anseong (132 times). This implies that vehicles that passed through the points of detecting wild birds with AIV visited farms in those regions the most. When the risk was weighted by these frequencies, the overall risk was the highest for Sangju (46 scores) followed by Cheonan and Asan (44 each) in

2019/2020. In 2020/2021, the highest risk was for Pocheon (430 scores), followed by that for Icheon (404), Hwaseong (Gyeonggi-do, 391), and Dangjin (Chungcheongnam-do, 391), and Cheonan (388). In the case of poultry, the highest number of HPAI outbreaks was confirmed in Icheon (7 farms). In addition, a number of outbreaks were confirmed in poultry farms in areas where high risks were predicted in association with the detection of HPAI virus in wild birds. HPAI was confirmed in six farms in Cheonan and four each in Pocheon and Hwaseong.

In 2019/2020, after passing 23 points of H5 AIV detection, 4,144 livestock vehicles visited 7,099 poultry farms for a total of 19,900 times. According to arithmetical calculation, one vehicle visited farms for 4.8 times. In 2020/2021, 16,580 livestock vehicles visited 26,635 poultry farms after passing 234 points of H5N8 HPAI virus detection. The total frequency of farm visits was 288,333, with 17.4 visits per vehicle. As for the number of vehicles by type, animal transport was the largest in both 2019/2020 and 2020/2021, followed by feed lorry, consultants, and egg transport. However, the frequency of farm visits per livestock vehicle varied depending on the year. In 2019/2020, the number of movements per vehicle was the largest for egg tray transport (9.7 times). The second and the third were for animal manure treatment (5.8) and veterinary pharmaceutical transport (5.6). In 2020/2021, movement was the highest for feed lorry (25.8 times), egg tray transport (24.1), and animal transport (17.7). The reason the frequency of farm visits per vehicle increased in 2020/2021 compared to 2019/2020 is interpreted as an association with the increase in the number of AIV detections. One vehicle might be related with several detections. It showed the necessity of intensive management on vehicles that are numerous or frequently moving, including animal transport, feed lorry, and consultant. The results of this study demonstrated that poultry farms with HPAI outbreak were observed in the regions with high risk of prediction. For example, both in 2019/2020 and 2020/2021, Cheonan was predicted to be at high risk, and the second largest number of farms with HPAI outbreak was confirmed in this region. In this study, risk assessment at the regional level was based on deep learning technique, multi-layer perceptron, and backpropagation, which had the characteristics of a black box. Therefore, as a limitation, the estimated risk could not be clearly explained [5]. Soon, indicators that can objectively understand risk factors (i.e., animal husbandry and environment of poultry, wild bird habitats, AIV detection status, and timing requirements) should be added.

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