

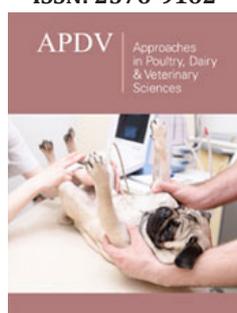
Surveillance of Highly Pathogenic Avian Influenza on Poultry Farms in Tracking Livestock Vehicles in the Republic of Korea

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Mini Review

Since the early 2000s, outbreaks of Highly Pathogenic Avian Influenza (HPAI) both in wild and domestic birds have continued worldwide. In the Republic of Korea, since the first confirmation of HPAI (H5N1) in a breeder chicken farm in December 2003, H5N8 and H5N6 HPAI viruses, as well as H5N1, have been detected for 20 years [1]. According to an investigation about geographical and environmental factors, outbreak timing, and phylogenetic characteristics of the isolated viruses, it was found that the causal virus was introduced to Korea in relation to the migration of birds for wintering [2]. This led the Korean animal health authority to implement a routine surveillance program for avian influenza, which involves sample collection from wild birds (feces or capture), monitoring at slaughterhouses, periodic laboratory tests for breeding farms of chicken and duck, pre-shipment tests (slaughter and eggs), and periodic inspections on live bird markets. Considering that the HPAI is associated with H5 and H7 types of Avian Influenza Virus (AIV), these two types of AIV must be dealt with promptly upon a HPAI outbreak [3]. In the surveillance of wild birds, the H5/H7 AIV can be detected as early as August and September, and usually from October every year. From October 2017 to April 2021, the monthly distribution of positive samples was 0.4% in August, 0.2% in September, 5.6% in October, 14.6% in November, 21.2% in December, 32.8% in January, 17.3% in February, 7.3% in March, and 0.6% in April. The number of positive samples sharply increased from November. Meanwhile, the number of winter birds (species of ducks and geese) were largest in December and January with 430,000 in October, 967,000 in November, 1,113,000 in December, 1,092,000 in January, 858,000 in February, and 220,000 in March in the winter of 2020/2021 [4], although it should be considered that the number of observations varied across months. This implies the necessity of preemptive risk management for the influx period of migratory birds in late autumn. Once H5/H7 AIV is detected in wild birds, the risk of avian influenza is estimated for each poultry farm to which livestock vehicles visited after passing through within a 3km radius of an AIV detection site from the day before to the day of laboratory confirmation. The risk was analyzed and communicated to the national and local animal health authorities for all of 519 H5/H7 AIV detections in 2017/2018 (53), 2018/2019 (73), 2019/2020 (24), and 2020/2021 (369).

Livestock vehicles can be tracked because all data related to animal health, including livestock vehicles, livestock facilities, and vehicle movement, are registered in a database called Korea Animal Health Integrated System (KAHIS) [5]. All business vehicles listed in the domain of livestock are required by law to be registered to the regional administration (city/county) office and have a Global Positioning System (GPS) device installed. For livestock facilities such farms, factories, and slaughterhouses, on the other hand, GPS ranges must be set [6]. When a vehicle with devices enters the boundary, the vehicles' device says, "You visit a

livestock facility”, then within a few minutes, “A visit record is sent.” Vehicles are registered in 19 types according to the transported goods and the driver’s work. As of October 2021, 61,768 vehicles were registered: animal transporter was the most numerous with 22,767 (36.86%), followed by 12,058 (19.52%) feed lorries and 7,165 (11.60%) farm managers. A total of 290,830 livestock facilities are registered in KAHIS, most of which are farms (279,317, 96.04%). According to the KAHIS records, the numbers of farms are 94,113 for Korean native chicken, 3,487 for broiler chicken, 1,600 for layer chicken, 562 for breeder chicken, 2,079 for broiler duck, and 139 for breeder duck [5]. Since KAHIS registration duplicates all livestock species in case one farm keeps multiple species of livestock, the data are more appropriate for individual farm management than statistical use.

According to the official statistics of the National Statistical Office for the third quarter of the year 2021, the number of farms (heads in thousands) for broiler chicken is 1,514 (83,639), layer chicken 941 (70,722), broiler duck 400 (6,882), and breeder duck 61 (648). All farms with more than three thousand chickens or two thousand ducks are censused. The administrative districts of Korea consist of one special city (Seoul), seven metropolitan cities, and eight provinces. Considering that metropolitan cities are central cities of adjacent provinces; metropolitan cities are included in their adjacent provinces in the statistics in this study. The regions with the most layer chicken farms were Gyeonggi-do (22.74%) surrounding Seoul, Gyeongsangbuk-do (16.90%) adjacent to Busan and Daegu, the second and third largest cities in Korea, and Chungcheongnam-do (15.09%). In case of broiler chicken, the largest number of farms is in Jeollabuk-do (22.99%), Chungcheongnam-do (18.30%), and Gyeonggi-do (16.91%). The regions with the most duck farms were Jeollanam-do (52.00%), Jeollabuk-do (25.50%), and Chungcheongbuk-do (9.50%), located in the southwest [7]. Among livestock facilities, hatcheries and slaughterhouses for chickens are most common in Chungcheongnam-do (22.47% and 18.28%, respectively), and the slaughterhouses for ducks are in Jeollanam-do (42.31%) and Jeollabuk-do (23.08%). Gyeonggi-do (21.56% for the northern part and 20.82% for the southern part) has the largest number of registrations for edible eggs grading and packing center. To use data for understanding the spread of AIV related to vehicle movement, records on movement of livestock vehicles linked to poultry farms were analyzed for a one-year period from September 2020 to August 2021. The number of GPS records were 22,183,541 for which visiting chicken farms and 12,579,145 for duck farms. The number of movements of livestock vehicles was highest in Chungcheongbuk-do (15.65%), followed by Chungcheongnam-do (13.92%) and Jeollanam-do (13.38%) for chicken farms. The percentage was 15.15% in Jeollabuk-do, 14.61% in Chungcheongnam-do, and 13.20% in southern

Gyeonggi-do for duck farms. As for the movement between livestock facilities, 87.96% of vehicles visited chicken farms and 88.13% of vehicles visited duck farms within the same region. In the case of chickens, movement from Jeollanam-do to Jeollabuk-do was most common, followed by from Jeollabuk-do to Jeollanam-do, and from Jeollabuk-do to Chungcheongnam-do. The first and second places in the movement of vehicles visiting duck farms were the same as chicken farms, but the frequency of vehicle movement from southern Gyeonggi-do to northern Gyeonggi-do was third. The most frequent vehicle type visiting poultry farms was animal transport, followed by feed lorry, egg transport, farm manager, and livestock manure transport. In ducks, it is different from chickens that the egg transport is missing from the list of the frequent visit. Livestock facilities visited most by livestock vehicles entering the chicken farm were feed factories, edible egg grading and packing center, slaughterhouses, livestock manure treatment plants. A same tendency was shown in duck farms, except for lacking of edible egg grade and packing center visits in the list. Tracking vehicle’s movement trajectory showed that 82.08% of feed lorry, 86.14% of livestock transport, 87.60% of egg transport, and 98.80% of farm manager vehicles moved within the same region. In this study, records of livestock vehicle movements linking poultry farms and livestock facilities were analyzed. Acquisition and utilization of such data are expected to increase gradually with advances in information and communication technology. The information-based surveillance system will contribute to preemptively responding to transboundary animal disease such as HPAI.

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