Department
for Environment
Food & Rural Affairs

Highly pathogenic avian influenza H5N1 rapid risk assessment

Catching-up of wild gamebirds in winter 2022 to 2023

January 2023

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Executive summary

The shooting season for pheasants in Great Britain ends on 1 February each year. In England those shoots that “catch-up” surviving birds for breeding have to complete by 1 February, although in Scotland this extends to 28 February. Wild (formerly wild) game birds once caught up are classified as captive game birds or poultry. The probability of wild (formerly wild) game birds caught up at the end of the 2022/23 shooting season in Great Britain being infected with highly pathogenic avian influenza (HPAI) H5N1 is assessed here. This probability at the “per shoot” level is assessed to be low, albeit at the “medium end of low”.

The uncertainty in this low risk “per shoot” level is high due to the estimate for the probability per infected shoot that not one infected pheasant is detected at point of catching up. This presumes that a proportion of infected birds is not presenting clinical signs at point of catching-up and therefore would be caught up. This also depends on the number of birds caught up per shoot and the expected prevalence of infection in the wild bird population. For example, the average number of pheasants caught-up per shoot is 206 birds. The local environmental contamination would depend on the habitat and the distance to an aggregation of infected wild birds, but in some cases it could be significant. In this scenario, if 1% of those pheasants were infected, then there would be two infected birds per shoot, of which neither, one or both may still be in the incubation period and hence not showing signs. Even if the two infected birds are showing signs they may be missed within the flock where there may regularly be dead birds resulting from other causes. Once caught up, infection would spread through the flock resulting in more sick birds and hence detection and reporting as an infected premises (IP).

Since the caught-up pheasants are classified as captive birds once deliberately brought together, an infected shoot is essentially an IP. Based on 1,000 shoots catching up pheasants across Great Britain, the probability of catching up in the winter of 2022 to 2023 leading to one or more new IPs at the “per Great Britain” level is very high. The uncertainty in this risk is low because of the large number of shoots.

In the absence of data on the prevalence of HPAI H5N1 in pheasants in Great Britain, the duration of viraemia and mortality rates, the number of IPs cannot be predicted with any accuracy. Some estimates are made here to demonstrate a prototype quantitative model. Assuming 1,000 shoots catching up in the winter of 2022 to 2023 and a “between-pheasant” flock prevalence of 1% for H5N1, the simple model would predict 10 new IPs provided no infected pheasants were detected at point of catching up (it is assumed that detection of sick pheasants would prevent catching up). According to the model this number decreases with increasing flock size and increasing probability of detection of an infected pheasant, but would increase with a higher between flock prevalence.

Risk question

1. Wild (formerly wild) game birds once caught up are classified as captive game birds or poultry. What is the risk of wild game birds caught up at the end of the 2022 to 2023 shooting season, being infected with HPAI H5N1 at the “per shoot” level?
2. What is the risk of this leading to one or more new infected premises at the “per Great Britain” level?

Overall approach

The ideal approach would have been to develop a quantitative risk assessment to estimate the number of IPs generated through the catching up process across Great Britain. However, the lack of data, particularly for the within flock and between flock prevalence of infection, prohibits the accurate parameterisation of such a quantitative model. The approach taken is therefore to develop a qualitative risk assessment to address the risk questions. The output of this qualitative approach (namely the probability of one or more new IPs through catching up) is limited by not being able to estimate the number of IPs across Great Britain from catching up. Nevertheless, the potential for a new IP as a result of this activity is a plausible outcome, based on the case in Wales in 2021. Not being able to estimate the number of IPs only becomes a limitation if the qualitative approach predicts a high or very high probability of at least one new IP in Great Britain in 2022 to 2023. Results from a hypothetical quantitative model are therefore presented to illustrate how the number of IPs could be predicted were data available and to show how changing certain input parameters affects that number.

Number of shoots catching up and number of pheasants caught up per shoot

There are over 10,000 shoots in the UK, but the majority do not catch-up. Dominic Boulton (The Game Farmers’ Association) estimates 500 to 1,000 shoots do catching-up. Mallard and red-legged partridges are rarely caught-up. However, pheasants are caught-up in significant numbers. This risk assessment therefore focuses on pheasants.

Data are not available on the number of pheasants caught up in Great Britain, but expert opinion provides a figure estimated from the number of pheasants reared annually (D. Boulton, personal opinion). Based on 42.5 million pheasants being reared annually in Great Britain, and assuming a hatching rate of 75%, it is estimated that 56.7 million eggs are laid annually. Since 45% are imported, 55% (31.1 million) are from UK birds. If each hen lays 50 eggs, then there would be 623,333 hens annually from the UK. However, only a third of these are from catching up, the rest being kept in captivity over winter for restocking supply. Thus 205,700 hens are estimated to be caught up annually (generally between 26 December and 1 February in England). Based on 1,000 shoots this represents an average of 206 hens caught up per shoot.

Assumptions and data

The assumptions and data are described more fully in the risk assessment. The key assumptions and data are:

1. The data regarding numbers of pheasants caught up per shoot and the number of shoots in Great Britain catching up in January comes from expert opinion (one expert from Game Farmers Association) rather than empirical data. Those data are used as a real world scenario for the purposes of the qualitative risk assessment here.
2. The pheasant contact rate in January with wild ducks, geese and swans (Anseriformes) on farmland habitat (fields) is very high and with gulls on grassland habitat is high with contacts with other wild birds assumed to be the same as set out previously for July and August in the gamebird release risk assessment.
3. While most infected pheasants will show overt clinical signs following the incubation period, infected pheasants will be regularly missed during catching up and go on develop an IP.

Qualitative risk assessment

The approach is to calculate the probability, p_{shoot}, of gamebirds caught up in the winter of 2022 to 2023 being infected with HPAI H5N1 and leading to an IP at the "per shoot" level. This is the output of risk question 1. The output of risk question 2 is then the aggregated probability taking into account both p_{shoot} and the number, N_{shoot}, of shoots catching up birds across Great Britain in the winter of 2022 to 2023. The term "aggregated probability" means the total probability across all shoots in Great Britain.

Entry assessment

Risk question 1 (RQ1). What is the risk of wild (formerly wild) game birds, caught up at the end of the 2022 to 2023 shooting season and hence being classified as captive gamebirds or poultry, being infected with HPAI H5N1 at the "per shoot" level?

Since the caught-up pheasants are captive birds once they have been deliberately brought together, an infected shoot is essentially an IP. The risk pathway for a shoot becoming an IP from catching up is shown in Figure 1 and the risk assessment is set out in Table 1.

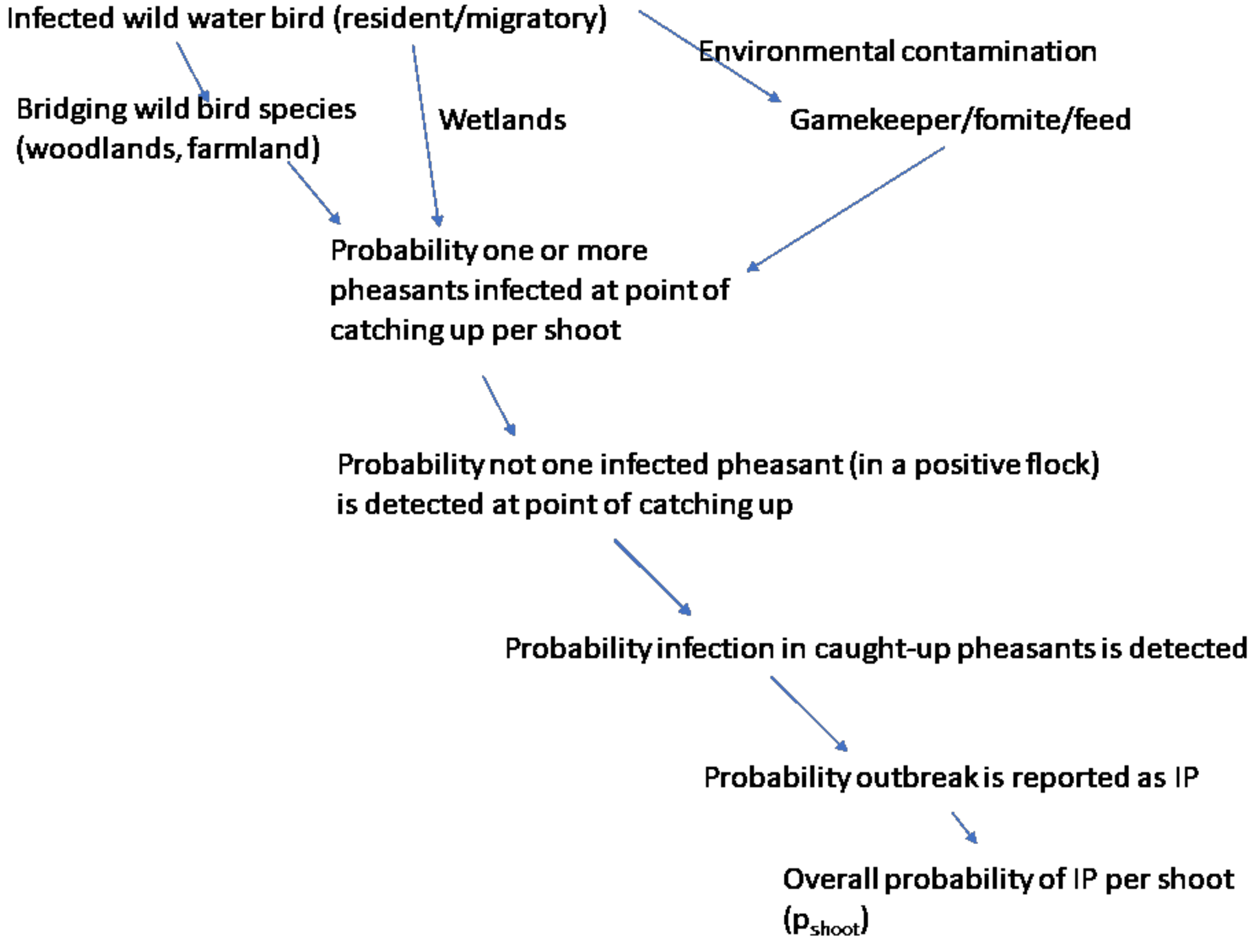

Figure 1: Risk pathway for shoot becoming an IP from catching-up pheasants

Released pheasants could be infected through two routes namely:

1. Contact with infected wild birds
2. Fomite contact with gamekeepers and their equipment or dogs during feeding and catching up.

A risk assessment previously conducted for risk of infection of wild bird groups through released pheasants set out the number of contacts between pheasants and wild birds in a range of habitats taking into account wild bird abundance in each habitat and the probability of pheasants being present. This is for the months of July and August when the pheasants are released and presented in Appendix 1. It is assumed here that these contacts remain broadly similar for the month of January when those pheasants are caught-up which the exception of the very high contacts for pheasants with wild ducks, geese and swans which feed on farmland fields in January and for the high contacts for pheasants with gulls on grasslands in January. This contact interaction can be considered to work both ways for the spread of highly pathogenic avian influenza virus (HPAIV). Contacts are high or very high for pigeons, passerines, corvids, waders and gulls particularly in farmland, woodlands and wetlands habitats. Contacts with Anseriformes are very high in farmland in winter and medium in freshwater habitats and high in wetland habitats. On the basis that most wild bird HPAI H5N1 cases (in December 2022) are in resident ducks (mallards), geese (Canada geese) and swans (Mute swan), it may be assumed that there are multiple contacts between pheasants and infected Anseriformes at wetland, farmland and freshwater habitats. Gulls are also regularly reported in the H5N1 wild bird cases as are some pigeon/dove cases more recently. Thus further contacts with infected gulls and pigeons could also occur at farmland, woodland and wetland habitats. Birds of prey can be excluded as they are generally dead ends in terms of spreading infection to pheasants.

Gamekeepers could also pick up infectivity as fomites from environmental contamination from infected wild birds. However, this would be no more than the released pheasants experience as wild birds, and the gamekeepers may even use some biosecurity measures to reduce the exposure.

While the number of contacts of wild ducks, geese and swans, gulls and pigeons with wild pheasants on farmland habitats is considered to be high to very high (as set out in the Appendix) not all wild ducks, geese, swans, gulls and pigeons are positive for HPAIV H5N1.The probability that at least one pheasant is infected at the point of catching up at a shoot is the same as the “between shoot” prevalence and, given the very high number of contacts of pheasants with wild birds in January, represents the H5N1 prevalence for a local group of wild birds at a given time point (such as the time point at catching up) and/or the likelihood of the gamekeepers introducing infection through the use of contaminated equipment during the process. While the national Great Britain wild bird risk is currently (22 December 2022) very high, the actual proportion of local wild bird “groups” with infected birds may be lower and is assessed here to be medium. That is, HPAI infection in separate localised groups of wild birds at a given point in time “occurs regularly” (medium) rather than “very often” (high) or “almost certainly” (very high).

There will clearly be variation from one shoot to another depending on the habitat and the proximity to areas with higher densities of HPAIV-infected wild birds, although there now seems to be a broad range of wild bird species infected with H5N1 across Great Britain representing a range of habitats. The increase in the number of reported cases in sparrowhawks in Great Britain is of note as it suggests HPAIV prevalence in smaller passerines as sparrowhawks are typically woodland birds favouring similar habitats to pheasants. There has also been an increase in pigeon and dove cases, again bird species that could contact pheasants. The prevalence of antibodies against avian influenza virus H5 in hunted pheasants in Germany was 0.5% (Gethöffer et al. 2021). This was from sera of 604 hunted pheasants collected from 2011 to 2015 when AIV prevalence in wild birds in Germany would have been lower than currently in Great Britain.

In the three weeks between 13 October 2022 and 4 November 2022, a total of 36 pheasants tested positive in Great Britain at 12 Ordnance Survey (OS) Map Reference sites in England and Wales and just 14 tested negative at two sites. On the basis that there are 10,000 shoots in Great Britain, the 12 sites would equate to 0.12% of shoots being positive. Of course, the affected pheasants may not have come from a shoot and many infected pheasant cases may not have been found or reported because of not meeting the threshold number of dead birds or HPAI already confirmed in the area in the previous two weeks.

The probability is assessed to be medium (occurs regularly) that not one infected pheasant (in the positive flock) is detected at the point of catching up at the premises. Therefore, if not one infected pheasant is detected in the positive flock that infected flock is missed to become an IP. Here, it is argued that for an infected flock, only those infected pheasants in the incubation period and hence not showing clinical signs would be missed. There may also be recovered birds that are still shedding, that would be missed too. Since the incubation period may be as long as one day or even two days there is a chance of infected birds being present that are not showing clinical signs. Thus, some HPAIV H5N6-infected pheasants were apparently still healthy at two days post infection and would not have been detected (Liang et al 2022). Clinical sings ranging from mild to severe were experienced 24 to 48 hours prior to death (Liang et al. 2022). However, the more birds caught up, the greater the probability that at least one bird would be past the incubation period and showing signs (and hence detected), although it is quite possible that such birds would be hidden in undergrowth and dying and therefore not caught up. It is not known what proportion of infected pheasants would not exhibit any clinical signs and would be infectious. Furthermore, the relatively high baseline mortality rates in pheasants at release sites for shoots could result in pheasant deaths from HPAI not constituting excessive deaths and hence not being noticed as indicating the presence of HPAI infection.

Although on average 206 female pheasants are caught up per shoot, only a small proportion may be infected and some of those may not be showing signs of infection and missed. For example, if 1% were infected then in a flock of 206 birds (the average caught up) there would be two infected birds of which some may still be in the incubation period and hence not showing signs. This leaves just one or two birds showing signs in the whole flock within which there may regularly be dead birds resulting from other causes. It is concluded that these few infected birds could be “regularly” missed, hence the medium probability that not one infected pheasant is detected at point of catching up. The number of birds caught up per shoot may vary from only a few birds to some shoots catching up thousands of pheasants. Shoots in certain areas and with a smaller number of birds caught up may have fewer infected birds, so that there is a lower chance of at least one infected bird being observed at point of catching up. While larger gatherings could have higher numbers of infected birds, the sheer number of birds may hinder recognition by the keeper as being a sign of an infectious disease. Although moribund birds would be spotted, they may not be sufficiently mobile to be caught up and may lie undetected in the undergrowth for example. Female pheasants are very well camouflaged and tend to go around in groups with a male bird. Infected birds that are not caught up because they are moribund would not contribute to the IP but their failure to be detected may disguise the presence of other infected cases in the incubation period in those being caught up.

Once the pheasants have been caught up into a tight group with multiple contacts, infection will rapidly spread within the group such that the proportion infected increases greatly with large numbers of birds infected. HPAIV H5N6 was transmitted efficiently between pheasants (Liang et al. 2022) with up to 100% mortality. Given ring-necked pheasants have high mortality from HPAI infection (up to 60% in the case of HPAIV H5N8 (Brookes et al. 2022) and 10% in the case of HPAIV H5N2 (Ajithdoss et al. 2017)), the probability that an infected group of caught-up pheasants is detected is assessed to be high. The probability of its being reported as an IP is assessed to be high (occurs very often). This assumes that a premises with infection only becomes an IP when it is reported.

Combining the four probabilities, the overall probability of infection "per shoot" is low (Table 1), albeit at the "medium end of low". This is based on two medium risks such that "medium x medium equals a low", albeit at the medium end of low. The uncertainty is high mainly due to the uncertainty in the probability that not one infected pheasant is detected (in a positive flock) at point of catching up.

Table 1: Qualitative risk assessment for risk question 1. The risk of infection per shoot.

Description of step in pathway	Probability	Uncertainty
Probability one or more pheasants infected at point of catching up (per shoot)	Medium	Low. Depends on size of catching and locality of shoot
Probability not one infected pheasant is observed (in a positive flocks) at point of catching up	Medium	High. Applies mainly to infected birds in the incubation period not showing signs. Decreases with increasing size of caught up flock because more pheasants mean more likely at least one infected bird is showing signs and hence observable at point of catching up.
Probability that infection in a caught-up flock of infected pheasants is observed	High	Low. Given infection will spread through the caught-up birds in the pen and that a high proportion of those infected pheasants will show clinical signs (Brookes et al 2022).
Probability outbreak is reported as IP	High	Medium. Gamekeepers would very often report infection on detection.
Overall probability, p_{shoot}, of IP per shoot	Low	High

The low probability is calculated as "medium x medium". Note at medium end of low.

It is concluded that the probability, p_{shoot}, of wild (formerly wild) game birds, caught up at the end of the 2022 to 2023 shooting season and hence being classified as captive gamebirds or poultry, being infected with HPAI H5N1 at the "per shoot" level is low, albeit at the medium end of low. Since the caught-up pheasants are captive birds, once they have been deliberately brought in, an infected shoot is essentially an IP.

Exposure assessment

Risk question 2 (RQ2). What is the risk of this leading to one or more new infected premises at the "per Great Britain" level?

This is the aggregated probability taking into account the probability "per shoot" from RQ1 and the number of shoots across Great Britain that are catching up in the winter of 2022 to 2023. The quantitative value of N_{shoot} and the qualitative value of p_{shoot} are combined using the approach of Kelly et al. (2018) to give an aggregated risk for p_{GB}. Thus, N_{shoot} of 1,000 shoots catching up pheasants for the winter of 2022 to 2023 is 3.0 $\log_{10}$ units and reading across the y = 3.0 in Figure 2 gives the corresponding aggregate risk value of p_{GB}.

The probability, p_{shoot}, for the individual probability (the X axis) is at the "medium end of low", and the aggregated probability, p_{GB}, of one or more IPs is therefore very high. The uncertainty in this estimate is low because of the large number of shoots and the fact that the value of p_{shoot} is at the medium end of low such that p_{GB} is well inside the very high contour as represented by the dark red area in Figure 2.

It is concluded, based on 1,000 shoots catching up pheasants across Great Britain, that the probability of catching up in winter 2022 to 2023 leading to one or more new infected premises at the "per Great Britain" level is very high.

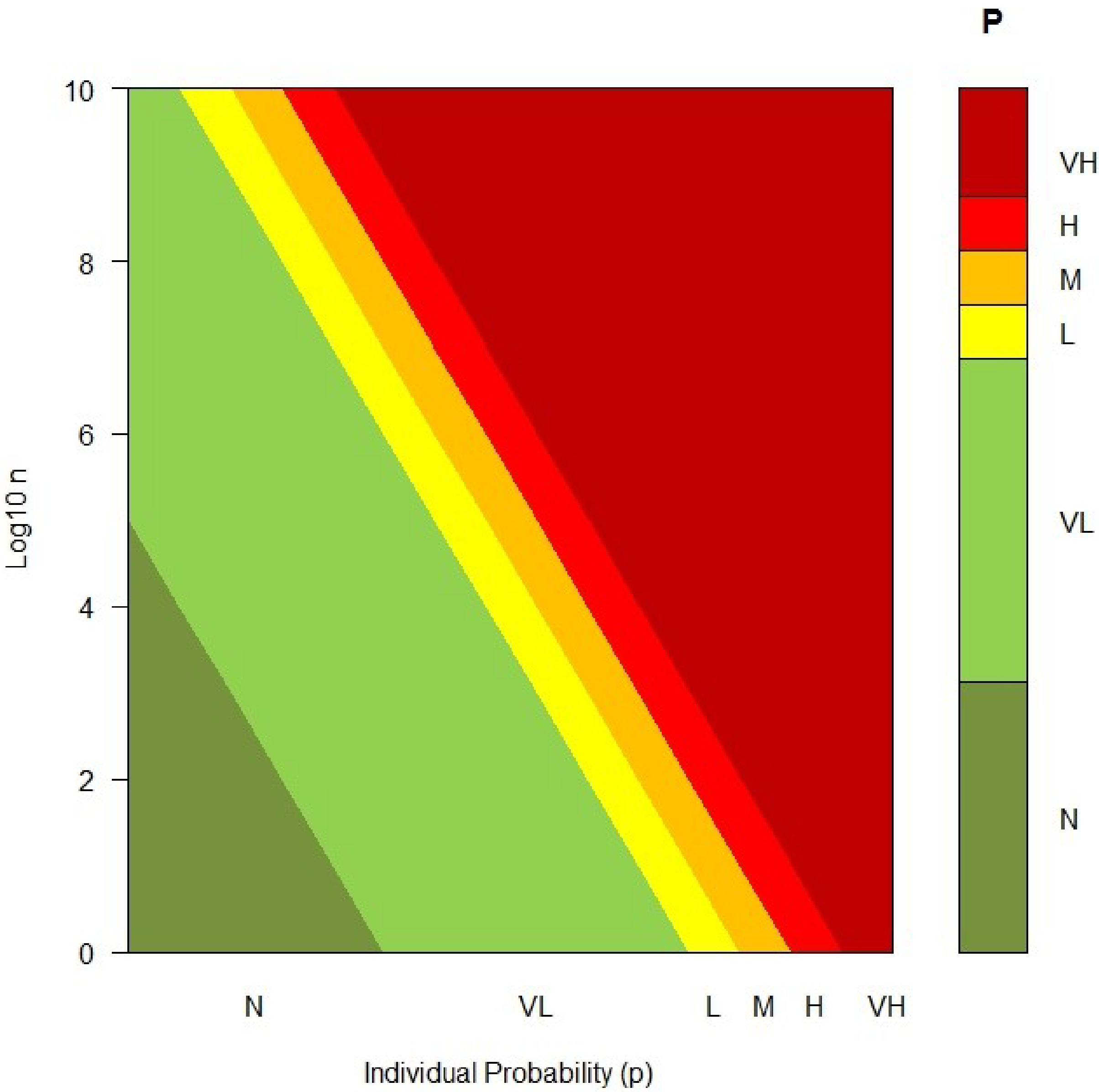

Figure 2: Contour plot for the aggregated probability (adapted from Kelly *et al.* 2018)

Consequence assessment

Onward spread to other IPs.

According to the Game Farmers' Association, a lot of breeding game farms are located close to the shoots they provide so most caught-up birds will remain fairly local but this is not always the case. Even local movement could result in new IPs. The risk from onward spread from caught up flocks to other premises is not considered here but would present a considerable risk where biosecurity is poor. Pheasants infected naturally with HPAIV H5N8 exhibiting even mild clinical signs maintained substantial levels of virus replication and shedding, with preferential shedding via the oropharyngeal (mouth/nose) route (Brookes et al. 2022). This supported epidemiological conclusions confirming that the movement of birds between sites and other standard husbandry practices with limited hygiene involved in pheasant rearing (including several fomite pathways) contributed to HPAIV H5 spread between premises. It should be noted that experimental data for this H5N1 strain in pheasants is not available. Our current surveillance reports those positive samples which were taken from naturally infected birds collected at time of disease suspicion, contact tracing, report case or cull and individual birds were not followed. Therefore, the exact times of maintenance of viral shedding are not known, although across a flock, shedding could be maintained for a period of days or even weeks.

Demonstration of a prototype quantitative model

The model is based on 1,000 pheasant flocks which are to be caught up in UK, of which 1% are infected. This equates to 10 positive flocks. Therefore, the worst case, with no detection of infected birds at point of catching up, is 10 IPs arising from catching up.

$$N_{positive\_flocks} = Number_{flocks} \times p_{flock}$$

Where p_{flock} is the probability that a flock is positive.
The key barrier is detection or identification of infected pheasants at the point of catching up, so that the gamekeepers stop the process before it becomes an IP. This is going to depend on the number, $N_{infected\_birds}$, of infected birds in the flock and the probability, p_{detect}, that a given individual infected bird is detected during catching up.

The probability, $p_{fail\_detect\_flock}$, that a positive flock is NOT detected is given by

$$p_{fail\_detect\_flock} = 1 - p_{detect} N_{infected\_birds}$$

Where the number of infected pheasants in a flock is given by

$$N_{infected\_birds} = N \times P_{pheasant\_infected}$$

Where N is the size of the flock *and $p_{pheasant\_infected}$ is* the probability that a pheasant is infected at point of catching up.

So if there are N = 206 pheasants caught up per flock, and 1% are infected, then there are 2.06 positive *birds ($N_{infected\_birds}$)*

The number of IPs is then calculated as

$$N_{IPs} = N_{positive\_flocks} \times p_{fail\_detect\_flock}$$

The size, N, of the flock caught up and the probability, $p_{\_detect}$, each individual infected pheasant is detected during catching are therefore key parameters as this table shows.

Table 2: Output of quantitative model, based on 1,000 shoots catching up gamebirds in winter 2022 to 2023. The percentage of shoots with infected pheasants is assumed to be 1%. The percentage of pheasants infected at point of catching is assumed to be 1%.

Size, N, of flock caught up, number of birds caught up per shoot	$p_{\_detect}$	Predicted numbers of IPs (N_{IPs}) in Great Britain in the winter 2022 to 2023
1000	0.1	3.4
1000	0.25	0.6
1000	0.50	0.01
206	0.1	8
206	0.25	5.5
206	0.50	2.4
100	0.1	9
100	0.25	7.5
100	0.5	5
10	0.1	9.9
10	0.25	9.7
10	0.5	9.3

The value of 206 birds for the size of the flock is the average value per shoot calculated form data provided by Dominic Boulton (Game Farmers' Association).

According to the model, the smaller the flock, the greater the chance of failing to detect.

Additional information provided by the Game Farmers' Association

The Game Farmers' Association provided additional information to reduce the uncertainty in this risk assessment.

Source of uncertainty	Impact on the outcome of the risk assessment
Mortality rate during catching up	Understood to be very low under normal circumstances but some uncertainty remains about whether disease could be introduced and spread while birds are in the holding pen, and whether normal background mortality masks initial cases of HPAI disease.
Time for catching-up	Catching pens are checked daily, catching up can take days or weeks depending upon how many are required but normally 1 -2 weeks, the weather often has an impact on how long it takes. They would be transferred to a crate and taken to a holding pen on site. On larger estates there is likely to be more than one holding pen so the birds will be split into batches, making management and monitoring easier.
Level of awareness of clinical signs	There is a very high level of understanding of the symptoms seen due to the sectors efforts in educating the keepers. If there were concerns, the shoot would contact their vet, cull the bird immediately and await further instructions
Reporting of cases	In most cases a shoot would report to their vet first and then if suspected report to APHA.
Level of mixing between birds from wide geographic areas	Probably limited but several hundred birds may be held in a pen and may have come from several kilometers apart. The greater the density of birds in a pen, the more will be infected in a shorter space of time.

Conclusion

This assessment considers the potential for wild game birds (namely pheasants) in Great Britain to be infected with HPAI H5N1 at the point of catching up such that infected birds are not detected. There is some uncertainty relating to the prevalence of HPAI in wild birds including pheasants through January, but this is very low (based on expert opinion which expects the epizootic in wild birds in Great Britain to continue well into March). There is also some uncertainty about the course of infection in gamebirds. It is quite possible that they will develop clinical signs rapidly and will not recover in which case they would not be caught up. However, where there is infection present, it is plausible that at least one infected bird will not be detected at the point of catching up given infection is present in the flock. While the risk is low for an individual shoot, the aggregated risk level increases to very high, that across Great Britain, at least one shoot may catch up an infected bird. Where this occurs, because of the management of the birds, infection will spread rapidly and clinical signs will be observed and reported, leading to a new infected premises being declared.

It is also possible that gamebirds have been exposed to infection during the winter months, since release and that by the time of catching-up, the survivors will be exposed and immune. Therefore, vigilance by the gamekeeper will provide assurance in the days following catching-up that there is not widespread infection in the sector.

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Appendix 1

Table 3: Estimated number of contacts between wild birds and released pheasants calculated by combining the likelihood of pheasants being present (see gamebird release risk assessment) with the number of contacts these pheasants would be expected to have with wild birds (see gamebird release risk assessment). Note that the wild bird abundance at each habitat was estimated for the months of July and August in Great Britain for the game bird release assessment. This has been modified to accommodate the larger number of ducks, geese and swans on Great Britain farmland habitats in winter and the larger number of gulls on grassland habitats in winter.

Habitat Type	Anseri-formes	Pigeons	Birds of prey	Owls	Passer-ines	Corvids	Sea-birds	Waders	Gulls	Pheas-ants
Coastal Habitats	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg	Neg
Farmland	Very high	Very high	High	Medium	High	Very high	Neg	Low	Very high	Very high
Freshwaters	Medium	Very low	Very low	Very low	Very low	Low	Neg	Medium	Medium	Very low
Grasslands	Low	Low	Low	Low	Low	Medium	Neg	Low	High	Medium
Heathlands	Neg	Low	Low	Low	Low	Low	Neg	Neg	Neg	Medium
Mountains	Very low	Very low	Very low	Very low	Very low	Very low	Neg	Neg	Neg	Low
Rocky Habitats	Neg	Neg	Very low	Very low	Very low	Very low	Neg	Very low	Very low	Low
Scrub	Neg	Low	Low	Very low	Low	Low	Neg	Neg	Neg	Medium
Wetlands	High	Low	Low	Very low	Low	Low	Neg	High	High	Very low
Woodlands	Neg	Very high	High	Medium	Very high	Very high	Neg	Neg	Neg	Very high
Urban Habitats	Low	Medium	Very low	Very low	Low	Medium	Neg	Neg	Medium	Very low

The number of contacts for Anseriformes on farmland is increased from medium to Very high because many ducks, geese and swans feed in fields in winter (much less so in July and August).

The number of contacts for gulls on grasslands is increased from low to High because many gulls feed on grasslands in winter (much less so in July and August).