Question to EURCAW-Poultry-SFA

Reference of the query: Q2E-Poultry-SFA-2021-006
Query received: 21.12.2021
Date of admissibility: 05.01.2022
Replied sent: 29.07.2022
Version2: 13.01.2022

Background context provided by the solicitor

None

Question

"We require an overview of the different on farm killing methods for turkeys and ducks, due to disease control situations (avian influenza).- This overview should have in consideration the depopulation good practices and experience, and also have regard to the following items:

- *Practicability of the different methods and solutions*
- *The efficiency of the different methods, especially the ones applicable inside the houses (very open houses due to hot weather conditions)*
- *Variability of animal weights (males up to 20-21 kg)-Animals with big weights and aggressive behaviour can pose additional handling challenges"*

Answer

1. Legal requirement about depopulation

The Regulation 1099/2009 states the following points in regard to depopulation:

Chapter IV, article 18:

1. The competent authority responsible for a depopulation operation shall establish an action plan to ensure compliance with the rules laid down in this Regulation, before the commencement of the operation.

[…]

3. For the purposes of this Article and in exceptional circumstances, the competent authority may grant derogations from one or more of the provisions of this Regulation where it considers that compliance is likely to affect human health or significantly slow down the process of eradication of a disease

4. By 30 June each year, the competent authority referred to in paragraph 1 shall transmit to the Commission a report on the depopulation operations carried out during the previous year and make it publicly available via the Internet. […]

Annex I:
Methods authorized for depopulation of turkey and ducks: penetrative captive bolt device (simple stunning), non-penetrative captive bolt device (simple stunning), fire arm with free projectile, cervical dislocation for animals up to 5 kg (manually up to 3 kg), percussive blow to the head for animals up to 5 kg, head-only electrical stunning, head-to-body electrical stunning (simple stunning), electrical waterbath (simple stunning except where frequency is equal to or less than 50 Hz), carbon dioxide at high concentration (except in ducks), carbon dioxide in two phases (simple stunning for poultry if the overall duration of exposure to at least 30 % of carbon dioxide is of less than 3 minutes), carbon dioxide associated with inert gas (simple stunning for poultry if the duration of exposure to anoxia is of less than 3 minutes), inert gas, carbon monoxide, carbon monoxide associated with inert gas, lethal injection.
Annex I also specified about ducks and turkeys:

- Carbon dioxide in high concentration is not authorized for ducks.
- Head-only electrical stunning should be with a minimal current of 400 mA for turkeys.
- In waterbath stunning the current should be applied for 4 s, with a minimal current of 130 mA and with <200 Hz in ducks; with a minimal current of 250 mA when <200 Hz and with a minimal current of 400 mA when > 200 Hz in turkeys.

2. Introduction

The 2021–2022 highly pathogenic avian influenza (HPAI) epidemic season is the largest epidemic so far observed in Europe, with a total of 2,329 outbreaks in poultry and 2,632 in non-poultry including wild birds (Figure 1). In this period, 46 million birds have been culled in the European Union (EFSA, 2022). HPAI is currently striking poultry farms in 20 out of 27 Member States (European Commission, 2022) and require a quick and efficient killing of the complete population of birds in the farm (*i.e.*, depopulation).

It is of great challenge to choose the most appropriate method for depopulation in response to urgent circumstances while considering the welfare of the birds since many logistic and welfare variables affects the choice.

In terms of logistics, the availability of equipment, skilled personnel and the biosecurity, cost and time are issues that have to be dealt. On the other hand, to ensure bird welfare, the depopulation method chosen should consider the specie, the body weight, the size of the flock and the housing system to design a plan for an emergency killing.

In farms allocated in warm areas of the EU, with heavy birds housed in open-sided barns are undoubtedly those present the most challenges in case of disease outbreak. Thus, in order to gather experience on the election about depopulation methods for this specific situation, the Centre sent a survey to the competent authorities (CAs) of the 27 Member States in which were encouraged to list the methods that are currently using to depopulate turkeys and ducks according to the size of the flock and average body weight. Three categories were applied for size of the flock (i.e., small: when flock was

below 500 birds; medium: when flock was between 500 and 1,000 birds and large: when flock was greater than 1,000 birds). An additional category was created in turkeys according to their average body weight (*i.e.*, < 5 kg, 5 to 10 kg and > 15 kg). Key parameters, time spent per flock and pros and cons were also asked.

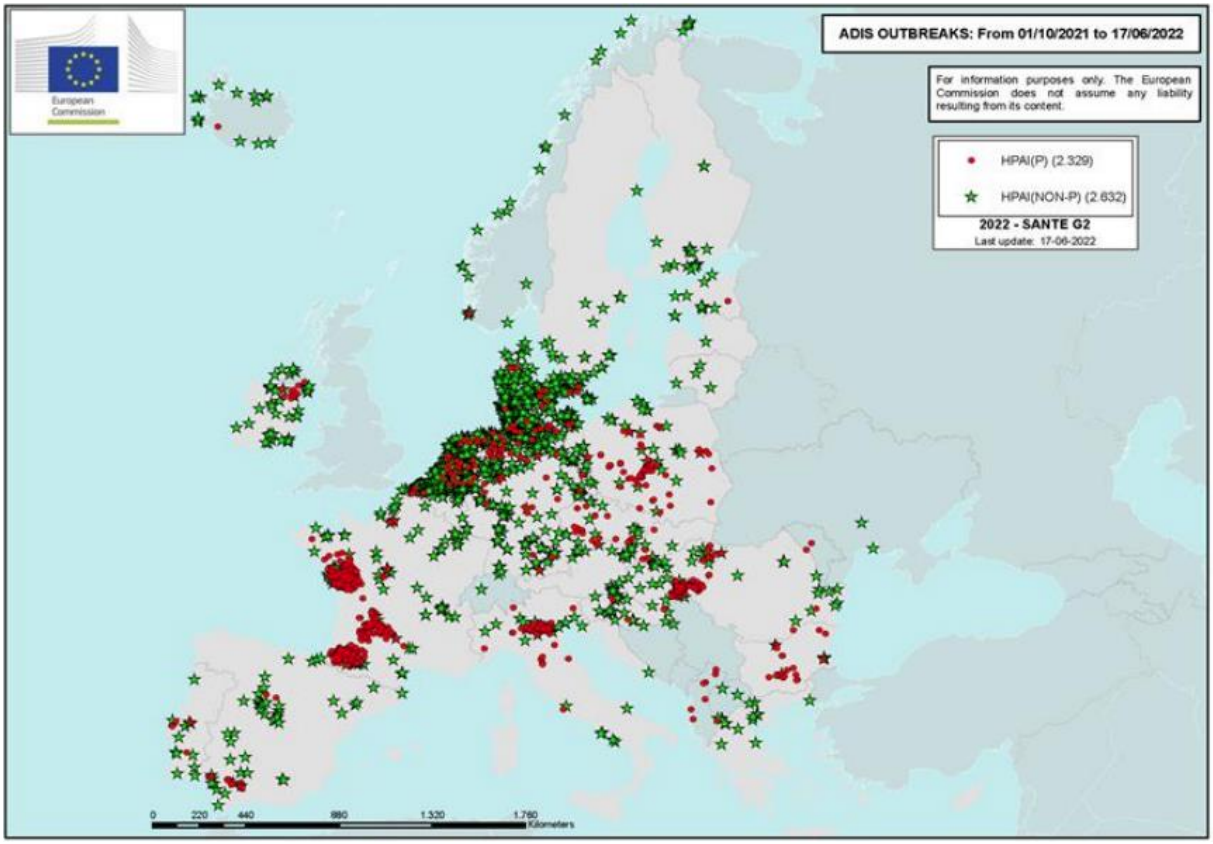

Figure 1. *Highly pathogenic avian influenza detections during the period 01 October 2021 – 17 June 2022. HPA(P) are those related to poultry and HPA(non-P) those related to non-poultry (including wild birds) Source: European Commission (2022).*

Ten out of 27 Member States replied to the Centre's survey. Nevertheless, only 8 out of these 10 had experience at depopulating ducks or turkeys. From these Member States, information of a total of 104 depopulated flocks were obtained. Three out of these 10 CAs also shared their standard operating procedures (SOP).

3. Description of available depopulation methods and good practices

For each depopulation method reported by EFSA (2019), the pros and cons, good practices retrieved from Member State's SOPS, CAs expertise, knowledge of the Centre and literature are described.

3.1. Mechanical

3.1.1. Captive bolt

Description

Captive bolts can either be penetrative or non-penetrative and powered by cartridge, compressed air or spring loaded (EFSA, 2019). Performing this method includes restrain the head by gently holding the beak or bill of the bird with one hand and placing the device on the bird's head with the other hand (European Commission, 2017). It is recommended to restrain the birds in a bleeding cone to contain wing flapping (EFSA, 2019). Captive bolt produces a massive concussion that causes loss of consciousness and destruction of the brainstem. However, with non-penetrating captive bolt not always result in death. Therefore, additional killing method not related to bleeding (to avoid biosecurity risk) is recommended (e.g., lethal injection, cervical dislocation).

Advantages

The use of penetrative captive bolt is effective to induce the death of both turkeys and ducks when properly applied (Gibson *et al*., 2018). It is suitable for small populations and there are spring-operated captive bolt guns available on the market specifically designed for ducks and turkeys up to 16 kg (EFSA, 2019).

Disadvantages

Operator fatigue can lead to poor welfare. In addition, heavy birds are source of additional difficulty since their restrain needs one operator holding the bird, while the other operator performs the shooting. In case of using either penetrative or non-penetrative captive bolt, back-up methods for killing should be taken into consideration in case of failure.

Good practices

The diameter and strength and penetration depth of bolt guns are key parameters to take into account to ensure efficiency of stunning according to the specie and size of birds (Raj and O'Callaghan, 2001; Gibson *et al*., 2018; Martin *et al.,* 2019). In terms of logistics, a sufficient number of guns should be made available such that each one can be rested to cool off since repeated use of a captive bolt gun can lead to overheating of the barrel and failure of the gun. It is also fundamental to clean the bolt guns regularly and maintain them according to manufacturer's instruction.

3.1.2. Percussive blow to the head

Description

It is performed by holding a bird by its legs, placing its head on a hard surface and delivering a blow to the back of the head with a hard object (European Commission, 2017). If it is performed with sufficient force and accuracy will lead to brain concussion and death (EFSA, 2019).

Advantages

It can cause unconsciousness to birds up to 16 kg body weight (Cors *et al*., 2015).

Disadvantages

As it only causes unconsciousness, a killing method not related to bleeding should be applied afterwards (e.g., lethal injection). Percussive blow to the head is entirely manual and therefore, prone to error. Thus, this method should be restricted only in those cases that no other stunning/killing method is available. Moreover, according to Council Regulation (EC) No. 1099/2009, it can be performed only on 70 birds per person per day, to avoid errors due to operator fatigue.

3.2. Electrical

3.2.1. Head-only

Description

This method is based on the principle that passage of an electrical current of sufficient magnitude through the brain of the bird induces generalised epilepsy and renders the bird temporarily unconscious. The device consists in two electrodes on either side of a tong. It is used to stun birds by placing the tong on both sides of the bird's head, such that they span the brain. Birds can be restrained either manually or placed upside down in a cone before stunning (see EFSA, 2019). Other devices include more sophisticated cones where the head of the bird is inserted into the V of the electrodes until the head is wedged. Then, the electrical current passes through the brain of the bird causing a temporary state of consciousness.

Advantages

It is quick and efficient.

Disadvantages

It requires to restraint the birds. In addition, head-only electrical devices do not lead to death. Thus, a killing procedure should follow (e.g., lethal injection, cervical dislocation).

Good practices

According to what is set down in EU legislation, minimum electrical currents are 400 mA for turkeys. However, as these animals are not intended for human's consumption, meat quality is not an issue. Hence, the Centre recommends a minimum electrical current of 600 mA using 50 Hz sine wave AC as recommended for ducks by EFSA (2006).The exposure time should be enough to guarantee that birds do not show indicators of consciousness (minimum 4 s). The electrodes must be cleaned from burnt feather debris at regular intervals, to avoid poor electrical contact.

3.2.2. Waterbath

Description

It consists in a mobile electrical waterbath system that goes from one farm to another. Once placed, the personnel hang the birds by their legs in metal shackles on a moving line which takes them to a waterbath, where they are immersed up to the base of the wings in electrified water, where they are stunned and killed. The contact of the head and neck with the water completes the electric circuit

between the water (positive electrode) and the shackle line, which acts as the earth or negative bar electrode, so that the electric current passes through the bird's head and body (EFSA, 2012).

Advantages

It is a faster method compared to the mechanical ones and the electrical head-only. Suitable for both medium and large-sized flocks.

Disadvantages

It involves catching and shackling live birds by their legs into metallic shackles and therefore, it needs enough manpower, especially in heavy birds or birds with aggressive behaviour. In addition, it involves contact of the personnel with infected birds. The line speed of portable waterbath system developed for on-farm killing is much lower than those found in most of the commercial slaughterhouses. This is because the shackle line is short, and this system is expected to operate outdoor in bright lighting conditions without bird calming measures (EFSA, 2019). In addition, conscious birds could receive potentially painful pre-electrocution shocks especially in ducks and turkeys.

Cardiac arrest could be induced in some ducks while they remain conscious due to the fact that their heads are not always immersed in the waterbath, instead base of the neck or crop contacts the electrified water. Ducks are particularly difficult to stun/kill effectively with an electric waterbath as they are able to curl their necks, lifting their heads above their breast. Thus, alternative methods may be preferable to the humane killing of these animals (HSA, 2007).

In addition, the height of the waterbath should be adequate to ensure that birds are immersed up to its base of the wings in the waterbath. The identification and humane killing of surviving birds is therefore crucial, and this would be difficult to achieve in electrocution systems that involve automatic removal of carcasses from the shackle (Gerritzen and Raj, 2009). Hence, it requires close monitoring and proper adjustment.

Bleeding after the electrical waterbath is not recommended during a disease control operation as it is a biosecurity risk, and so electrocution should be performed. Thus, the Centre recommends using a minimum current of 400 mA and waveform of 50 Hz sine wave AC to induce effective cardiac arrest (killing) in both ducks and turkeys. If electrocution fail and birds do not die from cardiac arrest, birds must be killed with back-up methods (EFSA, 2019).

3.3. Controlled atmosphere

3.3.1. Whole house gassing

Description

This is the method of choice for stunning and killing large commercial poultry flocks in a disease emergency. Birds are exposed to a pre-determined gas concentration using carbon dioxide (CO_2) pumped from a tanker into a sealed poultry house. However, this method it is only suitable when poultry houses can be sealed sufficiently to allow a CO_2 level of 45% to be reached since this is the level required for euthanasia of poultry. Inhalation of CO_2 induces respiratory and metabolic acidosis, causing unconsciousness, and eventually death by hypoxia within approx. 2-5 minutes, depending on the species

and concentration of CO_2. A controlled rise in the concentration of CO_2, which is obtained by filling the poultry house with the gas, causes the birds to become anaesthetised with low concentration before it causes aversive effects (>40% CO_2).

Advantages

It allows birds to be killed in their own living space without the stress of handling. On the other hand, CO_2 is readily available in sufficiently large quantities in tankers to enable WHG, thus keeping any zoonotic disease confined to the house and minimising contact of personnel with infected birds.

Disadvantages

The procedure is less controllable and needs closable and sealable barns, however, it is unavoidable a certain leakage of gas. Therefore, during the process, it is of utmost importance to measure gas concentrations throughout the whole barn (EFSA, 2019) but also outside where the personnel is for their safety. In addition, the effective slaughter of birds can only be determined using monitored CO_2 concentrations, due to the necessity of a sealed house, and therefore the impossibility of visual inspection of the birds. Actual observation of the birds can only occur when CO_2 has been allowed to clear from the house. On the other hand, personnel require specialist knowledge to enable them to perform WHG (few people can perform the process). There is certain risk for the personnel, and in terms of birds' welfare, animals get scared initially but are killed in a fast way. At the end of the process, it needs handling in combination with mechanical removal of dead birds.

Good practices

Recommendation provided include that before adding CO_2, personnel must check that the barn is empty of people, ventilation shut down and all exterior doors are closed and can withstand overpressure. The gas must be preheated to a temperature of 15 to 25°C to convert the liquid CO2 into the gas phase before entering the barn. Otherwise, the direct injection of liquid CO2 can cause the temperature in the chicken house to drop severely in the area and the gas may not be evenly distributed throughout the barn. Then, the gas must be supplied by a specialist until the desired concentration is reached at bird's head (approx. 20 min). Then, smoke divers should be sent in to observe signs of life in the birds in all sections of the house. If there is still life, corrective action should be taken. The barn is aerated until the CO_2 level is below 0.1%. CO_2 concentration is measured in different places in the barn (max. 0.1%) before collection personnel are sent in. The veterinarian responsible for killing must check that the killing is carried out correctly and that the animals are dead. Signs of death are lack of rhythmic breathing and no corneal reflex. Any bird with signs of consciousness must be killed with back-up methods.

3.3.2. Partial house gassing

Description

This is the method of choice for stunning and killing large commercial poultry flocks in barns that cannot feasibly be sealed to keep adequate concentrations of gases (AVMA, 2019). It involves an assembly of a plastic-panelled chambers in the barn within which a flock can be gassed in one or more groups. The birds are driven into it when ready. Once the birds are in the chamber, birds are exposed to a pre-determined gas concentration using carbon dioxide (CO_2). Inhalation of CO_2 induces respiratory and metabolic acidosis, causing unconsciousness, and eventually death by hypoxia within approx. 2-5 minutes, depending on the species and concentration of CO_2.

Advantages

It allows birds to be killed in their own living space without the stress of handling. Birds like turkeys and ducks can be driven to the chamber making this method feasible for these species. In addition, this method allows minimising the contact of the personnel with infected birds.

Disadvantages

The effective slaughter of birds can only be determined using monitored CO_2 concentrations, due to the necessity of a sealed chamber, and therefore the impossibility of visual inspection of the birds. Actual observation of the birds can only occur when CO_2 has been allowed to clear from the chamber.

Good practices

The veterinarian responsible for killing must check that the killing is carried out correctly. Signs of death are lack of rhythmic breathing and no corneal reflex. Any bird with signs of consciousness must be killed with back-up methods.

3.3.3. Gas mixtures in containers

Description

This is the method of choice for the humane slaughter of small numbers of poultry and it is a suitable alternative for the slaughter of large numbers of poultry when WHG is not feasible. Gas mixtures used to cause unconsciousness and death are CO_2 (> 40%) or a mixture of Argon (Ar) and CO_2 (< 20%) with less than 2% of residual O_2.

Advantages

The mixture of Ar and CO_2 is considered welfare friendly since Ar is undetectable by animals and CO_2, at the levels exposed (< 20%), is non-aversive to birds and causes hypoxia, unconsciousness and death. On the other hand, Ar is heavier than oxygen and replaces oxygen which makes it suitable for using in enclosed spaces. In addition, it is quick, effective and an easy-to-use system. In waterfowls, the gas mixture of Ar and CO_2 (< 20%) with less than 2% of residual O_2 has an advantage for dealing with ducks compared with CO_2 at levels above 40% (AVMA, 2019). This is because waterfowls are able to hold the breath when detect the higher levels of CO_2 making the killing procedure longer in time.

Disadvantages

It requires catching and handling birds in combination with mechanical removal following gassing. Therefore, infected poultry have to be caught and placed in modules to allow gassing in containers with resultant health and safety implications for personnel involved. CAs reported that personnel require physical strength when turkeys are heavier than 10 kg body weight. In addition, personnel involved require training, as handling by untrained personnel has the potential for compromising bird welfare. Successful euthanasia of poultry can only be confirmed post gassing.

The mixture of Ar and CO_2 was reported to be more expensive than only CO_2 in containers.

Good practices

Handling of poultry can be stressful if not carried out by properly trained personnel. Once caught, birds must be handled with care and consideration. Fractures, dislocations and bruising can be common injuries associated with poor handling and these will result in unnecessary suffering. Thus, handling of

birds should be minimized where possible, so it is preferable to drive the birds rather than carry them, especially when heavy birds or with aggressive behaviour.

Moving birds should be done quietly, in a controlled manner, using barriers or simply by shaking an empty paper bag (meal bag) behind the poultry, a timber board or other such barrier moved behind the poultry is an effective method of moving birds. If feasible the birds should be corralled towards their destination using a gently sloping funnelled passageway. Turkeys can be effectively moved using barriers. Birds will become easier to handle if subdued lighting is used. Lighting should always be sufficient to allow a safe working environment for personnel.

Turkeys must never be lifted or carried by the head, neck, wing, tail or by a single leg. Small growing turkeys (7-14 weeks) should be caught by holding both legs, lowering the bird onto its breast and lifting the bird while holding your arm over one wing to prevent flapping. To lift adult turkeys, grasp the shoulder of the wing furthest away from you, while your free hand grips the legs. The turkey should be lifted and held close to your body. Adult turkeys can also be caught and carried by the shoulder joints. Once caught, the bird should be loaded into the module headfirst, taking care to ensure that the keel of the bird does not impact the front of the module.

Ducks must never be lifted or carried by the head, wing, leg or tail. Ducks should be handled by placing one hand on each side of the body over the wings and lifting the bird. They should never be carried by the legs since it easily leads to ducks becoming lame. Ducks should be lowered gently into the module trays onto their breasts and allowed to regain their balance before other birds are added to the tray.

Since successful killing can only be confirmed post gassing, back-up slaughter methods should be considered.

3.4. Others

3.4.1. Lethal injection

Description

It consists in prepare an anaesthetic injection and then capture the bird and inject it intravenously, intraperitoneally or in the occipital sinus. The method of choice is barbiturate overdose. It causes loss of consciousness followed by irreversible death from veterinary drug injection.

Advantages

CAs stated as pros for lethal injection that it is welfare friendly, fast an efficient method. It is especially suitable for small populations.

Disadvantages

Expensive cost per animal, individual handling of birds so it can be a challenge in terms of work safety (e.g., error-injection, etc) and the lack of suitability for larger flocks since it requires many veterinarians. Otherwise, the risk of poor performance will increase with time due to operator fatigue (Gerritzen and

Raj, 2009). If lethal injection is not performed correctly, it can be very painful and birds remain conscious/alive experiencing severe welfare consequences, such as pain, fear and distress.

In addition, CAs pointed out that lethal injection is not used in heavier turkeys because of problems that arise in handling and dosing.

Good practices

Lethal injection should be administered strictly following the manufacturer's instructions in dose, route and rate of administration. The veterinarian responsible for killing must continuously check that the killing is carried out correctly and that the animals are dead. Recommended signs of death are lack of rhythmic breathing, no corneal reflex and absence of heart beats. In case of failure, a back-up killing method should be ready at any time.

4. Depopulation methods used in Europe, according to the survey

In case of HPAI, birds are usually depopulated on farm. However, when the number of outbreaks is too high, alternatively, birds can be sent to (dedicated) slaughterhouses or transported to a mobile slaughterhouse placed in the middle of the infected zone. Nevertheless, the 8 countries that answer this survey are not among the countries having had the most HPAI outbreaks in 2021-2022, therefore, we did not manage to retrieve to information about the majority of ducks and turkeys depopulated in Europe. Since we received answer only from some Member States, we did not get information about all methods, but only about main methods that are used to depopulate on farm (in the answering Member States). Hence, the chosen depopulation methods applied on farm in flocks of ducks and turkeys in 2022 according to CAs were gathered and summarized in the following sections.

4.1. Ducks

Data from a total of 32 depopulated flocks of ducks were retrieved from CAs that answer the survey, 19 of which were small-sized flocks. Within the small-sized flocks, the preferred method is mechanical by far (17 out of 19) being the lethal injection the most used (10 out of 17). In flocks of ducks of less than 3 kg body weight, the chosen methods were captive bolt, percussive blow to the head or cervical dislocation (6 out of 17). In one flock, ducks were stunned with percussive blow to the head and then killed by lethal injection. Setting aside the mechanical methods, one flock was killed with an electrical head-only device and another one with carbon dioxide (CO_2) in containers although no further information was provided.

Only information of depopulation methods applied in two medium-sized flocks of ducks were retrieved from CAs. One of them were depopulated using electrical waterbath while the other through WHG with more than 40% CO_2 (Figure 2B). Time spent per flock where below 1 hour in both cases although waterbath was a faster method than WHG.

Information of depopulation methods applied in 12 large-sized flocks of ducks were retrieved from CAs. The most popular depopulation methods applied were those related to kill trough modified atmospheres (11 out of 12) and electrical waterbath (1 out of 12). Modified atmosphere killing methods included CO_2 in containers (5 out of 11), followed by a gas mixture containing Argon and CO_2 in

containers (2 out of 11), carbon monoxide in containers designed for minks (2 out of 11) and WHG with CO_2 (2 out of 11) as shown in Figure 2C.

4.2. Turkeys

Data from a total of 73 depopulated flocks of turkeys were gathered. Subsections were created to split methods used according to the average body weight of the flock.

4.2.1. Turkeys of less than 10 kg body weight

All small-sized flocks (*n* = 4) were sacrificed using mechanical methods, two of them by lethal injection and the other two with percussive blow to the head and cervical dislocation afterwards as were in both cases ducks of less than 3 kg.

Only information of one medium-sized flock of turkeys was retrieved from CAs. In this specific case, turkeys were killed using a mechanical method consisting in captive bolt and low calibre rifles (LCR; cash poultry killers with 'E' brown 1 grain cartridges 0.22 rim fire, segmented hollow point). Pros of LCR is that it eliminates the need of handling animals over captive bolt. Cons revolve around the low killing speed per animal (time spent was around 8 hours for 1,200 individuals) and the availability and maintenance of the equipment and the need of very skilled personnel (in addition of licensing in the case of LCR).

All large-sized flocks (*n* = 5) were depopulated using modified atmosphere methods. The most popular was WHG with CO_2 (in 3 out of 5 flocks) where the gas was filled until reached 40, 60 or 80% CO_2 concentration. When depopulating with WHG with CO_2, the time spent to depopulate was around 10 hours. Other modified atmosphere methods reported include WHG with Ar keeping less than 5% available oxygen (*n* = 1) and through 40% CO_2 in containers (*n* = 1).

4.2.2. Turkeys between 10 and 15 kg body weight

One small-sized flock was sacrificed using a lethal injection. No information on depopulation methods for medium-sized flocks were gathered. However, information about many large-sized flocks (*n* = 16) were retrieved. Most of them used modified atmosphere as depopulation method. The most popular was WHG with CO_2 (in 14 out of 16 flocks) where the gas was filled until reached diverse concentrations in the range of between 40 and 80% CO_2 concentration according to the flock. One flock was killed in containers using a mixture of Ar and CO_2 and another one used mechanical dislocation.

4.2.3. Turkeys of more than 20 kg body weight

Information on two depopulated small-sized flocks were gathered. One of them was sacrificed using electrical head-only devices. The CA pointed out that there is no alternative method for male turkeys (>32 kg). Nevertheless, it is a fast method considering small-sized flocks (20 animals/hour) but it needs enough manpower. The other one was killed using high CO_2 concentrations (> 40%) in big bags. As pros of this method is that is relatively inexpensive and quick to perform (1 hour per flock) but the heavier the animals, the more difficult to handle.

No information on depopulation methods for medium-sized flocks were gathered. However, information about 6 large-sized flocks were retrieved. Most of them used modified atmosphere as depopulation method (n = 5). Four of them used WHS with high concentrations of CO_2 (40 to 80%) while one of them used CO_2 in containers. Finally, one flock of turkey hens was depopulated using electrical waterbath.

5. Conclusions

Expertise from the Centre, literature review and feedback from CAs was intended to answer the present query. Nevertheless, only 10 out of 27 Member States replied to the Centre's survey but only 8 out of these 10 had experience at depopulating ducks or turkeys but none of them were among the countries having had the most HPAI outbreaks in 2021-2022. Therefore, the Centre was only able to gather partial data and always related to killing on farm procedures. Despite of this, the information gathered allows to conclude that:

- Within the methods of killing on farm, mechanical, electrical and modified atmosphere methods in containers or bigbags involve handling of animals and sometimes can be difficult to manage when the birds are especially heavy or aggressive. In flocks of less than 500 ducks or turkeys, the most used methods by far are the manual ones (i.e., lethal injection or percussive blow to the head followed by cervical dislocation) covering the different animals' body weight, showing with high practicability and efficiency.
- In flocks of more than 500 ducks or turkeys, the most used, practicable and efficient methods are those using modified atmosphere whichever the poultry specie. However, barn design, poultry specie, size of the flock and average body weight of birds are key factors at choosing the specific modified atmosphere method.
    - In case of sealable barns, the most practicable and efficient method is WHG in both ducks and turkeys whichever their body weight.
    - In non-sealable barns, PHG and gas mixtures in containers are the most practicable and efficient method for both ducks and turkeys. However, in PHG there is no need of handling animals since these poultry species can be driven to the built-in plastic chambers. In addition, this method allows minimising the contact of the personnel with infected birds. In case of choosing gas mixtures in containers, the combination of Ar (80%) and CO2 (< 20%) with less than 2% of residual O2 is the most preferable method in terms of welfare and efficiency, especially for ducks.

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