



Evaluating the effectiveness of wild bird deterrents in Poultry Operations for Avian Influenza Control: A literature review

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Foreword

This project was funded from industry revenue which is matched by funds provided by the Australian Government.

This report is an addition to Australian Eggs Limited's range of peer reviewed research publications and an output of our R&D program, which aims to support improved efficiency, sustainability, product quality, education and technology transfer in the Australian egg industry.

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Table of Contents

Foreword.....	ii
Acknowledgments.....	iii
About the Authors	iii
Abbreviations.....	v
1 Introduction	1
1.1 Difficulties of Controlling Birds in Poultry Sectors.....	1
1.2 Study Designs of Bird Deterrent Research	2
2 Types of Bird Deterrents.....	3
2.1 Visual Deterrents.....	3
2.2 Predatory Decoys	3
2.3 Lasers.....	4
2.4 Auditory Deterrents.....	5
2.4.1 Designing Effective, Species-Specific Auditory Deterrents	7
2.5 Tactile/Habitat Modification Deterrents.....	8
2.6 Chemical Deterrents.....	10
2.7 Reproductive Deterrents.....	11
2.8 Lethal Deterrents.....	11
3 Short-Term vs Long-Term Effectiveness and Habituation	12
4 Knowledge Gaps and the Need for Future Research.....	12
5 Conclusion.....	13
References	16
Plain English Summary.....	19

Abbreviations

AI	Avian influenza
BACI	Before-After-Control-Impact
CD	Compact Disk
HPAI	Highly pathogenic avian influenza
LPAI	Low pathogenicity avian influenza
MA	Methyl Anthranilate

1 Introduction

Avian Influenza poses a significant threat to poultry health, public health, and the global agricultural economy. The growing concern over Avian Influenza (AI) in commercial poultry operations, particularly free-range systems, has underscored the importance of effective bird deterrents. Wild birds, especially migratory species, act as natural reservoirs and vectors for both low pathogenicity avian influenza (LPAI) and highly pathogenic avian influenza (HPAI) viruses. The transmission pathways, which include direct contact, contaminated water sources, and environmental vectors such as bird droppings and feathers, make it necessary to mitigate wild bird interactions with poultry. This literature review explores various bird deterrent strategies including visual, auditory, tactile, habitat modification, exclusion, chemical, reproductive, and lethal methods and assesses their short- and long-term effectiveness. It evaluates the implications of these deterrents in reducing AI risks within the free-range poultry sector, where wild bird contact is most challenging to control.

1.1 Difficulties of Controlling Birds in Poultry Sectors

Bird deterrents play an important role in biosecurity by minimising direct and indirect contact between wild birds and poultry. Wild birds are the reservoir for AI viruses and can introduce infection to farms via multiple routes: through direct mingling with poultry, contamination of feed or water sources with droppings, or simply by shedding virus in areas where farm staff or equipment may come in contact (Yang et al., 2024). Free-range flocks face higher risks because wild waterfowl, sparrows, or starlings may be attracted to the farm due to available feed, water, or shelter. Deterrents play a crucial role in actively keeping wild birds away from poultry areas, creating a protective buffer zone.

Controlling wild bird populations in the poultry sector poses significant challenges due to the intricate behaviours of avian species, the variety of species involved, and the fluctuating dynamics of agricultural environments. One primary obstacle is the mobility and adaptability of wild birds, especially migratory species that travel extensive distances, thereby introducing AI into poultry systems from disparate geographic locations. These birds often inhabit areas near poultry farms, particularly where there are abundant water sources, feed, and nesting opportunities.

Environmental variables further complicate avian control initiatives. Seasonal fluctuations influence migratory behaviours, food resource availability, and local bird population dynamics, necessitating adaptive management strategies capable of addressing these evolving risks. Additionally, ecological and ethical considerations regarding bird deterrence present another layer of complexity. Numerous bird species are protected under wildlife conservation regulations, constraining the array of permissible control methodologies. More aggressive measures, such as culling, frequently encounter public opposition and may yield ecological repercussions, including potential disruptions to local ecosystems and compensatory immigration, where newly arriving birds quickly fill the niche vacated by those removed.

The multifaceted nature of avian behaviours, coupled with logistical, environmental, and ethical challenges, underscores the need for integrated, multi-modal deterrent strategies. These strategies should incorporate real-time monitoring, adaptive technologies such as artificial intelligence-driven deterrents, and habitat management practices to establish a dynamic and responsive framework for bird control.

1.2 Study Designs of Bird Deterrent Research

The scientific evaluation of bird deterrents involves diverse study designs aimed at quantifying deterrent effectiveness under both controlled and field conditions. The methodologies typically include:

- **Before-After-Control-Impact (BACI) Designs:** Used in ecological studies, BACI designs allow for comparisons between treated and untreated areas before and after deterrent application. Holmes et al., (2024) applied this approach to assess the impact of visual and auditory deterrents on Arctic-nesting birds. Although the high-intensity treatment using hawk-kite effigies and audio deterrents slightly reduced the density of specific species, overall effectiveness was limited in this study.
- **Field Trials:** Real-world application trials, such as those by Manz et al., (2023) involve introducing deterrents (e.g., laser scarecrows) into operational agricultural environments. These trials captured real-time responses of birds and showed that laser treatments significantly decreased the probability of birds initiating feeding on sweet corn ears, though the duration of foraging bouts was not directly affected by laser exposure.
- **Longitudinal Studies:** These studies evaluate deterrent effectiveness over extended periods, providing insights into habituation and long-term impact. For example, studies on the use of reproductive deterrents like nicarbazin analyse population-level changes over multiple breeding seasons (Klug et al., 2023).
- **On-farm demonstrations:** In some cases, researchers or extension agents do on-farm trials where a farmer's problem area is treated with a deterrent and results are noted anecdotally or with simple counts. While not as rigorous as BACI or controlled trials, these provide practical insights and often drive adoption if the results are positive. For instance, Mason and Clark (1995) showed that adding reflective tape around free-range yards led to immediate drops in wild bird sightings and less faecal contamination on egg belts.

2 Types of Bird Deterrents

Bird deterrent solutions vary widely, ranging from physical barriers and sensory repellents to reproductive control measures and habitat modifications. Short-term solutions like netting, spikes, and visual deterrents effectively prevent birds from accessing specific areas but may require frequent maintenance and adaptation as birds habituate (DeLiberto et al., 2020). Sensory-based methods, such as noise cannons and chemical repellents, provide immediate deterrence but often lose effectiveness over time due to desensitisation. (Mason & Clark, 1995). In contrast, long-term strategies, such as reproductive control through contraceptives like nicalbazin or environmental modifications that reduce food and nesting availability, offer sustainable population management but require ongoing coordination and monitoring (DeLiberto et al., 2020; Pennell & Rolston, 2013). The effectiveness of any bird deterrent method depends on factors such as species behaviour, site-specific conditions, and the integration of multiple deterrent techniques for a comprehensive, long-lasting solution.

2.1 Visual Deterrents

Visual deterrents use sight-based stimuli to scare or repel wild birds from poultry areas. Birds have excellent vision and are sensitive to movement and certain patterns, so visual cues can trigger their instinctive fear of predators or unknown threats. For free-range poultry farms, visual deterrents are appealing because they are generally simple, passive devices and can cover large areas with minimal labour.

The study by Di Giorgio et al. (2017) can be directly applied to bird deterrent strategies by leveraging birds' innate predispositions and learned preferences to influence their behaviour. The research demonstrates that birds, particularly chicks, have an instinctual attraction to objects resembling biological motion or familiar social stimuli. This insight can be used to develop deterrent methods that disrupt these innate preferences by making environments less attractive for roosting, feeding, or nesting. For instance, visual deterrents such as predator decoys, eye-like patterns, or movement-based deterrents can exploit birds' natural fear responses, discouraging them from settling in targeted areas.

Additionally, the study highlights the role of learned associations in reinforcing attachment behaviours, which can be applied to long-term deterrent strategies. Birds can be conditioned to avoid specific locations through repeated exposure to negative stimuli, such as auditory deterrents, flashing lights, or unpleasant tactile surfaces. Understanding how birds imprint on safe environments allows for the design of dynamic deterrent systems that continuously modify stimuli to prevent habituation (Blumstein, 2016). By integrating these insights into bird control strategies, deterrent methods can be more effective, reducing reliance on harmful interventions while promoting sustainable and humane population management.

2.2 Predatory Decoys

Predatory Decoys (Owl/Hawk Effigies and Scarecrows) are some of the most common visual deterrents available. Movement is a powerful trigger of alarm in birds, so many visual deterrents leverage motion or sudden changes to exploit the fear-based response in birds. However, multiple studies and field observations highlight a major limitation of habituation. Birds quickly comprehend that decoys are immobile and do not present any genuine threat. For example, observations in

poultry housing have indicated that chickens can become habituated to robots designed to facilitate their movement within a shed. In some cases, the chickens may even choose to perch on these devices and 'ride' them, recognising them as non-threatening. Seamans (2013) demonstrated that sparrows acclimatise to plastic owl decoys within 3 to 4 days, subsequently returning to their normal feeding behaviours in their presence. This suggests that while predator effigies can show promising short-term efficacy, evidenced by a significant reduction in avian activity over the first couple of days, their long-term effectiveness is limited.

To maintain efficacy, a dynamic deployment strategy for these decoys is essential. More elaborate motion-based deterrents are kite or balloon systems designed to resemble predators in flight. "Hawk kites" are kite silhouettes of hawks or falcons that soar and dive on breezes; some are attached to helium balloons to keep them aloft and moving even on calm days. Research in crop fields found that predator kites, especially when suspended from balloons, significantly reduced bird damage in corn and grapes compared to no deterrent (Brown & Brown, 2021; Clark & Avery, 2013; Manz et al., 2024). The irregular circling of the kite simulates a hunting raptor, tapping into birds' fear of aerial predators. They likely won't solve a severe bird problem alone, but they can contribute to a multisensory deterrent strategy.

The key with kites/balloons is variability; using them for a short period e.g. during a high-risk AI outbreak in the area but then removing them, relocating them or changing the design to prevent habituation. Some products combine features – e.g. a hawk-shaped balloon with eyespots and reflective streamers on it (Rivadeneira et al., 2018).

The study by Holmes et al., (2024) explored the use of hawk-kite effigies, audio deterrents, and flash tape in Arctic-nesting bird habitats. Using a before-and-after control-impact design, the research evaluated the response of Lapland Longspurs and Horned Larks to varying intensities of visual stimuli. While the deterrents effectively reduced Horned Lark density, other species showed minimal behavioural changes, highlighting species-specific responses.

Other simple examples of visual deterrents include the use of reflective tape or streamers that flutter in the wind, flashing lights, and moving silhouettes. Reflective bird scarers (such as metallic tape, mirrors, or old CDs hung in trees) flicker light and rustle unpredictably, which has been shown to repel certain species in the short term (Varriano et al., 2025). However, birds often habituate quickly if the motion and reflections are constant in the same spot and there is no follow-up negative consequence to the fear response. Farm managers have also used devices like rotating propeller-like scarers, inflatable dancing tube men, or wind-driven owl mobiles. These create unpredictable motion that can keep birds on edge. For instance, a spinning mobile with an owl figure that swoops in circles has been suggested for inside barns to deter roosting sparrows (Berry, 2003).

2.3 Lasers

Lasers have emerged as a high-tech visual deterrent to disperse wild birds and have shown to be effective in many trials at dispersing birds at roost or preventing them from setting in low light conditions. Handheld or automated laser systems project a moving bright beam that startles birds, especially under low-light conditions (dusk, dawn, or overcast days) when the beam is highly visible (Varriano et al., 2025). For example, trials using green laser beams successfully scared away roosting cormorants and crows, though only for a short period (a few hours to a few days) before the birds began returning (Varriano et al., 2025). Effectiveness can depend on species: waterfowl like geese, ducks, herons, and cormorants show sensitivity to lasers and will take flight, whereas some birds

(gulls, coots, shorebirds) were unfazed by the same laser stimulus. This may relate to the differences in how species perceive the laser or their level of wariness and risk appetite (Di Giorgio et al., 2017).

One study noted that crows disturbed by lasers at night reoccupied their roost later that same night, without permanently abandoning the site (Rivadeneira et al., 2018). This underscores that while lasers provide an immediate, non-lethal harassment method, birds may quickly resume activity once the laser exposure stops. To extend efficacy, modern “laser scarecrow” devices use continuously moving beams that sweep across a field at random intervals. In agricultural trials, an automated green laser scarecrow covering half of a crop field led to significantly fewer birds and less crop damage on the treated side compared to the untreated side (Brown & Brown, 2021). These robotic laser systems reduced bird damage to sweet corn by over 50% in some tests, though researchers caution that birds could potentially habituate over longer periods (Brown & Brown, 2021).

Manz et al., (2024) evaluated the effectiveness of laser scarecrows in mitigating bird-induced harm to sweet corn crops. The researchers conducted experiments with 18 captive flocks of free-flying European starlings (*Sturnus vulgaris*), presenting them with fresh sweet corn ears in controlled plots where laser and non-laser treatments were alternated daily over five days. The trials included "Stick Trials," where corn ears were mounted on sticks at varying distances from the laser units, and "Natural Trials," involving corn grown directly in the flight pen. The findings revealed that laser treatments significantly reduced crop damage, with a more pronounced effect observed in the natural trials. However, damage increased over each week in both trial types, suggesting potential habituation (Blumstein, 2016; Manz et al., 2024). Additionally, damage was inversely related to proximity to the laser units, with significant protective effects extending up to approximately 20 meters from the lasers. These results align with previous field studies (Blumstein, 2016; Holmes et al., 2024), indicating that laser scarecrows can effectively decrease avian damage to sweet corn, though their efficacy diminishes with distance and over time due to possible habituation.

Managing habituation with lasers involves varying the timing and location of laser use and occasionally pairing lasers with additional stimuli (e.g. loud sounds) so that birds do not learn a predictable pattern (Blumstein, 2016; Seamans & Gosser, 2016). In free-range poultry settings, lasers might be used at dawn and dusk to discourage wild waterfowl from settling on ranges or farm ponds. They offer a promising option for covering large areas with minimal labour, but farmers must monitor bird responses and adjust tactics to maintain the element of surprise.

2.4 Auditory Deterrents

Waterfowl possess a hearing capability predominantly tuned to mid-range frequencies, akin to that of other avian species (McGrew et al., 2022). Audiometric analyses indicate that ducks, along with geese and swans, exhibit peak auditory sensitivity within the 1000–4000 Hz frequency range (Crowell et al., 2015; Dooling, 2002; McGrew et al., 2022). Specifically, the mallard (*Anas platyrhynchos*) displays optimal sensitivity around 2000 Hz with the best threshold of approximately 15 dB SPL (Dooling, 2002). Most waterfowl demonstrate a U-shaped audiogram typical of avian species, wherein sensitivity peaks in the mid-frequency range and declines at both lower and higher extremes (Crowell et al., 2015; McGrew et al., 2022).

When evaluating hearing thresholds in ducks, the lowest (most sensitive) thresholds are observed between 1000–3000 Hz, with a pronounced decline in sensitivity beyond 4000–5000 Hz (Crowell et al., 2015; Dooling, 2002). Their high-frequency hearing is notably limited, with minimal detection capabilities above 8000–10000 Hz; for instance, the mallard’s effective hearing range extends only to about 5000–6000 Hz at moderate sound pressure levels (McGrew et al., 2022). Although data on geese and swans remain scarce, their hearing is assumed to parallel that of ducks, given their

classification within the Anatidae family. Waterfowl are most attuned to sounds in the lower hertz range while exhibiting reduced sensitivity to ultrasonic or excessively high-frequency sounds that exceed their natural vocalisations.

Auditory communication is integral to waterfowl social structures and survival strategies. They deploy a suite of instinctual vocalizations—quacks, honks, whistles, and grunts—serving as their primary communicative mechanisms (Kross, 2006). These calls predominantly occur within the frequencies most detectable to waterfowl, specifically around 1000–3000 Hz (Crowell et al., 2015). For instance, the drake mallard's extended "raeb-raeb" call functions to attract mates while simultaneously alerting conspecifics to potential threats (Kross, 2006).

Communication plays a pivotal role in maintaining cohesion within avian groups. Flock members utilise contact calls, particularly in environments with dense vegetation or low visibility, to stay connected. Waterfowl, for example, often emit pre-flight calls to facilitate synchronised departures, ensuring that both mates and flock mates remain grouped during movement. Notably, even at the embryo stage, auditory recognition is critical; duck embryos begin to familiarise themselves with maternal calls before hatching, enabling ducklings to identify their mother and siblings post-hatch. This recognition aids in the synchronisation of hatching and promotes efficient navigation to resources like food and water (Kross, 2006). The capacity to discern subtle variations in calls acts as a crucial survival mechanism, allowing individuals to locate mates or offspring amidst the cacophony of a crowded flock (Kross, 2006).

Species-specific alarm calls serve as critical auditory signals for warning conspecifics of predation risks. Interestingly, birds within mixed-species flocks often engage in eavesdropping, utilising alarm calls from other species to enhance their vigilance (Seamans & Gosser, 2016). Additionally, waterfowl exhibit responsive behaviours to the sounds produced by predators; for instance, the distinctive whistling of wings from an approaching falcon or the vocalisations of a hawk can elicit evasive manoeuvres before visual confirmation of the threat (Davies, 2016; Seamans & Gosser, 2016). Research on magpie geese indicates that juvenile individuals develop learned associations with specific aerial predator calls, cultivating a tailored alarm response to the presence of eagles, thereby enhancing their detection capabilities of such threats (Kross, 2006).

The use of propane cannons that produce loud, gunshot-like blasts at set intervals has become a known deterrent method within agriculture (Berry, 2003; Mason & Clark, 1995; Seamans et al., 2013). Birds respond to the sudden noise by initially avoiding the area however if the pattern of the signals is predictable and there is no negative consequence, the birds will often habituate. To counter this, operators set cannons at random intervals or move them periodically to provide variability in their presentation (Seamans et al., 2013). A significant drawback on livestock farms is that cannons can startle animals too. Chickens are susceptible to distress from persistent loud noises, such as cannon fire, leading to an elevated risk of smothering behaviours in flocks (Gregory, 2008; Groves, 2021). Consequently, the deployment of noise deterrents, such as cannons, on poultry farms should be approached with caution. Optimal practices may include situating cannons at a considerable distance from the flock, restricting their use to periods when chickens are secured, or limiting the frequency of blasts per day. Furthermore, the proximity of residential areas may pose additional complications, as complaints from neighbours can render the use of cannons impractical (Gregory, 2008; Groves, 2021).

When employed temporarily, such as during a high-risk period lasting about a week, cannons can effectively establish a "no-go zone" for numerous wild bird species. This strategy has been implemented around farms experiencing outbreaks as an urgent containment measure to deter wild bird visitation while managing the spread of infection. Overall, noise deterrents such as propane cannons, distress-call speakers, and similar devices tend to have a limited window of effectiveness

due to the rapid acclimatisation of waterfowl to these stimuli, culminating in a substantial decrease in efficacy after repeated exposure (Rivadeneira et al., 2018).

Another method for deterring birds involves the use of continuous noise to create an inhospitable environment. A concept referred to as a "sonic net" employs broad-band sound to disrupt bird communication (Rivadeneira et al., 2018). Research has demonstrated that this approach can lead to an 82% reduction in bird presence within the affected area, with its effectiveness lasting for at least four weeks without the birds becoming accustomed to it (Rivadeneira et al., 2018). By overlapping the frequencies of bird calls, the sonic net makes it difficult for birds to communicate, effectively encouraging them to vacate the area. Unlike conventional scare tactics that often lead to acclimatisation, this continuous sound does not function as a discrete scare cue, which helps maintain its efficacy.

In contrast, generic noises such as sirens and horns played repeatedly are quickly disregarded by birds unless they are occasionally paired with genuine consequences (Rivadeneira et al., 2018). Overall, noise deterrents such as propane cannons, distress-call speakers, and similar devices, tend to have a limited window of effectiveness due to the rapid acclimatisation of waterfowl to these stimuli, culminating in a substantial decrease in efficacy after repeated exposure (Rivadeneira et al., 2018).

To enhance the effectiveness of avian deterrent strategies, employing techniques such as alternating alarm calls, integrating periods of silence, and varying sound source locations can be advantageous. A well-established methodology involves the synergistic use of bioacoustics and real aversive stimuli: for instance, emitting an alarm call in conjunction with an immediate threat (e.g., an individual pursuing the birds or a pyrotechnic explosion) can intensify the conditioned fear response (Rivadeneira et al., 2018; Seamans & Gosser, 2016). Research indicates that birds are less prone to habituation when auditory signals consistently precede negative experiences (Blumstein, 2016).

2.4.1 Designing Effective, Species-Specific Auditory Deterrents

Understanding waterfowl auditory capabilities is crucial for developing deterrent strategies that work. First and foremost, deterrents must use sounds within the hearing range of the target species. Many commercial "ultrasound" devices fail because most birds (waterfowl included) cannot hear frequencies above ~10,000 Hz (McGrew et al., 2022; Rivadeneira et al., 2018; Seamans & Gosser, 2016). Effective acoustic deterrents for ducks, geese, and swans should focus on roughly 500–5000 Hz signals, where these birds hear best. For example, recorded alarm calls of Canada geese or mallards played back at natural volume can immediately trigger an avoidance reaction in those species (Seamans & Gosser, 2016).

Using species-specific bioacoustic signals (such as their own alarm or distress calls, or the calls of their natural predators) leverages the birds' innate recognition therefore making it a far more effective stimulus than random noise. Field observations suggest that a genuine goose alarm call prompts a flock to take flight much faster than an artificial siren, as it conveys meaningful information about danger. Similarly, ducks respond strongly to the calls of predatory raptors or the agitated alarm quacks of fellow ducks, which can be used in deterrent systems with variation.

Recommendations to prevent habituation are below:

1. **Species-Specific Tuning:** Different waterfowl species have nuances in their hearing and behaviour, so deterrents should be adjusted accordingly. Geese, for instance, are very

social and one sentinel's alarm honk can clear an entire field. A device that detects approaching ducks and plays a duck alarm call sequence might exploit this social spread of fear.

2. **Varying the Sounds:** Rotate through different calls and sounds so birds don't hear the same sequence (Rivadeneira et al., 2018). For example, alternate between distress calls, predator calls, and loud percussive noises (propane cannon, starter pistol) randomly. Unpredictability keeps waterfowl alert, as they are unable to settle into a consistent routine.
3. **Timing and Randomisation:** Avoid emitting sounds at fixed intervals—instead use irregular timing or trigger the deterrent only when birds are present (Seamans & Gosser, 2016). Random timing prevents birds from “expecting” the noise. Additionally, avoiding constant sound when birds are absent keeps them from learning the sound in a harmless context.
4. **Volume and Distance:** Use realistic volumes by playing calls at a volume that mimics natural warning calls or threats (Seamans & Gosser, 2016) as excessively loud broadcasts might signal something unnatural. By using the volume waterfowl expect for a given call (adjusted for distance), the deterrent seems more believable. Additionally, moving sound sources around (or having multiple speakers) can create the illusion of a threat moving through the area, reducing the likelihood of habituation.
5. **Multi-sensory Reinforcement:** Combine auditory signals with visual or physical stimuli to reinforce the danger. For example, pair a goose alarm call with the appearance of a dog or a person, or follow a series of alarm quacks with a remotely fired pyrotechnic “bird banger.” Birds that both hear a threat and then see a pursuer (or feel a mild aversive stimulus) will develop a sustained wariness of the sound (Seamans & Gosser, 2016). Even the occasional use of real predator decoys or limited culling (in management contexts) in conjunction with sounds can reset habituation by re-establishing the sounds as genuine predictors of danger.

By aligning the design of deterrents with the hearing abilities of waterfowl, birds perceive the stimuli as significant and relevant to their biology. An effective acoustic deterrent mimics a “real” threat in the birds' auditory environment. For example, a sequence of distress quacks from mallards, combined with wing-flapping sounds, can simulate a frightened flock mate, prompting other birds to flee. The goal is to maximise the initial impact of the sound and then maintain that effect without the birds becoming accustomed to it. This can be achieved by selecting the right sounds, those at frequencies the birds can hear and signals they instinctively fear and by employing strategic deployment methods that involve randomness, variety, and occasional real consequences.

2.5 Tactile/Habitat Modification Deterrents

Tactile deterrents are designed to create environments that are physically uncomfortable or unstable for avian perching, roosting or nesting. These methods don't rely on causing fear; but rather they make the environment mechanically inhospitable for birds. Similarly, altering the surrounding environment can reduce habitat suitability for wild birds. Immediate impacts on wild bird presence in free-range areas of commercial poultry operations can be achieved through vegetation management, such as reducing grass height to deter foraging and covering water sources (McGrew et al., 2022; Ramey et al., 2022).

In poultry farms, tactile deterrents are especially useful for targeted areas like building ledges, rafters, fences, or equipment where wild birds might perch and defecate (e.g., above feed storage or inside sheds). By preventing birds from settling in these areas, farmers can reduce contamination and nesting opportunities.

A range of deterrent strategies has been assessed, including sticky gels, polybutene coatings, and physical spikes, all of which have shown immediate efficacy in disrupting avian perching behaviour (Klug et al., 2023; Seamans et al., 2013). Sticky gels establish a non-lethal barrier that birds find uncomfortable, effectively redirecting them from treated surfaces. Polybutene coatings create a sticky substrate that discourages landing while also obstructing the birds' ability to preen or groom after landing (Mason & Clark, 1995). Physical spikes, although more invasive due to surface alteration, deter birds by creating inhospitable perching sites. Micaelo et al., (2023) investigated the long-term effects of spikes, wires, and netting, and concluded that netting proved to be the most durable option, whereas spikes are particularly effective in urban and industrial contexts. The study emphasised the necessity of strategic placement, as coverage gaps can severely diminish the deterrent's effectiveness. Roderick et al., (2019) examined landing dynamics of Pacific parrotlets on varying perch diameters and textures, and showed that while flight mechanics remained consistent, foot, toe, and claw dynamics adjusted upon contact to accommodate specific surface characteristics. On smoother or less stable perches, parrotlets exhibited rapid claw movements, within 1–2 milliseconds to achieve a secure grip, underscoring aversion to unstable perches and suggesting that the implementation of deterrents like spikes and wires was beneficial.

Electric track systems that deliver a mild shock are often used to prevent swallows from nesting (Seamans & Blackwell, 2011). These systems are also employed to deter larger birds, such as pigeons and gulls, from landing on ledges. When a bird lands on the track, it receives a small electric pulse, prompting it to fly away. This method conditions the birds not to return. However, these systems require a power source and are more commonly found in urban or commercial settings. In contrast, using them on a farm may be less practical due to dust accumulation and a lower emphasis on achieving perfect aesthetics (Seamans & Blackwell, 2011).

The immediate action of tactile deterrents is particularly beneficial in scenarios demanding urgent intervention, such as protecting sensitive environments like poultry sheds or feed silos from wild bird contamination. While spikes and netting offer longer-term solutions by physically barring access, they require more extensive installation and may not immediately address management needs in high-traffic avian areas (Micaelo et al., 2023).

To further mitigate avian presence, habitat modification and exclusion apply by enhancing the local environment, making it less suitable for wild birds. Immediate effects on wild bird behaviour can be significant when habitat suitability is altered. Harris and Davis (1998) demonstrated that managing grass height around airports reduced the presence of birds, a principle that can effectively be applied to poultry operations. Pennell and Rolston (2013) introduced endophyte-infused grasses that emit alkaloids, making the vegetation unpalatable to birds. This significantly reduced bird foraging activity in treated areas, providing a long-term solution without the need for frequent maintenance.

Concerning the avian influenza threat posed by wild birds, Ramey et al., (2022) focused on water source management, emphasising that covering or draining ponds reduced waterfowl presence in agricultural areas. Since water sources are common points of avian influenza transmission, this strategy is particularly relevant for free-range poultry farms. Shimizu et al., (2018), in a matched case-control study, investigated whether inland waters (rivers, ponds, lakes, canals) near poultry farms in Japan increased the risk of avian influenza (HPAI) outbreaks. The authors found that farms closer to inland waters (within about 100 meters) were significantly more likely to experience

outbreaks during the 2016–2017 period, but not during the 2010–2011 outbreaks. The authors suggested that improved biosecurity after 2010 may have made environmental factors (like water bodies attracting wild birds) more influential. Proximity to inland waters is a clear risk factor for avian influenza outbreaks, highlighting the need for enhanced biosecurity at farms near such areas (Shimizu et al., 2018).

The studies by Rivadeneira et al., (2018) and Varriano et al., (2025) highlight the benefits of using physical barriers, such as exclusion netting, in conjunction with habitat modification to deter wild birds from agricultural areas. Their research underscores that exclusion netting is one of the most reliable methods for mitigating avian damage, especially in sensitive environments like poultry operations where the risk of avian influenza transmission is high. Their work emphasises that netting, when designed with an appropriate mesh size (typically less than 2 cm), effectively prevents both large and small bird species from accessing poultry range areas while maintaining essential airflow and light penetration.

Pearce et al., (2007) studied the use of netting and structural modifications to prevent nesting in bridges and culverts, demonstrating the adaptability of exclusion methods in different environments. This research supports the application of netting over poultry enclosures and feed areas. Matyjasiak (2008) also examined exclusion wires and netting in airport settings, noting that customising barrier configurations based on bird flight patterns can enhance effectiveness. This is valuable for poultry farms, where specific bird species pose varying levels of risk.

2.6 Chemical Deterrents

Chemical and reproductive deterrents aim to reduce wild bird presence by non-physical, non-scare means, using substances that birds dislike or controlling their population through fertility. These approaches are more subtle and longer acting, complementing physical barriers and scare tactics. They often require regulatory approval and careful use but can provide unique benefits such as area-wide impact or humane population reduction. Chemicals used to repel birds typically exploit birds' senses of taste or smell (or cause mild irritation) to create an unpleasant experience, conditioning birds to avoid treated areas. A key feature is that these chemicals are usually designed to be non-toxic (just irritating or bad tasting) so they don't harm the birds or other wildlife/humans.

Methyl Anthranilate (MA) is a grape flavour compound used in many bird repellents. It irritates bird trigeminal nerves (like chilli pepper does to mammals). Birds find food or water treated with MA to taste bad or cause a slight burning sensation, so they quickly learn to avoid it. MA is used in products sprayed on crops or turf to stop geese grazing or starlings feeding. On poultry farms, one use is to spray it on grass or standing water around the range to deter wild grazers and waterfowl. Harris & Davis (1998) found that MA-based sprays significantly reduced bird feeding on treated plots immediately. The short-term effect is that birds sampling the area have a negative reaction and leave. However, some significant challenges associated with MA are its longevity and cost-effectiveness (Matyjasiak., 2008; Micaelo et al., 2023). MA washes off in rain and degrades rapidly in the environment so frequent reapplication is necessary to maintain protection. This increases costs if on an ongoing basis, though the use of MA in high-risk time periods may be beneficial (Harris & Davis, 1998; Micaelo et al., 2023).

Another alternative to chemical deterrents is the use of a repellent that triggers mild gut irritation. Birds that ingest anthraquinone-treated food get an upset stomach later, making them associate that location with feeling sick. It's been used to protect seedlings and rice from geese/ducks. Birds

cannot detect it by taste strongly, so they might feed but then they feel unwell and avoid coming back. Over time, this can train local birds to stay away. One could use anthraquinone around a farm pond or in sacrificial feed outside the range to teach birds not to eat near the farm.

The use of Capsican, a hot pepper extract has been shown to deter mammals predominately though its success in birds is less defined. Some products use garlic oil, predator odours, or other smells that might keep birds away. Effectiveness is variable and not backed by research for wild birds (though some small trials with predator odours have limited effect because birds rely more on visual cues for predator presence (DeLiberto et al., 2020; Mason & Clark, 1995; Stevens et al., 1998).

2.7 Reproductive Deterrents

These methods aim to reduce the population of nuisance wild birds in the area over time by preventing them from reproducing successfully. Fewer birds mean less risk of disease introduction, in a more lasting way than just chasing them off (since new ones won't be born to replace them) as a long term solution.

Nicarbazin is a poultry coccidiostat that, when fed to birds like pigeons or geese daily, causes their eggs not to hatch as it interferes with the vitelline membrane in the egg (González-Crespo & Lavín, 2022). González-Crespo & Lavín (2022) ran a 3-year pigeon control program in Barcelona with nicarbazin and showed a 55% reduction in pigeon numbers in treated areas. Importantly, no noticeable harm to the adult birds or non-targets (only minimal consumption by collared doves). Over longer periods (eight years in another study), pigeon populations in multiple cities were halved or more by continuous nicarbazin baiting (González-Crespo & Lavín, 2022).

Yoder and Miller (2006) explore various avian contraceptive methods, including chemical agents like nicarbazin and physical interventions such as egg-oiling. Yoder & Miller (2006) reviewed avian contraceptives and included egg oiling as a physical method. Oiling eggs with corn oil prevents embryo development by blocking oxygen transfer. The parents continue to incubate (not laying a new clutch) but no chicks hatch, thus reducing population recruitment. This is labour-intensive but effective on a small scale. It highlights that different bird species respond differently to contraceptive approaches, necessitating species-specific strategies for effective population control (Yoder & Miller, 2006). One limitation on farm is immigration: if you reduce local pigeons, new ones from elsewhere might move in if attractants remain. Ideally a community approach or also reducing attractants is needed. Micaelo et al., (2023) caution that if you knock down a population in one area, birds from surrounding areas might fill the vacuum.

2.8 Lethal Deterrents

Lethal control involves directly reducing wild bird numbers by killing them, whether through shooting (culling) or poisoning (toxicants). It is a controversial and extreme measure, usually reserved for emergency situations like an active outbreak or when non-lethal methods have failed to protect a high-value flock. Because of ethical concerns and potential public backlash, lethal control is typically considered a last resort. However, it can be effective in the short term at quickly reducing the density of high-risk birds (e.g., if migratory waterfowl are actively spreading HPAI in an area, culling some flocks might reduce immediate risk). During a severe HPAI outbreak, wildlife agencies might remove waterfowl in the vicinity of infected poultry farms to create a buffer. Klug et al., (2023) noted culling programs can immediately drop local populations and thereby exposure risk. For instance, if a farm is near a lake where many infected ducks are congregating, a targeted cull could reduce that source of virus.

Lethal removal is immediately effective in removing those birds and stopping their contributions to the risk pool. If attractants remain (food, etc.), new pigeons or sparrows from the surrounding area may move in over weeks or months. So culling often has only a temporary effect unless combined with deterrents or habitat changes to prevent new birds from taking advantage of the now available resources. Ecologically, culling can also trigger compensatory breeding population rebounds or shifts in bird species composition. Public opposition and ecological concerns limit the widespread use of lethal deterrents. Micaelo et al., (2023) underscored the ethical considerations surrounding lethal deterrents, advocating for their use only in high-risk scenarios where non-lethal methods have failed.

3 Short-Term vs Long-Term Effectiveness and Habituation

A primary and consistent challenge mentioned above is the concept of habituation (Blumstein, 2016). Research demonstrates that while loud noises or the playback of alarm calls can effectively disperse birds in the short term, this response tends to diminish significantly over time if no genuine threat is present. Birds tend to "tune out" these false alarms (Rivadeneira et al., 2018). For instance, high-fidelity recordings of alarm or distress calls may prompt immediate aversion, but subsequent use without reinforcement is likely to lead to habituation, resulting in a return to normal behavioural patterns. (Seamans & Gosser, 2016). Seamans and colleagues (2013) conducted a study that evaluated the effectiveness of tactile and auditory repellents in mitigating wildlife hazards to aircraft. The research concluded that while certain repellents can be effective in the short term, their success largely depends on species-specific sensory perceptions and behaviours (Seamans et al., 2013).

In another study, sparrows and starlings overcame their fear of stationary owl decoys within a few days once they realized the decoy never moved or attacked (Seamans & Gosser, 2016; Varriano et al., 2025). Similarly, crows stopped reacting to nightly laser harassment when it became routine, returning to roost despite the laser once they associated it with no danger (Rivadeneira et al., 2018). Eye-spot balloons might only guarantee 1–2 weeks of reduced bird pressure before birds acclimatise (Varriano et al., 2025). This erodes the long-term effectiveness of visual deterrents if no changes are made. To combat habituation, deterrent strategies must be dynamic and varied.

By applying these measures, farmers can extend the usefulness of deterrents from mere days to weeks or months. Nevertheless, no deterrent remains 100% effective permanently. Birds will eventually habituate if a stimulus is static. The consensus in research and extension literature, therefore, is that an integrated approach is vital. Deterrent strategies should be centred on a multi-model approach, utilising all types of available deterrents, and these should be rotated regularly as part of an ongoing wild bird management program.

4 Knowledge Gaps and the Need for Future Research

Despite extensive research into bird deterrent strategies, significant knowledge gaps remain that limit the development of fully effective and sustainable avian influenza (AI) mitigation approaches. One of the most critical gaps is the limited understanding of the long-term ecological impacts of deterrent use, particularly concerning migratory bird behaviour and local biodiversity. Many studies

focus on short-term deterrent success without adequately addressing how repeated or prolonged use affects bird populations and their ecological roles. Additionally, there is a lack of data on species-specific responses to deterrent technologies, which is essential for tailoring interventions to target high-risk AI carrier species without adversely affecting non-target wildlife.

Another substantial gap exists in the integration of adaptive technologies, such as AI-driven monitoring and multi-modal deterrent systems, which can dynamically adjust strategies based on real-time bird behaviour and environmental conditions. Current deterrent methods often suffer from habituation, where birds become accustomed to static stimuli over time, diminishing long-term effectiveness. The development of intelligent, self-adjusting deterrent systems could significantly improve efficacy and sustainability.

Furthermore, there is insufficient research into the cumulative effects of combining different deterrent strategies, such as integrating habitat modification with chemical or reproductive deterrents. Understanding these interactions could optimise multi-faceted approaches that enhance deterrent strength while minimising environmental impacts. Similarly, studies on cost-effective and scalable exclusion methods are limited, posing challenges for large-scale implementation in extensive free-range poultry operations.

The potential impacts of chemical deterrents on non-target species and ecosystem health also remain underexplored. As environmental concerns grow, the demand for biodegradable, species-specific repellents increases, yet current research lags behind these needs. Ethical considerations and public perception heavily influence reproductive and lethal deterrents and their acceptance, necessitating the exploration of humane alternatives such as fertility control and gene-editing techniques.

Given the evolving nature of AI threats, continued research is needed to refine existing deterrent technologies and develop innovative solutions that address current limitations. Future studies should focus on long-term ecological monitoring, the integration of adaptive artificial intelligence-driven deterrent systems, and the development of multi-modal, species-specific strategies. This research is vital not only for enhancing the resilience of poultry operations against avian influenza outbreaks but also for promoting sustainable agricultural practices that safeguard wildlife and ecosystem health. By closing these knowledge gaps, the poultry industry can adopt more effective, ethical, and environmentally responsible strategies for AI mitigation.

5 Conclusion

The threat of Avian Influenza in the commercial poultry industry, particularly within free-range systems, demands robust and multifaceted bird deterrent strategies. Diverse approaches, ranging from visual and auditory methods to exclusion and reproductive controls, offer unique benefits and drawbacks. Integrating multiple deterrents into a cohesive biosecurity plan enhances overall effectiveness, mitigates habituation, and reduces AI transmission risks. Future research should prioritise adaptive deterrent technologies, such as artificial intelligence-driven monitoring systems and dynamic deterrents, which can respond in real time to changing bird behaviours and environmental conditions. Additionally, long-term ecological studies are needed to understand the broader impacts of deterrents on local ecosystems, ensuring sustainable poultry production that safeguards both animal health and biodiversity. By investing in comprehensive, science-backed deterrent strategies, the poultry industry can better navigate the complex challenges posed by Avian Influenza, securing the future of free-range poultry production while maintaining high standards of biosecurity and animal welfare.

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Plain English Summary

Project Title:	Evaluating the effectiveness of wild bird deterrents in Poultry Operations for Avian Influenza Control: A literature review
Australian Eggs Limited Project No	ENGA002
Researchers Involved	Dr Alex-Kate Langfield
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Objectives	To conduct a literature review of the strategies available to deter wild birds to manage the risk of Avian Influenza
Background	Avian Influenza poses a significant threat to poultry health, public health, and the global agricultural economy. The growing concern over Avian Influenza (AI) in commercial poultry operations, particularly free-range systems, has underscored the importance of effective bird deterrents. Wild birds, especially migratory species, act as natural reservoirs and vectors for both low pathogenicity avian influenza (LPAI) and highly pathogenic avian influenza (HPAI) viruses. The transmission pathways, which include direct contact, contaminated water sources, and environmental vectors such as bird droppings and feathers, make it necessary to mitigate wild bird interactions with poultry.
Research	This literature review explores various bird deterrent strategies including visual, auditory, tactile, habitat modification, exclusion, chemical, reproductive, and lethal methods and assesses their short- and long-term effectiveness. It evaluates the implications of these deterrents in reducing AI risks within the free-range poultry sector, where wild bird contact is most challenging to control.
Outcomes	Presentation of information about the options available for deterring wild birds.
Implications	Informed decisions may be made regarding the best option(s) to deter wild birds from poultry farms.
Key Words	Wild bird deterrent, Avian Influenza
Publications	None – Final report only