Department of Defense Noise Working Group (DNWG)

Technical Bulletin

Effects of Aircraft Overflights on Domestic Fowl

SUMMARY

This Technical Bulletin provides an overview of the existing literature on the effect of noise on domestic fowl, with particular emphasis on those studies that have focused on the observations of the behavioral effects produced by jet aircraft and sonic booms.

INTRODUCTION

This *Effects of Aircraft Overflights on Domestic Fowl* Technical Bulletin is one of a series of Technical Bulletins issued by the U.S. Department of Defense (DOD) Noise Working Group (DNWG) under the initiative to educate and train DOD military, civilian, and contractor personnel and the public on noise issues (*DOD Instruction 4715.13*). This bulletin will provide military personnel, local officials, other stakeholders, and the general public with a better understanding of noise effects on domestic fowl.

For this Technical Bulletin, domestic fowl includes chickens, turkeys, ducks, geese, and ratites, including ostriches, emus, and rheas, commercially grown for consumption or egg production. The Bulletin is intended to clarify the possible effects of low-flying jet aircraft on domestic fowl and eliminate concerns proven to be unfounded. Some of the studies included herein report the effects of other types of aircraft noise, such as sonic booms or helicopters, included because they provide corroborating detail unavailable in studies of low-flying aircraft. Where responses to these stimulus types differ, an explicit statement to that effect is included. When perceptual components aside from noise were important, such as visualization of an overflight, it has been stated.

Every attempt has been made to provide generalized predictions, because detailed information on responses of every breed to every aircraft type is not available. Based on the existing literature, the most important predictors of effect are sound level, duration of exposure (*from impulsive to continuous*), approach distance (*slant distance*), habituation of the flocks to noise and disturbance, breed temperament and genetic predisposition, group size, and management system. These predictors may or may not be specific to a particular breed or type of noise.

The DNWG conducted a literature review on the enclosed content and determined that the current body of research still represents the best available science on the subject.

BACKGROUND

Although some studies report that the effects of aircraft noise on domestic animals is inconclusive, a majority of the literature indicates that domestic animals exhibit some behavioral responses to military overflights but generally seem to habituate to the disturbances over a period of time.

This position is based on an extensive body of pertinent scientific data accumulated over the past forty years and supported by records of claims for damage to domestic fowl. Potentially serious effects that can occur are:

- Mortality or morbidity due to panic reactions
- Changes in productivity
- Changes in marketability

Several definitions are used throughout this document. Occasional aircraft overflights produce acute effects, such as piling and crowding or bruising, which are the result of panic reactions. Frequent overflights are more likely to produce chronic effects, such as losses in productivity, which may arise in the absence of overt behavioral responses. Naïve birds are defined as those not previously exposed to aircraft overflights or sonic booms; habituated birds are those that have become accustomed to overflights or sonic booms.

A “startle” or “startle response” is defined as the sequence of events that occur when an animal is surprised, including behavioral responses (*e.g., muscular flinching, alerting, and running*) and physiological changes (*e.g., elevated heart rate, increase in catecholamine production, and changes in gut motility*). This mechanism is a natural response of domestic birds to avoid predators. If the behavioral component of the startle is uncontrolled, particularly if the bird runs or jumps without concern for its safety, it is often called a panic.

“Piling” occurs when birds climb on top of one another during attempts to fly away from a disturbance, and “crowding” occurs when large numbers of birds bunch up against surfaces in their enclosures. Birds may also pick or peck at other flock members after a startle event. Picking is a natural behavior that may be aggravated by confinement; however, this etiology is poorly understood.

When known, weighting is specified in all measures of sound pressure level (SPL), regardless of units. If weighting is not specified, the measurement was regarded as unweighted. Unless otherwise specified, SPL refers to A-weighted sound pressure level (*integration time will be specified where known*), and SEL and ASEL refer to sound exposure level (*unweighted or A-weighted*), and all measures are in dB re 20 μPa.

Sounds that last less than one second are called "Impulsive sounds," which are perceptually less loud than longer sounds (*Gelfand, 1990*). Therefore, it is important to distinguish between impulsive sounds and intermittent or continuous noise. Intermittent noise lasts longer than one second, but is interspersed with periods of silence. The total time an intermittent sound is "on" is called its duty cycle. Continuous noise lasts for hours or days without interruption.

Domestic fowl exhibit a short-term startle response after exposure to sudden intense noise (*Bowles et al., 1994, 1999b; Bradley et al., 1990; Milligan et al., 1983*). This reaction ceases as soon as the stimulus ceases, and all birds return to normal activity within a few minutes. Mild startle reactions from fowl can be provoked experimentally, but the birds soon habituate. There has been only one reported death in experiments with hundreds of birds. One study demonstrated effects on marketability due to exposure to aircraft noise (*Bradley et al., 1990*), but no studies identify the effects on productivity as measured by weight gain or egg production. Therefore, it is a challenge to reconcile experimental studies with claims for damages against the Air Force due to panic reactions.

Panic reactions to low-flying, high-speed aircraft can cause incidents of smothering and trauma as a result of piling or crowding. Deaths due to piling and crowding are rare in normal circumstances, although birds not habituated to loud sounds are known to respond by piling and crowding. Reports of or claims for damages should be carefully investigated as other disturbances can cause piling and crowding, especially in flocks of several thousand birds or when there are contributing stressors, such as heat.

The only information available on the effects of Air Force overflights to domestic fowl is from the archive of claims for damages against the Air Force submitted by growers. There were 100 recorded claims for alleged damages to domestic fowl during the years 1956 to 1988. Unfortunately, these claim files represent a biased sample as they do not include small claims that were paid without submitting a report, nor do they document flight activity in the area where the claim was submitted. Therefore, the number of claims per flight mile cannot be estimated. Additionally, many of these claims were either disproved or insufficient evidence existed to support them. However, the claim files provide the only available data on the relative importance of effect types that can arise.

Most of the claims were for losses due to panic reactions (*55%*), while the remainder were for decreased production (*31%*), reduced hatchability (*6%*), weight loss (*6%*), and reduced fertility (*less than 1%*). The number of claims against the Air Force varied between 1956 and 1988, but averaged less than three per year. Peak numbers of claims (*nine in 1962*) followed the publication of studies on the effects of noise on fowl (*Stadelman, 1958a, 1958b; Stadelman and Kosin, 1957; Heinemann and LeBrocq, 1965*). The number of

claims are small when compared to the hundreds of thousands of flight miles logged each year during Air Force training activities. The clumped distribution associated with publication of these studies suggests that sociological factors are responsible for a number of the claims in the early 1960s.

Claims for damages have cited effects on productivity such as changes in egg production, hatchability, and poult growth; however, most claims cannot be substantiated by controlled studies. Some decrease in egg production may be observed when skin lesions received during a panic become infected. Otherwise, effects of aircraft overflights on fertility, egg production, hatchability, and poult growth have never been identified in controlled studies or documented clinical examinations. It should be noted that effects on fertility have not been adequately studied.

Effects on marketability include a decreased carcass quality, particularly by bruising of meat poultry, and egg quality. In fowl that are already stressed by disease, environmental conditions, or genetic makeup, other effects of aircraft overflights are theoretically possible, but have not been studied. The most likely of these effects are changes in egg production or shortening of productive life span and failure to gain weight (*"productivity disease"*). Like piling and crowding, these conditions arise for many reasons. In particular, egg "cannibalism" and loss of egg production due to premature molt are usually the results of inadequate nutrition, water deprivation, or other poor management practices.

Bowles et al. (*1999b*) reviewed Air Force claims data of damages to ratites between 1993 and 1994. There were 73 claims and complaints, and 22 incident reports during this timeframe. Of the approximately 2,000 birds claimed to have been overflown, a total of 19 birds were claimed to have been killed — a one percent loss rate. Breeding declines and cases of stress were also mentioned. Twenty-two percent of the $570,436 claimed was paid.

Twenty-seven responses to questionnaires covering a variety of disturbances were returned from ratite farmers/ranchers from 11 states, representing over 3,350 birds (*Bowles et al., 1999b*). These responses declared DOD was responsible for three deaths, one leg injury, and two minor injuries. Bowles et al. (*1999b*) calculated a loss rate of 0.1 percent.

DISCUSSION

A. Status of Scientific Research

1. Panic-Induced Piling and Crowding

Most reported damages in the claims files were for massive losses due to panic-induced trauma (*e.g., death, suffocation*). Experimental studies show that such losses are rare (*two losses in three experiments with hundreds of poults*). Therefore, factors leading to piling and crowding merit further examination.

The most common causes of piling and subsequent deaths are predatory animals and unusual activities of caregivers, but noise with sudden onset, such as aircraft overflights, can also be a cause. In general, reactions to subsonic aircraft overflights or sonic booms are similar to reactions to barking dogs, blowing paper, backfiring trucks, thunderstorms, etc. Most comparative accounts of behavior in response to aircraft noise (*real or simulated*) emphasize the pronounced reactions of poultry when contrasted with the reactions of farm mammals (*Bell, 1972; Ewbank, 1977*). This is a consequence of major predator avoidance mechanism-flight and relative stereotypical bird behavior.

When confined birds pile up, they incur and inflict nonfatal injuries (*usually on their backs*) (*Milligan et al., 1983*). These injuries following an incident may reduce feed and water intake for as long as 4–5 weeks but, in the absence of a secondary bacterial infection, do not result in significant mortality. These incidents can result in bruising that may persist until the birds are processed (*Bradley et al., 1990*). Any deaths as a result of piling occur within 72 hours of the incident. Experience indicates that morbidities of 10–25 percent can be expected in large turkey flocks that pile and crowd severely, including the small percentage of 72-hour-post-incident, injury-related deaths (*Milligan unpublished*). These deaths do not occur after every overflight incident, however, because poultry do not always pile severely and because good management conditions greatly mitigate losses. Tom turkeys at market weight would be expected to experience higher mortality due to their weight and hormone-related susceptibility to heart attacks. One substantiated claim showed a mortality rate of 38 percent in mature tom turkeys. In that claim, heat resulting from an aircraft-noise-induced pile up was a contributing factor to mortality (*Milligan et al., 1983*).

Based on experimental studies and interviews with growers, panic piling and crowding behavior occurs only in naïve birds and is extinguished within five exposures to a startling stimulus (*usually within two exposures*). Bradley et al. (*1990*) exposed naïve turkey poults 6 weeks of age to simulated aircraft noise at levels of 95 dBA or greater and observed behavioral responses. The turkeys were housed in pens with 20, 40, and 100 birds, simulating different flock sizes. No panic-induced losses were observed in this study, although panic was induced on initial exposure in all pens. Stadelman (*1958a*) exposed chicken poults of varying ages to aircraft noise, observing panic reactions in naïve poults 31 days old, but not in younger poults. The degree of experience of the younger birds was not fully documented. During this panic, one poult was lost to smothering. Von Rhein (*1983*) found that 1-week-old chicken poults in groups of 80 piled up in response to jet aircraft overflights whereas older, experienced chicks did not. No deaths were observed in that study, despite over 100 exposures to actual overflights. Bowles et al. (*1998; 1999a*), exposed 3-week and 8-week chicken poults to simulated aircraft noise up to 115 dB ASEL while monitoring behavior, food and water intake, and changes in body weight. No piling and crowding were observed. During the first few exposures of those poults to a high-level dose, increased aggression was observed.

Ratites of three species were exposed to noise from real and simulated aircraft at levels of up to 105 dB ASEL without any observations of panicked responses or injuries (*Bowles et al., 1999b*); however, running and flock running were commonly observed during disturbances.

The threshold for the naïve response in turkeys can be estimated at around 85-95 dBA. Below this threshold, severe crowding does not occur, and above it, crowding is likely to occur. The rate of habituation is somewhat independent of sound level, as birds habituate as rapidly to sounds of over 100 dB as to sounds of 85 dB (*Bradley et al., 1990*). The decline in response is much more rapid than that predicted from neurophysiological and physiological responses to the sound, which indicates that adaptation is behavioral. The decline in response is as rapid to actual overflight noise as to simulated aircraft noise. If birds can see the aircraft, the proportion of the flock that responds may be greater or the chances of panic may be greater, but this effect has not been studied in normal housing. Since most large poultry growers keep stock in closed houses for safety reasons, smaller growers are the most vulnerable to the added impact of visual stimuli. In the experiment by Bradley et al., birds that had been disturbed by transport, handling, heat, etc., were less susceptible to panic, suggesting that those rarely exposed to humans may be more susceptible than those that are often disturbed. Previous disturbance reduces the incidents of panic because the birds habituate to the disturbance.

Once panicked, however, environmental stressors can contribute to high mortalities in a pile up, particularly in the case of turkeys (*Milligan et al., 1983*). Heat alone will not cause piling in turkeys, but can cause heavy losses after piling occurs. The opposite extreme, exposure to cold, will cause piling as birds try to thermo-regulate by huddling. No losses have been reported due to this cause, possibly because cold birds are usually fairly torpid. Heat-related deaths will occur at random, with symptoms similar to deaths from an acute febrile disease, such as fowl cholera, erysipelas, or colibacillosis. Birds dying acutely from one of these febrile diseases would be indistinguishable, on necropsy, from those dying of heat stress. In both cases, the dead birds would show signs of dehydration, vascular engorgement, and “cooked” muscles. The significant difference between death due to an acute febrile illness and death due to an externally stimulated heat stress would be random distribution of dead birds in the former case, and distinct evidence of piling in the latter. Domestic fowl lose heat through convection and evaporative cooling (*panting*). Due to heavy reliance on panting, high humidity can further compound heat-related losses.

The immediacy of these losses is always great. Turkey deaths following a frightening noise will be acute, with no long-term effect seen in the survivors except changes in marketability. The hyperactivity caused by the noise, when added to the heat stress of piling, will cause the birds to pass out immediately. Lethal body temperature in turkeys is 116°F, a temperature that is very rapidly reached after piling, and death occurs due to cardiovascular collapse. A few birds might linger for an hour or so during heat prostration, but most deaths will occur in less than 1 hour. No long-term physiological effects of heat stress due to piling have been uncovered (*Milligan et al., 1983; and unpublished data*).

2. Other Types of Mortality

In the Bradley et al. (*1990*) study, a greater number of turkey poults exposed to frequent jet noise above 95 dBA were lost due to picking compared to a control group. However, in numeric terms, the total number of birds lost was smaller than losses normally anticipated in a commercial setting. The losses due to picking were important not for their economic significance, but because picking and cannibalism can spread. An increase in picking was observed in the 8-week chicken poults exposed to simulated aircraft noise (*Bowles et al., 1998, 1999a*). However, Bowles et al. (*1999a*) did not see this behavior in younger poults (*3 weeks*) or in laying hens.

It should be noted that picking does not occur in a natural setting (*i.e., it is not observed among wild birds or free-ranging domestic poultry*). However, it is a common behavior among confined chickens and turkeys. The incidence is so prevalent that most experienced poultrymen either obtain commercially debeaked chicks and poults, or debeak their own birds at an early age. Picking is common in both young and old poultry, as well as in both noise-habituated and naïve birds. Experimental attempts to sort out the reasons for this poultry activity have been unsuccessful. It is, therefore, not currently possible to state the contribution of aircraft noise or any other stimulus to picking.

3. Effects on Production, Fertility, Hatchability and Laying

There have been claims for damages due to decreased growth, but the documentation in these claims was inadequate. No effects on growth of fowl were detected in experimental studies of the effects of jet overflights, helicopter overflights, and sonic booms (*Stadelman, 1958a; Cottereau, 1972; Kagan and Ellis, 1974; Von Rhein, 1983*). Sample sizes were large enough in those studies to detect subtle differences in growth rate.

Stadelman and Kosin (*1957*) exposed 7,860 chicken poults to playbacks of jet and propeller aircraft overflight noise (*73–116 dB SPL*) at a range of ages, and found no significant change in growth. Cottereau (1972) found no change in weight gain of laying hens exposed to sonic booms of varying peak overpressures of up to 64 lbs per square foot (psf) or 134–168 dB. Kagan and Ellis (*1974*) found no change in weight gain of 100 White Leghorn hens exposed to continuous traffic noise. Bradley et al. (*1990*) found that growth rate in 160 domestic turkey poults was not affected by worst-case exposure to simulated aircraft noise — 10 weeks of exposure to 17 simulated incidents per week at sound levels over 95 dBA. At the end of the experiment, differences in mean weight of control and experimental groups were still below the level of statistical detection, and the birds all fledged at or above industry standard weights. Bowles et al. (*1998; 1999a*), exposed laying hens to simulated aircraft noise (*up to 115 dB ASEL*) while monitoring behavior, body weight, food consumption, e.g., production and egg quality. Egg productivity and egg quality were not affected by the disturbances.

Egg production is a complex, dynamic process influenced by many factors. Maximum egg production by White Leghorn hens, for example, requires a combination of optimum nutrition, age, lighting, water, temperature, housing, and health. There are many reasons for hens to stop laying eggs, the most common being decreasing day length, disease, advancing age, improper nutrition, and environmental stress. Inadequate floor space, nesting boxes, feeder space, and water troughs are also factors, which can have a cumulative effect of reducing egg production. Furthermore, infrequent coop cleaning and lack of litter result in a high ammonia concentration in the air, creating respiratory stress or distress, which also reduces production. A sudden decline in egg production or a poor production record, therefore, necessitates a careful examination of all aspects of flock management, including: age of birds, culling, artificial lighting, housing, floor space, feeding, water, number of nests, sanitation, parasite control, change in environment, and economic management. Therefore, controlled studies of the effects of noise on egg production probably provide the most useful indication of noise effects.

In addition to the studies summarized above, the Air Force also conducted numerous unpublished field studies under controlled conditions to determine the effects of aircraft noise on broiler production and egg production in laying flocks (*Milligan, personal observation*). The Field Environmental Services Division at Brooks AFB conducted one such study from June through September 1966 in Arkansas, an area heavily engaged in poultry production. Eleven farms were involved in the study, and veterinarians examined the management practices at these farms prior to the experiments. Aircraft used in the tests were A-6s, A-4s, F-4s, and B-52s. The planes flew at speeds from 200–600 kts at altitudes as low as 50 feet over or near the poultry houses. Noise levels were as high as 99 dBA. Although the noise stimulated flying and crowding among the birds, there were no production losses during the period of the test (*i.e., no decreases in broiler weight gain or losses in egg production*).

There is some evidence of a decrease in egg production by hens exposed to continuous, or very frequent intermittent loud noise. The noise sources include ambient sounds in a commercial poultry operation, radios, bells and sirens, and army maneuvers (*including air reconnaissance*) (*Belanovskii and Omel'yanenko, 1982; Ivoš et al., 1976; Hamm, 1967*). Okamoto, Gota, and Kogo (*1963*) reported that the laying rate in experimental hens decreased more rapidly than in a control group when birds were exposed to continuous sound (*jet plane noise*) throughout at least 1 month of their laying periods. However, the data were not tested statistically, the differences in means were small, the standard deviations were large, and, unlike real jet noise, exposures were continuous rather than intermittent. An examination of the graphic presentations in the published account suggests that significant differences were not observed. Jeannoutet and Adams (*1961*) found no differences in productivity of turkey hens between a group given realistic exposures to jet aircraft noise and one that was not exposed.

Infrequent, intense noise bursts of the sort expected along military training routes and military operating areas did not affect egg productivity, even after exposures as high as 120–130 dBA (*Stadelman and Kosin, 1957; Von Rhein, 1983*). Cottereau (*1972*) failed to find changes in productivity of hens exposed to six sonic booms of over 10–31 psf or 148–157 dB (*unweighted*) per day. Unfortunately, the results were not analyzed statistically in this study, and sufficient data were not presented for an analysis after the fact. The summary values for these data suggest no effect.

Practical experience shows that characteristic reduction in egg production could occur in large poultry operations where hens are housed in groups. Based on consultations with poultry growers and claimants, Milligan et al. (*1983*) determined that drops in egg production for 2–3 weeks in duration are often due to infectious causes (*e.g., viral pneumonia*), while those lasting 5-6 weeks could be due to physical injuries such as skin wounds. When startled, hens pile and can often inflict deep scratches to each other. When this occurs, a statistically significant initial drop in egg production lasting for about 6 weeks could occur. After that, production would be expected to resume its characteristic profile. The drop in production only occurs in cases where hens damage themselves or one another in a confined space; hens housed singly and free-range hens are much less susceptible. It should be noted that the observations from Milligan, et al. were based on data from large flocks (*12,000 hens*). Experimental attempts to confirm these observations with small flocks have been unsuccessful because piling and trauma are much less likely in small flocks (*Bowles et al., 1998, 1999a*).

Some claims and one experimental study reported that disturbed hens cannibalized eggs. This was attributed to water deprivation, not aircraft overflights, in all cases.

Sudden noise can affect broodiness. Decreased broodiness does not affect large commercial growers because commercial laying hens do not brood their own eggs; however, small growers might be affected.

Stadelman and Kosin (*1957*), Stadelman (*1958b*), and Jeannoutet and Adams (*1961*) reported substantial declines in broodiness of hens and turkeys exposed to aircraft noise and sonic booms. It was not clear what dosages were required or how long the effects lasted, but at least one incubation cycle was affected by the treatment (*Stadelman and Kosin, 1957*). Semi- domesticated game species and wild birds may not be susceptible, because wild turkeys in one experiment (*Lynch and Speake, 1978*) did not exhibit loss of broodiness. Low-level aircraft overflights and sonic booms did not affect nesting behavior and physiology of peregrine falcons in another study (*Ellis 1981; Ellis, et al., 1991*).

Although one claim of decreased fertility was made to the Air Force, there is little evidence in the literature to support or deny the hypothesis that significant reproductive problems are caused by intermittent, intense noise. For example, high levels of continuous noise had no effect on the fertility of male chickens (*Kosin, 1958*), and intermittent noise (*95–120 dB unweighted*) did not affect spermatogenesis (*Stadelman and Kosin, 1957*). However, Kosin (*1958*) reported somewhat lower laying rates in hens receiving sperm of exposed males. These data are insufficient to determine whether this effect was the result of noise exposure or other factors and whether intermittent exposure had the same effect as continuous noise. At present, effects on fertility should be characterized as poorly known and likely to be subtle.

Egg breakage and reduced hatchability are very unlikely after exposure to aircraft noise, particularly low-altitude jet noise and sonic booms (*Heinemann and LeBrocq, 1965; Cottereau, 1972; Cogger and Zegarra, 1980*). Cottereau tested high-amplitude impulses (*up to 64 psf; 164 dB unweighted*) with the majority of sound energy at low frequencies (*10 Hz and below*) and was unable to find evidence of damage, even after daily exposure. Bowles, Awbrey and Jehl (1991) tested high-amplitude, high-frequency impulses (*172.9–180 dB unweighted; peak energy at 437.5–837.5 Hz*) with the same result. In follow-on experiments using a sonic boom test facility, Bowles et al. (*1994*) exposed 252 fertile White Leghorn chicken eggs to simulated sonic booms. Eggs exposed to higher levels of exposure (*20 or 30 psf*) had statistically higher survival rates than those of lesser exposure (0 or 3 psf). Other experiments (*particularly Cogger and Zegarra, 1980*) exposed eggs to impulses of intermediate frequency and amplitude (*average sound levels 156.3 dB peak flat SPL and 127.7 dB ASEL, with 88 percent of the sound energy below 200 Hz*). Domestic chicken and quail eggs did not break or crack, existing cracks did not worsen, and embryos were not killed in any of these experiments.

Bowles, et al. (*1994*) reported the resonance frequencies of chicken eggs to range between 468 and 1036 Hz and quail eggs between 1274 and 1475 Hz, 6-7 octaves above the peak energy in simulated sonic booms. Ting, Garrelick, and Bowles (*2002*) developed two models of avian eggs to predict the level of sonic boom overpressure required to cause damage. Throughout that analysis, even under extraordinary circumstances, supersonic aircraft maneuvers would not damage an avian egg.

"Panic flights," during which the parent leaves the nest after a noise disturbance, are of such short duration that damages due to exposure of eggs or young are unlikely except in wild birds (*Bowles and Stewart, 1980; Schreiber and Schreiber, 1980; Awbrey and Bowles, 1990*). Commercially important poultry operations would not be subject to this effect in any event because their hens do not brood their own eggs.

4. Effects on Marketability

Effects on Carcass Quality

Bradley et al. (*1990*) discovered that behavioral responses of turkeys poults exposed to aircraft overflights over long periods resulted in detectable effects on carcass quality. The effect might have been due to the naïve panic response or to slightly elevated levels of picking and aggression in exposed birds over the long term. The differences in carcass quality were attributable to small surface lesions and bruising. This effect was not reported in previous experiments because none had examined either behavioral effects or effects on carcass quality.

The economic effect of carcass downgrading (*23% relative loss after 10 weeks of worst-case exposure to jet noise*) depended on the size of the turkey operation. Small growers producing mainly whole-body turkeys for the holiday market can sell only grade-A birds and would be most severely affected by downgrading. For a large grower, the worst-case loss predicted by the experiments result in an overall economic loss of approximately 13 percent, because most large growers sell downgraded or lower-grade stock for processed meats. Exposure to aircraft noise would have its greatest effect during the later rearing period when losses due to picking are greatest and when healing is unlikely to occur before processing.

Effects on Egg Quality

Egg quality was affected by noise in several experiments. More blood spots were found in eggs laid by chickens exposed to continuous whistles and "medium-loud" radios, although there were no changes in other measures of egg quality (*such as egg weight, shell thickness*) (*Stiles and Dawson, 1961*). Okamoto et al. (*1963*) found a significant decrease in the total weight of eggs laid by chickens exposed to jet plane noise. However, the study was inadequate in that methods were not described (*for example, the rate of stimulus presentation*), and sound levels were measured in a unit of loudness developed for humans—the "phon" — a measure likely to have little meaning in other contexts. Neither Stiles, Dawson (*1961*), nor Okamoto et al. (*1963*) determined the cause of changes in egg quality, and replicate experiments were not done, so the effects on egg quality could have been caused by other factors. Therefore, effects on egg quality after aircraft overflights are possible but should be regarded skeptically without sufficient clinical information. Effects on egg quality would be found only within 24–48 hours of the overflight.

5. Effects of Different Types of Aircraft

The study by Bowles et al. (*1999b*) used fixed wing and rotary wing aircraft and simulated aircraft noise. High-speed F-16 overflights elicited lower responses than slower aircraft. Only marginal differences were seen between responses to simulated versus real aircraft. No other studies have been conducted testing the responses of poultry to a wide range of aircraft types. The claims files indicate that birds may respond more often to sonic booms than mammals, but the data in the claims are biased. Separate studies using military jet overflights, helicopter overflights, and sonic booms all reported similar responses, so differences in response to different types of aircraft noise will be quantitative rather than qualitative.

FINDINGS/CONCLUSIONS

The most serious potential damages to poultry are injuries and suffocations that occur when panicked birds pile or crowd. Damages during a piling incident may be compounded by other factors, such as heat stress, poor management practices, or high densities of birds. Any type of aircraft noise of sufficient sound level can induce piling and crowding. However, only naïve birds panic, and birds habituate quickly to noise. The likelihood of damaging panicked responses is small based on experimental studies and interviews with growers (*Von Rhein, 1983; Bradley et al., 1990; Bowles et al., 1999a*). Reports or claims should be investigated carefully for the possibility of more common sources of disturbance, such as predators.

Large or dense flocks are more susceptible than small ones. Poultry are housed in flocks ranging from small (*1–2 hens in a battery cage*) to large (*thousands of poults in a pen*). At present, there is no way to predict how the size of a group increases the possibility of damage. Estimates of expected losses in large groups if birds panic range from 10–38 percent based on anecdotes and grower reports, but these values have not been substantiated experimentally. At present, there is no way to predict if flocks will panic.

Based on the existing experimental evidence, effects on productivity (*effects on growth and egg production*) are considered unlikely, but, if present, are most likely to be subtle changes in productivity that result from secondary infections in birds that received superficial wounds in a panic. Predictions of the potential for effect in special situations (*e.g., for particular breeds or for prestressed birds*) cannot be made because little is known about the physiological effects of stress, in general, on birds. Hormones used to measure stress in mammals cannot be presumed to be useful measures for birds. More research is needed to show the relationship between physiological responses to noise and effects on production. Areas of further study might include detailed clinical studies of birds after a panic, basic research to develop physiological measures of stress, studies of immune suppression, and clinical studies of the function of the reproductive system in birds exposed to noise.

Effects of aircraft overflights on marketability are possible. Changes in egg quality will be limited to eggs in the tract at the time of exposure (*within 24–48 hours of exposure*). Effects on carcass quality will not be discovered until poults or hens are slaughtered, which may be many weeks after an exposure. Poultry inspectors can determine the age of bruises fairly well, so an independent inspection is recommended for cases where heavy damages due to bruising are experienced. For most large growers, the economic losses due to aircraft overflights will be minimal.

The idea that sonic booms can damage bird eggs has never been demonstrated. To the contrary, empirical, analytical, and observational evidence is so overwhelming, that no further research is necessary and any suggestion of egg damage due to sonic booms should be immediately discounted.

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As members of the community, the Military Services (*i.e., Army, Navy, Marine Corps, Space Force, Air Force*) want to be good neighbors. The Military Services continue to work with civilian partners and listen to residents' concerns regarding the sounds associated with military training that may be disruptive to our community. Military Service staff are available to meet and discuss noise associated with military training. Contact the local Public Affairs Office or the Community Plans and Liaison Officer with any questions or concerns.

For more information or questions about the DOD Noise Program, please contact us at: *osd.noiseprogram@mail.mil*.

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