STAPHYLOCOCCUS INFECTIONS IN BREEDING STOCK

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INTRODUCTION

A *Staphylococcus* infection, or Staphylococcosis, refers to diseases caused by *Staphylococci* bacteria, creating a different lesion depending on the affected area (**Table 1**). *Staphylococcus aureus* (*S. aureus*) is a gram-positive, catalase-positive, coccoid bacteria that appears in grape-like clusters on stained smears. In breeding stock, *S. aureus* is the most common form of the infection and involves tenosynovitis (inflammation of the tendon sheaths) and arthritis of the hock and stifle (leg) joints in birds of all ages.

Table 1. Staphylococcal-related infections in poultry.

LOCATION	AGE	LESION	USUAL
Bone	Any, usually older	Osteomyelitis	Lameness
Joint	Any, usually older	Arthritis/ Synovitis	Lameness
Yolk sac	Chicks	Omphalitis	Death
Blood (septicemia)	Any	Generalized necrosis	Death
Skin	Young	Gangrenous dermatitis	Death
Feet	Mature	Plantar abscess (bumblefoot)	Lameness

Source: Claire B. Andreasen. Staphylococcosis. In: Diseases of Poultry. Fourteenth Edition. Ed. 2020.

Staphylococcus infections occur more frequently under conditions that cause breaks in the epithelial lining, intestinal mucosa or skin barrier and could be exacerbated by immunosuppressive diseases or situations that allow them to cause disease. For this reason, it is considered an opportunistic bacterium. Clinically significant times of the birds' life are summarized into four periods:

0–2 weeks — Omphalitis and femoral head necrosis (FHN) or bacterial chondronecrosis with osteomyelitis (BCO) are often related to egg or hatchery contamination and procedures like toe treatments. Red hock lesions could allow pathogens to enter through the skin barrier. These situations are more common during hot and humid months of the year.

2–8 weeks — Infected hock and stifle joints secondary to coccidiosis or harsh vaccine reactions (**Figure 1**).

10–20 weeks — Infected hock and stifle joints secondary to vaccination challenges or improper handling during vaccination. Overcrowding, poor feed distribution, and insufficient feeder space worsen these problems.

24–30 weeks — Infected hock and stifle joints and bumblefoot (plantar abscess) secondary to the challenges of moving, mating, and onset of egg production. Male aggression and injuries associated with poorly maintained feed equipment, nest boxes, slats, and poor litter quality also contribute to the development of Staphylococcal infections during this period.

Figure 1. Swollen hocks caused by *Staphylococcus* infection.

PATHOGENESIS

Staphylococcus aureus is a ubiquitous organism in the breeder house environment and can be isolated from litter, dust, and feathers. The bacterium is considered a normal resident of the chicken—located on the skin and feathers and in the respiratory and intestinal tracts—and, under normal circumstances, poses no threat.

The organism must enter the circulatory system to cause disease; thus, the probability of infection is increased by any injury, providing the bacteria with a route of entry. The two most obvious routes of infection are through a break in the skin or the intestinal mucosa, likely the result of a wound caused by injury or an intestinal challenge like enteritis or coccidiosis. In addition, some studies have shown that another major route of entry for *Staphylococcus* may be through the respiratory tract. Poor air quality or "hot" (more virulent) respiratory vaccines facilitate *Staphylococci* entry through the respiratory tract.

Once in circulation, *Staphylococci* have a high affinity for collagen-rich surfaces, such as the articular surface of joints and synovial sheaths around joints and tendons. *Staphylococci* also localize in the growth plate of actively growing bones—explaining a higher incidence of FHN—also referred to as BCO (more prevalent in young versus more mature chickens).

The likelihood that *Staphylococci* can cause disease increases when the host's immune system is impaired. Viral agents such as infectious bursal disease (IBD) and chicken anemia virus (CAV) have been shown to suppress immune function and increase the incidence of such Staphylococcal diseases as BCO and gangrenous dermatitis. Other agents that may cause similar immunosuppressive effects include Marek's Disease virus, reovirus, and aflatoxins in feed.

Poor management can be a significant cause of immunosuppression, and it should be avoided as it can impair immune function or create a situation where birds are more susceptible to infection. Major factors impacting bird welfare include overcrowding, insufficient feed, drinking and nest space, poor feed distribution, improper handling, inadequate clean-out and biosecurity procedures, extreme temperatures, and poor ventilation and air quality.

It has been proposed that skeletal deformity plays a role in Staphylococcal arthritis. Angular limb and rotational bone deformities—such as valgus-varus disease—increase the stress on joints and skeletal support architecture. Subsequent damage to tendons, ligaments, and articular surfaces provides the opportunity for bacterial colonization. Insufficient activity during rearing also makes skeletal structures more susceptible to minor injuries, such as strains and sprains. These mild injuries can then provide a site for infection.

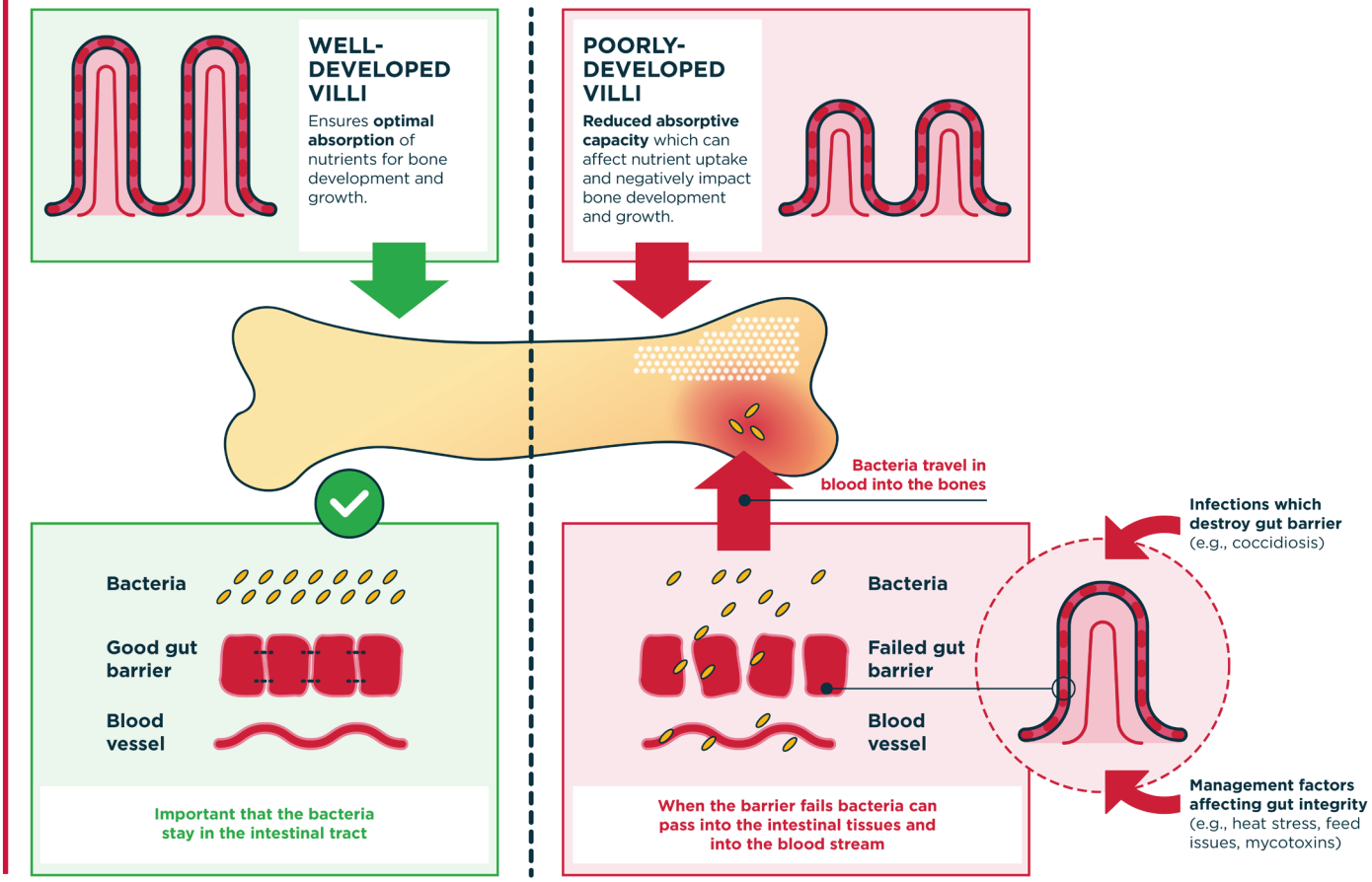
Management practices known to help reduce the risk of disease include:

- Promoting excellent early intestinal tract development and integrity.
- Maintaining optimal skin integrity.
- Preventing and controlling respiratory challenges and respiratory reactions to vaccines.
- Optimizing management to prevent or minimize factors that may impact welfare.

1. Intestinal development and integrity.

- Early intestinal tract development is important for long-term enteric health, more beneficial for leg health, and often overlooked. Failure to provide the correct brooding conditions likely results in poor villi development, leading to an intestinal tract with a reduced capacity for absorption. An environment that promotes the proper development of intestinal tissues during the early life of the bird ensures a good gut barrier, preventing bacteria such as *Staphylococcus* from infecting young birds.
- Within the intestinal tract is a large community of bacteria known as the gut microbiota. These bacteria are essential for promoting and maintaining enteric health; they are normal members of this community, which can cause disease should they pass from the intestinal tract into the bird's body (e.g., *E. cecorum*, *E. coli*, and *S. aureus*). The cells lining the villi have a secondary function to nutrient absorption—they form a barrier that prevents bacteria from passing from the intestinal tract into the intestinal tissues (**Figure 2**). This barrier can fail due to infection, heat stress, poor ingredient quality, imbalance in the intestinal microbiota, and mycotoxins. Following barrier failure, there is a reduction in nutrient uptake, which can lead to poor growth in the birds and bacterial overgrowth in the intestinal tract (dysbacteriosis). Furthermore, bacteria can then pass into the intestinal tissues, where they are/may be transported in the blood to the bones and joints, where they can cause disease. Therefore, ensuring good management, optimal nutrition, and disease control strategies are essential to maintain the integrity of this barrier.

Figure 2. The role of villi development in ensuring a good gut barrier.



- Effective control of coccidiosis is required to minimize the damage to the lining of the intestine. If the intestinal lining is excessively damaged, Staphylococcal organisms may enter the bloodstream through the intestinal blood vessels and cause the development of secondary Staphylococcosis. Live coccidiosis vaccines have proven to be an excellent method for controlling coccidiosis, but reactions to the vaccines must be carefully monitored. Vaccinated flocks must be examined regularly from 2–5 weeks of age to determine the degree of reaction. Prompt treatment with an anticoccidial could be necessary when an excessive vaccination reaction is present.

2. Skin integrity.

- The environment in the chicken house should be managed to prevent scratches that may allow Staphylococcal bacteria to enter through the skin. Management of the amount and distribution of light, feed, and water is necessary to avoid scratches. Birds must have adequate feed and water space, which is best provided by avoiding excessively high population densities. Some exercise is also required during rearing to produce strong bones, joints, muscles, and tendons; this can be accomplished by having adequate light intensity and placing perches or drinkers on low slats to encourage activity.

- Careful handling of the birds during vaccinations and at transfer is essential. Care must be taken during vaccination to prevent vaccine contamination, and needles and wing web applicators must be changed frequently. Feed boosts and supplemental vitamins or supplements may help relieve the stress associated with handling. Minimize the number of times the flock is handled by combining as many procedures as possible. Birds should be caught carefully and held in a way that minimizes distress, damage, and injury (e.g., bruising or dislocations). Ensure there are two points of contact on the bird: both legs, wings, or sides.

- Because wounds provide a significant portal of entry for *Staphylococci* bacteria, actions must be taken to reduce the chance of injury. Sharp objects—rocks, wire, metal, rough edges on equipment, nails, and splinters—must be removed. Slats and equipment should be well maintained. Setting the slat height correctly (maximum 25–30 cm [10–12 in]) and using ramps reduces leg and foot injuries.

3. Prevention and control of respiratory challenges.

- Prevention of early exposure to immunosuppressive viruses like IBD, CAV, and Marek's Disease by providing high levels of maternal antibodies, vaccination, and sanitation also helps prevent Staphylococcosis.

- "Hot" respiratory vaccines—Newcastle disease LaSota strain, for example—could cause reactions that allow bacteria to enter.

- Staphylococcal bacterins have not proven to be beneficial. Bacterial interference using *Staphylococcus epidermis* strain 115 in turkeys decreased Staphylococcosis and improved livability in turkeys (Jensen, 1990). However, studies in chickens have not demonstrated any benefit (McNamee and Smyth, 2000). Competitive exclusion products and probiotics may help to reduce the incidence of Staphylococcosis, but more research is warranted.

4. Optimize management practices.

- Maintaining good litter quality reduces footpad damage. Proper ventilation, good quality litter material, removal of caked litter, and correct drinker management help preserve litter quality.

- The onset of sexual maturity and egg production can be a stressful period. Care should be taken to achieve sexual synchronization between males and females and adhere to recommended mating ratios and the number of nests per hen. Proper management of feed and lighting programs during this critical period is essential.

- Thorough cleaning and disinfection between flocks can minimize the level of *Staphylococcus* challenge. Most good quality disinfectants are effective against *Staphylococcus*. Field observations have shown that cleaning the water supply and lines can reduce leg problems. Using a closed water system (nipple drinkers) and a water sanitation program has also proven beneficial.

CLINICAL SIGNS AND GROSS LESIONS

Egg- and hatchery-related Staphylococcal disease is evidenced by depressed chicks, high early mortality (first 2 weeks), wet or unhealed navels, and omphalitis. Another predisposing factor is skin abrasions (red hocks) at hatch. Infection of the bone (osteomyelitis) may also occur, often causing FHN.

Chickens with arthritis and tenosynovitis experience lameness. The hock joint is typically involved, swollen, and warm to the touch. The stifle joint is the second most commonly affected joint. When opened, the joint and surrounding tissue contains a white- to yellow-colored caseous exudate. Inflammation may also be evident on the articular surface and nearby tendons.

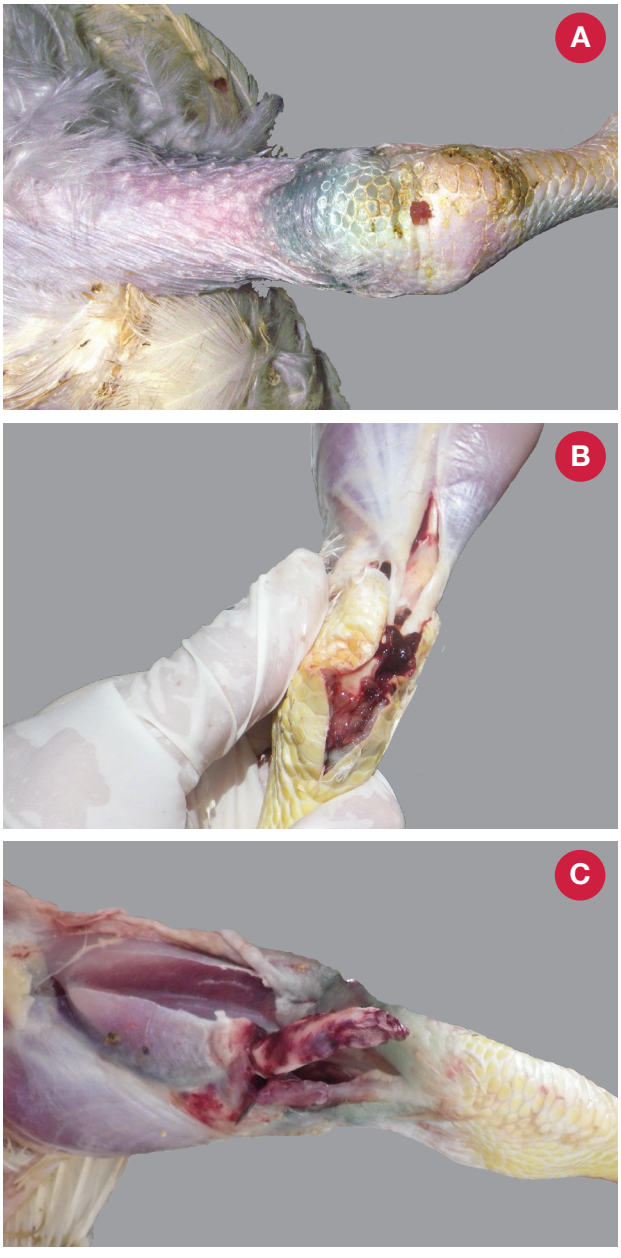
Experimental work has shown that early infection with either *Staphylococcus* or reovirus can cause inflammation of the hock joint and nearby tendons (Hill, et al., 1989). Chronic infection of the tendons with either organism leads to progressive fibrosis and calcification. As birds gain weight or are placed in slatted houses, these tendons may rupture, resulting in permanent loss of use of the affected leg. A large knot (fibrosis) may form at the site of the rupture. A differential diagnosis of reovirus arthritis must be made using some or a combination of the following:

- Serology
- Histopathology
- Virus isolation
- Virus identification via molecular analysis

However, diagnosis becomes difficult if more than 5 weeks have passed after infection because the important microscopic lesions become similar over time. Most evidence from field problems fails to adequately prove that reoviruses are the cause, and most issues have improved or been resolved with no change in the reovirus status of the flock.

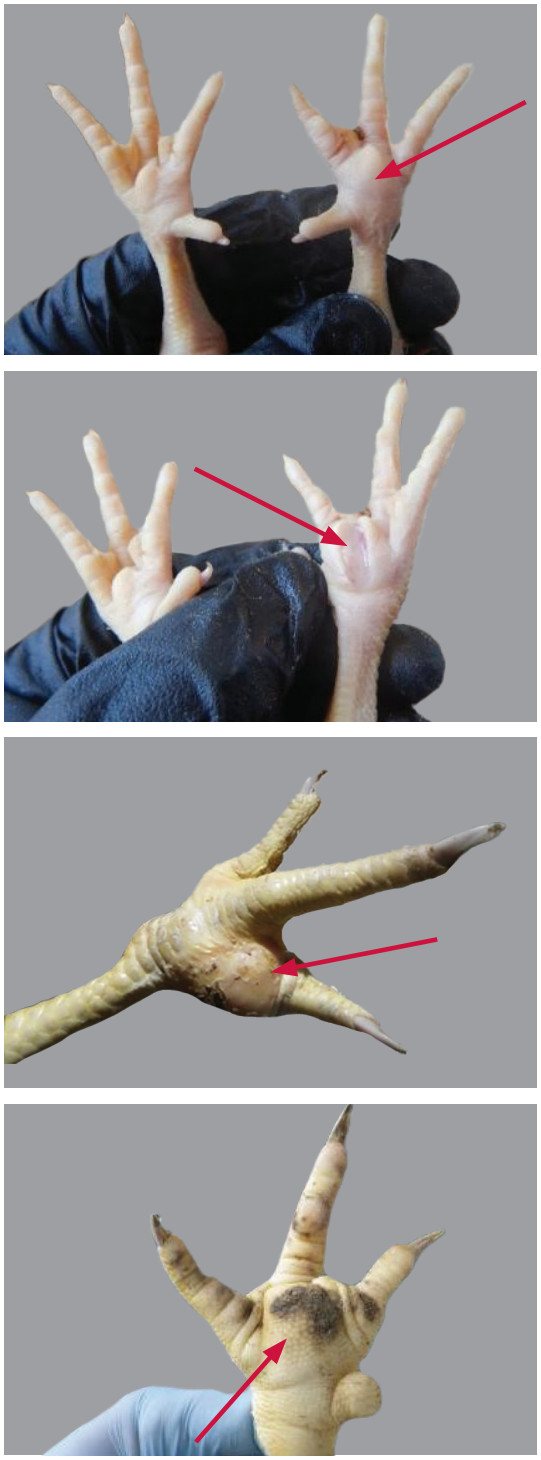
Initially, the area surrounding the ruptured tendon—typically seen in the gastrocnemius tendon above the hock—changes color, turning reddish-purple from hemorrhage, then green (**Figure 3**).

Figure 3. Ruptured tendons: (A) Greenish color, (B) Ruptured tendon (hemorrhage), (C) Ruptured tendon exposed.



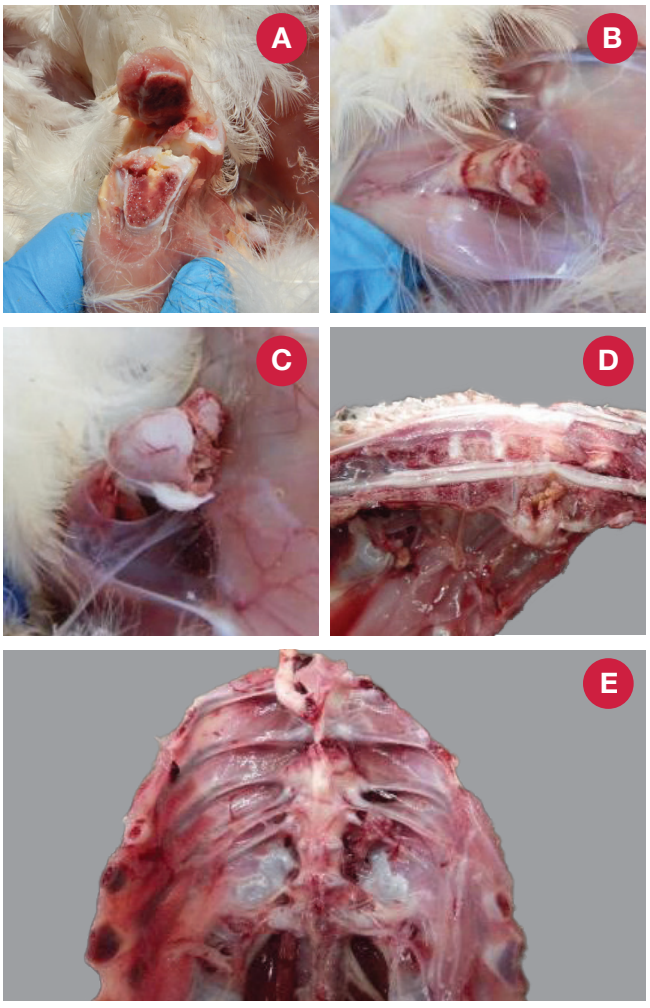
Staphylococcal infections of the footpad and toes ("bumblefoot") are common in adult chickens (**Figure 4**). The severe swelling of the footpad and toes results in subsequent lameness.

Figure 4. Plantar abscess, or bumblefoot.



Osteomyelitis may cause either lameness or paralysis depending on whether a long bone or the spine is affected (**Figure 5**). Bone sites most frequently involved are the proximal head of the tibiotarsus, the proximal femur (hips), and the free thoracic vertebrae (T4). Birds with infections in the leg bones are reluctant to walk. When the femur is affected, the proximal section of the femur breaks from the shaft when disarticulating the femoral head from the hip joint (FHN). Gross lesions may include a yellow-brown exudate or necrosis in the head of the femur (metaphysis). Infections of the joint spaces between vertebrae may cause paralysis of the legs. A histologic examination of formalin-fixed tissue is often required for an accurate diagnosis.

Figure 5. (A) Osteomyelitis in the proximal end of the tibia, (B) Mild FHN, (C) Acute FHNs, (D) and (E) Vertebral Osteoarthritis (VOA)-free thoracic vertebrae.



KEY FACTORS FOR DECREASING STAPHYLOCOCCAL INFECTIONS IN BREEDING STOCK:

Hatching egg management — egg and farm hygiene

- Use the proper temperature in the farm egg room to avoid condensation.
- Collect eggs frequently and keep the nest clean.
- Handle eggs according to best practices at the farm.
- Follow strict sanitation guidelines.
- Do not send floor eggs to the hatchery.

Hatchery management and sanitation — egg and hatchery hygiene

- Incubate clean eggs.
- Avoid egg condensation.
- Correctly use tray and chick box washers.
- Use clean egg trays, hatching trays, and chick boxes.

Farm management — factors impacting bird comfort and welfare

- Provide recommended feeder space.
- Provide recommended stocking densities.
- Distribute feed to all birds within three minutes.
- Follow guidelines and recommended weight goals and bird uniformity.
- Increase feed amounts regularly during the rear period.
- Ensure there are two points of contact on the bird: both legs, wings, or sides (minimal handling is recommended).
- Manage birds to achieve sexual synchronization between males and females.
- Ensure correct feed and lighting management around the onset of sexual maturity/egg production.
- Adhere to the recommended mating ratios.

Management of the farm environment

- Encourage the use of water sanitation systems.
- Use a closed-water system.
- Use good quality litter.
- Manage litter quality through ventilation and litter cake removal.
- Remove sharp objects.
- Encourage exercise with adequate lighting, perches, and training slats; allow access to perches from 28 days of age.
- Install slats at a maximum of 25–30 cm (10–12 in) and keep them well-maintained.
- Utilize ramps to aid hens onto the slats.
- Incorporate a suitable alighting/perching rail in the nest box design.

Vaccination and health programs

- Ensure proper biosecurity in the hatchery and on the farm.
- Ensure high levels of maternal immunity by utilizing appropriate vaccination programs.
- Monitor and control coccidiosis and other intestinal challenges.
- When using “hot” (more virulent) respiratory vaccines, first expose birds to intermediate or mild strains; avoid rolling reactions.
- Prevent vaccine and needle contamination by changing needles and wing web applicators frequently.
- Use prebiotics and probiotics to help establish proper gut flora early.

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- *Parent Stock Management Handbook*
- *Egg Handling from Nest to Setter (poster)*
- *Coccidiosis Control in Broiler Breeders with the Use of Vaccines*

TREATMENT

Treatment of Staphylococcosis varies in efficacy but may be cost-effective and advantageous for bird welfare. Most *S. aureus* isolated from poultry are sensitive to penicillin, but sensitivity tests should always be performed, as antibiotic resistance is common. Penicillin resistance may develop quickly in birds undergoing treatment, so it may be beneficial to switch to another antibiotic after 5–7 days of penicillin therapy. Other water-soluble antibiotics that may be effective include erythromycin, lincomycin, and tetracyclines, though they are not available in all countries. Consult your poultry veterinarian for advice on antibiotic treatment, as some antibiotics can only be used when prescribed by a licensed veterinarian.

Antibiotics are most effective if given early in the disease. Established infections—especially with arthritis and osteomyelitis—do not respond to medication due to the amount of damage already done to the joint and the bone or difficulty reaching an adequate concentration of the antibiotics where the damage is located. Such birds are best removed from the flock.

SUMMARY

The most effective long-term solutions to Staphylococcosis are to focus management practices toward prevention by minimizing all factors that may contribute to Staphylococcal infection; this involves identifying and removing the likely sources of *Staphylococci* and reducing any factor that may increase the susceptibility of the birds to infection. Consider reducing the overall bacterial load by practicing optimum cleaning and disinfection, especially following flocks that have previously had a *Staphylococcus* infection. In addition, promoting best husbandry practices improves the birds' environment and helps reduce the risk of Staphylococcal infections.

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