

BURLEIGH DODDS SERIES IN AGRICULTURAL SCIENCE

Achieving sustainable production of poultry meat

Volume 3: Health and welfare

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SCIENCE PUBLISHING

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Introduction

Poultry production faces a range of challenges. These are addressed in the three volumes of *Achieving sustainable production of poultry meat*. The three volumes are:

- Volume 1: Safety, quality and sustainability
- Volume 2: Breeding and nutrition
- Volume 3: Health and welfare

Volume 3 discusses recent research on improving poultry health and welfare.

Part 1 Health

Chapters in Part 1 look at key aspects of poultry health, disease prevention and management. Poultry are infected by numerous pathogens that cause a wide variety of diseases. Effective disease surveillance is critical to identify and combat both existing and emerging diseases. Disease surveillance is a staple program in most developed poultry systems and is a cooperative effort between individual poultry companies, regional and national disease control agencies and programs, public and private diagnostic laboratories and other partners.

As Chapter 1 points out, surveillance can be active in the form of sacrificing birds for clinical necropsy examination or submitting samples for diagnosis during a disease outbreak. It can also be passive in the form of routine diagnostic assays designed to provide a historical picture of a flock or region. The chapter reviews key challenges and best practice for both types of surveillance, covering diagnostic laboratories, diagnostic assays, high quality sampling and submission. The data that these submissions and clinical cases provide is invaluable both in highlighting particular problems and in identifying epidemiological patterns of disease. These patterns can help to develop models that can predict the spread of disease and make management of disease outbreaks timely and effective.

Most pathogens of poultry and other vertebrates enter the body via a mucosal portal of entry, and for most birds, this means either the respiratory or gastrointestinal tract (GIT). Chapter 2 surveys the main bacterial pathogens found in the GIT of poultry such as *Salmonella*, *E.coli* and *Clostridium*. The chapter also discusses what we know about the intestinal microflora of chickens, notably phyla such as Firmicutes and Bacteroidetes, and how the assembly of gut microflora is regulated by complex host–microbial and microbial–microbial interactions. The chapter then goes on to review what causes dysbiosis, the shift in the microbiome which results in an imbalance between beneficial and harmful bacteria. This imbalance has a negative impact in the GIT, including reduced nutrient digestibility, increased gut permeability and upregulated inflammatory responses. The eubiosis/dysbiosis status of the microbiome is thus a major factor in poultry health or disease. As the chapter points out, the fragile balance can be altered by any kind of stress that induces inflammation, including environmental factors, diet or pathogens. The chapter also examines the effects of inflammation of the GIT on anaerobiosis and assesses the role of mucins, glycoproteins that cover epithelial surfaces of the intestine and form a mucus layer to protect epithelial cells from infection. After exploring the effect of gut

infections in disrupting dietary function, it assesses the impact of airborne infections of enteric bacteria on poultry.

As suggested in Chapter 2, infectious diseases, particularly those caused by viral pathogens, pose one of the most serious threats to the sustainability of the global poultry industry. The industry has relied heavily on vaccination-based control strategies, but there are major drawbacks in this approach, such as the immunosuppressive effects of some viral pathogens and the increasing diversity of pathogens. This chapter reviews viral diseases affecting poultry, including the most significant viral diseases: Newcastle disease, infectious bronchitis, infectious bursal disease, Marek's disease, infectious laryngotracheitis and avian influenza. It discusses each in terms of their distribution, effect on avian health, and role in producing economic losses. For each disease, current findings on symptoms, diagnosis and control measures are discussed. The major threats to vaccination-based strategies are reviewed together with potential solutions.

Many of the avian pathogens continue to emerge and re-emerge, showing huge diversity which poses immense challenges to traditional vaccination-based methods of control. These challenges are evident in diseases such as Marek's disease, where there is something of a biological arms race between vaccines and pathogens able to evolve resistance. Pathogen diversity also poses problems in diagnosis, although the advent of new generation sequencing and PCR-based diagnostic tests are helping to tackle the issues. In this context, development of DIVA (differentiating infected from vaccinated animals) tests and rapid diagnostic tools that could be deployed in the field are vital for curbing outbreaks. Finally, it is important to examine the heavy reliance on vaccination strategy for sustainable control. The recent success of recombinant vectored vaccines against a number of avian diseases is a welcome change as some of the more traditional vaccines are becoming less effective in inducing protection.

Like viruses, parasitic infections and infestations are a major challenge to poultry production worldwide. Chapter 4 provides a comprehensive survey of parasites affecting poultry, divided into the broad categories of protozoa, flagellates and worms. It also discusses arthropods including lice, bedbugs, flies, beetles, mites, fleas and ticks. The chapter examines diagnosis, control, management and disinfection for each of the major parasites associated with poultry farming. It also addresses the pathology, epidemiology and molecular biology of the major parasitic infections.

As the chapter points out, the most severe parasitic diseases are caused by protozoans and include coccidiosis and histomoniasis which are discussed in detail. The chapter also discusses blood-borne protozoan parasites, roundworms, tapeworms and trematodes (flukes) in poultry. As the chapter highlights, future control of parasites in poultry will have to be maintained with fewer, less-effective vaccines. Current avenues of research include selection of poultry for improved disease resistance, and the use of natural products to stimulate innate and acquired resistance to infection. With the increasing importance of free-range rearing of poultry, more research is needed on roundworms, tapeworms and methods for their prevention. The interaction of nematode parasites and protozoan parasites, is of major importance, as well as the interaction of parasites with bacterial diseases such as necrotic enteritis. The chapter concludes by noting the need to find new ways to control parasites if we are to maintain production to meet the demand for high quality food by a growing world population.

As described in previous chapters, diseases in intensive poultry flocks may occur due to viral, bacterial, fungal, protozoal, metazoan or arthropod infections or infestations. Chapter 5 describes current disease preventative measures, health monitoring and

disease investigation techniques, and the management of infected poultry flocks. The chapter discusses both routine monitoring and more targeted investigations in the face of a particular outbreak. It also highlights the value of systematic investigation of outbreaks to both improve understanding of a disease and improve techniques for its prevention and management. This systematic approach involves: systematic epidemiological investigation to identify potential risk factors; investigation of risk factors through controlled experiments; and confirmation of the findings in field situations.

Chapter 5 also provides a comprehensive review of biosecurity measures to prevent disease and minimise its spread. Key measures include an 'all-in all-out' approach which, for example, avoids multi-age flocks where older, infected flocks spread disease to young birds. The chapter looks at appropriate quarantine and hygiene procedures, including disinfection regimes and litter management, including composting. The chapter also summarises best practice for dealing with an outbreak of disease in the flock, including hygiene procedures in these situations and methods of disposing of dead birds.

In the perpetual battle against common poultry pathogens and other environmental antigens, the role of the immune system is an important and ongoing topic of research. Chapter 6 reviews the various elements of the host defense system in poultry, including innate and adaptive immune systems. By boosting local immune function at mucosal sites (digestive and respiratory), subclinical infections could be averted or suppressed, thus enhancing growth and general health. The chapter discusses examples of how dietary supplements can modulate the immune system and its response to common diseases. Among the most commonly used modulators are feed and/or water supplements such as probiotics and prebiotics which have been the subject of extensive research.

The chapter focuses particularly on the challenge of coccidiosis and the role of probiotics. As the chapter explains, prior to the activation of an adaptive immune response, the innate immune system will attempt to inhibit the infection through various pathways such as competitive exclusion by commensal microbiota, gastric secretions, phagocytosis and other components. The adaptive immune system uses three main mechanisms: competitive exclusion, bacterial antagonism (for example bacteriocins) and stimulation of the immune system. Research shows the role of probiotics in supporting these mechanisms in the immune system, reducing the rate and severity of enteric infections while maintaining optimal performance in poultry. It also demonstrates the potential of combining probiotics with prebiotics as well as the role of pre-hatch immune interventions. The chapter concludes by highlighting the need for more research on the immune system and its response to nutritional and other interventions.

As mentioned in Chapter 6, competitive exclusion (CE) describes the protective effect of the intestinal microflora against colonization of pathogenic bacteria. Building on Chapter 6, Chapter 7 discusses the current use of treatments to boost CE to prevent *Salmonella* infections in poultry, focussing on the administration of cultures of intestinal origin to day-old chickens. The chapter reviews research on the effectiveness of these treatments in preventing the risk for *Salmonella* infections in newly hatched chickens from being further spread horizontally in a flock or vertically in the case of breeding animals. The chapter reviews the development of undefined and defined CE cultures together with methods of evaluation and administration. It also looks at pathogen and host specificity of CE treatments and factors affecting their efficacy. As the chapter points out, the administered cultures compensate for the delayed development of the protective intestinal microflora in chickens hatched under hygienic conditions in modern poultry production.

As well as bacterial, viral and other infections, poultry are susceptible to a range of other health problems. Bacterial chondronecrosis with osteomyelitis (BCO) is widely recognized as one of the most common causes of lameness in broilers. Chapter 8 starts by summarizing the pathogenesis of BCO. Experimental models that successfully trigger BCO are then reviewed. Sources of bacteria that infect the bones are discussed, with the primary emphasis on bacterial translocation across the gastrointestinal epithelium. Finally, the chapter reviews the efficacy of probiotics as a prophylactic treatment for BCO.

Part 2 Welfare

In the context of poultry production, behavioral studies have been particularly useful in optimizing management strategies to promote the welfare of commercially raised poultry. Chapter 9 provides an overview of the contribution that the study of animal behavior has made to the debate about poultry welfare. It also discusses the design, execution and interpretation of behavioral research. The chapter begins with an overview of commonly used research methods and methodological challenges that should be considered before behavioral data is collected. These include issues such as sample size and sampling strategy. These issues are explored in detail through a case study looking at the importance and consequences (positive and negative) of improving perch access for poultry.

As noted earlier, genetic selection for highly efficient, fast-growing broilers has had negative effects on broiler welfare. The high stocking densities used in some broiler production systems has also been an issue. These factors mean that activity levels of fast-growing broilers can be low, especially during the second half of their life. This can lead to leg health problems such as lameness, footpad dermatitis and hock burns. It has also been found that fast-growing broilers are more sensitive to heart and circulation problems compared with slower growing genotypes, especially when placed in a suboptimal environment. Chapter 10 examines the welfare problems arising from intensive poultry systems, and reviews how both factors have been addressed within the European Union.

These issues are discussed in more detail through two case studies. The first examines the welfare effects of hatching environment and early feeding, whilst the second looks at the benefits of alternative and free-range broiler production systems. Both case studies illustrate how research can contribute to better standards of welfare and more sustainable broiler production. As an example, allowing chicks access to feed and water directly after hatching has the major advantage that chicks that hatch early do not have to wait for access to feed and water until all chicks have hatched. This long fasting period is increasingly criticised by animal protection organisations. Furthermore, early access to feed seems to benefit early muscle development as well as an early colonisation of the gut, boosting gut health and immunity. This may also be the reason why broilers from this type of systems seem to require fewer antibiotic treatments. The chapter also highlights the potential benefits of poultry operations that use slower growing genotypes in lower stocking densities. Evidence suggests fewer health and welfare problems and lower mortality rates in these alternative systems; however, as time to market weight is delayed, it can increase the risk of exposure to behavioural and disease maladies. In some cases these 'middle-market' systems have been shown to outperform conventional and organic systems both in welfare and cost efficiency, but remain to be demonstrated across bird final body weights and market segments.

Broiler breeders are the parent stock of broiler chickens. Appropriate management in rearing and in the production period is essential to produce a high number of fertile eggs and high quality broiler chickens. However, research has shown that current management practices may affect the welfare state of broiler breeders, both during rearing and in the production period. Chapter 11 describes the housing and management of broiler breeders during the rearing and the production periods. It then reviews major welfare issues relating to the management of broiler breeders, including feed and water restrictions, still one of the most important welfare issues in broiler breeders. It suggests that using feeds with higher insoluble fibre contents or lower protein content in the rearing period, as compared to standard commercial diets, may help to alleviate the effects of feed restriction. Another alternative is the use of slower growing or dwarf female broiler breeders that do not need to be feed restricted. The chapter also review research on excisions as well as on environmental enrichment and facilitating mating behaviour. Finally, it discusses the potential for management strategies to have transgenerational effects on the health and quality of offspring.

Chapter 12 examines the specific effects of exogenous and endogenous heat on embryonic growth during different stages of incubation, with an emphasis on control of incubation temperature. The chapter explores the challenges inherent in establishing a temperature recommendation for incubation of poultry eggs, and considers forms of pre-incubation holding as well as the outcomes of both early and late incubation temperatures. Finally, the chapter addresses the connection between incubation temperatures and poultry immunology, as well as thermal manipulations and the impact of temperature on post-hatch stress in chicks.

Environmental enrichment comprises stimuli added to the poultry housing environment to enhance the biological adaptation of the birds and improve their welfare. By promoting species-typical behavior, it has the potential to reduce the risk of harmful behaviors and health conditions, and to guide birds to use the available resources more uniformly. Environmental enrichment may also promote positive emotional states and enhance the birds' ability to cope with unpredictable environmental changes. Chapter 13 reviews environmental enrichment strategies that are relevant to commercial meat poultry production. These include cover panels, perches, barriers and ramps as well as lighting. The chapter also looks at ways of enriching foraging and grooming behaviour. The chapter discusses the benefits of such strategies in terms of the behavior and welfare of the birds and their potential for contributing to more efficient and sustainable poultry production. Potential risks or problems that may arise when environmental enrichment is not appropriately implemented are also discussed.

As discussed in other chapters, maintaining an environment that minimizes stress on poultry is a significant part of obtaining a healthy bird that reaches its full genetic potential. One challenge that producers face is preventing heat stress and maintaining performance in hot weather conditions. By keeping bird body temperature at the right level, birds will continue to grow, develop and efficiently utilize feed. Chapter 14 focuses on the principles of poultry management that farmers can implement in their poultry houses during hot weather to prevent heat stress and maintain normal bird body temperature. The chapter reviews ventilation, evaporative cooling and management practices that influence the ability of the farmer to keep birds cool.

A variety of factors before and during transport affect the welfare of poultry. Chapter 15 begins by considering the pre-loading factors which can affect the birds' welfare during transportation. It then reviews the physiological, behavioural and psychological responses

which birds may have during transport. The chapter goes on to discuss a wide range of factors which may affect welfare during transport, including the design of containers and trailers, journey duration, noise, vibrations and stocking density. The chapter also considers the effects of lairage as well as the transport of hens other than adult broilers.

Stunning of animals before slaughter is widely recognised as an essential element in humane slaughter. Chapter 16 reviews current research on the physiological basis of stunning. It then assesses the relative merits of differing stunning systems, starting with electrical stunning methods and gas stunning systems. It also discusses other systems such as maceration, manual neck dislocation, concussive stunning and low atmosphere pressure systems.

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