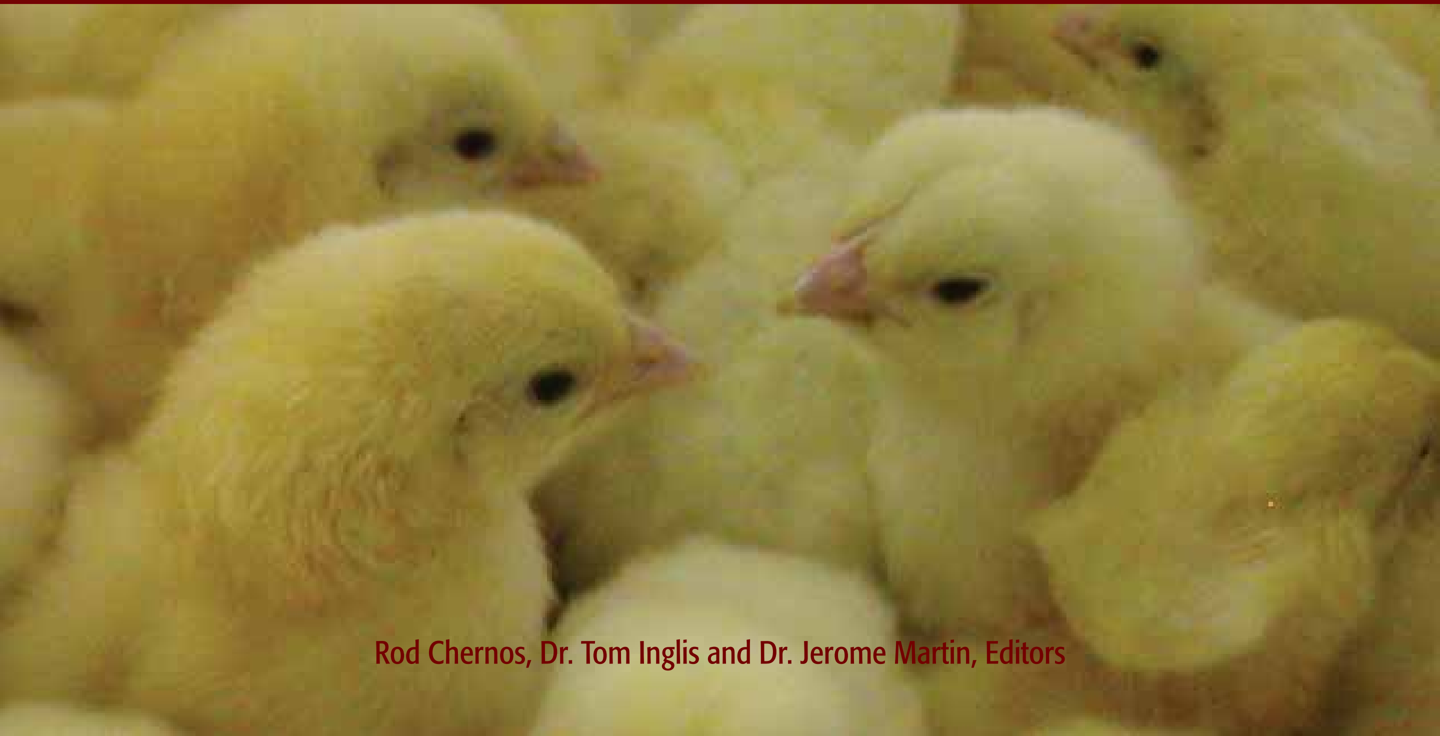
The Responsible Use of Health Management Products for Poultry Production

A Home Study Course for Alberta Producers



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National Library of Canada Cataloguing in Publication

ISBN 978-0-9780415-8-8 (e-book)

Funding for this publication was provided by The Alberta Livestock Industry Development Fund, in co-operation with Alberta Chicken Producers, Alberta Egg Producers, Alberta Hatching Egg Producers and Alberta Turkey Producers.

Editor: Jerome Martin, PhD
Design and Layout: Melanie Eastley and Lu Ziola, some production!

Printed and bound in Canada.

Introduction

Lloyd Johnston
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On behalf of the four Alberta poultry Boards, Chicken, Egg, Turkey and Hatching Egg, we are extremely pleased to have led the development of the Home Study Course for Alberta Producers entitled *The Responsible Use of Health Management Products for Poultry Production*. We offer a special thank you to the Alberta Livestock Industry Development Fund for their generous financial support of this project. It will make a difference to the health, safety and welfare of poultry in Alberta.

We were fortunate to have the project co-ordinated by an extremely knowledgeable and dedicated individual, Rod Chernos. Rod's career has spanned primary production, government service (he was a Poultry Specialist with Alberta Agriculture), many years of international consulting and generally making a significant contribution to agriculture both domestically and internationally.

Dr. Tom Inglis, Poultry Health Services added considerable value by providing the technical editing of the material. Dr. Inglis also contributed directly to the content of the course. Dr. Tom, as he is affectionately known among his colleagues, provides service to the Alberta and Saskatchewan poultry industry through diagnostics, veterinarian and management advice to producers, processors and hatcheries.

A special thank you to the authors of the chapters contained within this course. We are fortunate to have the specialty experts in all areas offer their expertise to the poultry industry via this course. Well done. The authors are acknowledged in the respective chapters.

Dr. Jerome Martin of Spotted Cow Press has done an amazing job of editing a large amount of material and getting it into plain language and useable form. Users have a choice of a paper book and a digital, full-colour version online.

Finally, we expect that this course will provide primary producers, industry service personnel and suppliers with a technically sound reference document. It will also allow producers to study at home to improve their knowledge and understanding of the material contained in the course.

We encourage producers to complete the exercises and return them to the respective Board offices. They will be reviewed by a professional for accuracy, and feedback will be provided to questions. This document, like other self-study courses, is intended to allow users to gain knowledge and understanding in the comfort of their business and at a time when it is convenient.

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General Manager
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1 Biosecurity on the Poultry Farm

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On-farm disease control focuses on three areas: decreasing susceptibility to disease, increasing resistance, and decreasing exposure to pathogens such as bacteria, viruses, and coccidia (Figure 1). Decreasing bird susceptibility to disease is accomplished by optimal management, including proper nutrition, good water, limited stress, prudent antimicrobial use and proper parasite control.

Increasing bird resistance to disease is primarily accomplished by vaccination. Novel to the poultry industry is increasing resistance by competitive exclusion, the process by which beneficial bacteria are administered to newly hatched birds to exclude pathogenic bacteria from colonizing the gastrointestinal tract and causing disease.

The cheapest and most effective means of disease control is using biosecurity to decrease disease exposure. Inadequate biosecurity can contribute to industry-wide epidemics of highly pathogenic or exotic diseases, resulting in quarantine and condemnation of flocks, with massive financial losses to producers.

Poultry farms are difficult and expensive to clean and disinfect. Biosecurity consists of the following practices that prevent the spread of disease onto or within the farm.

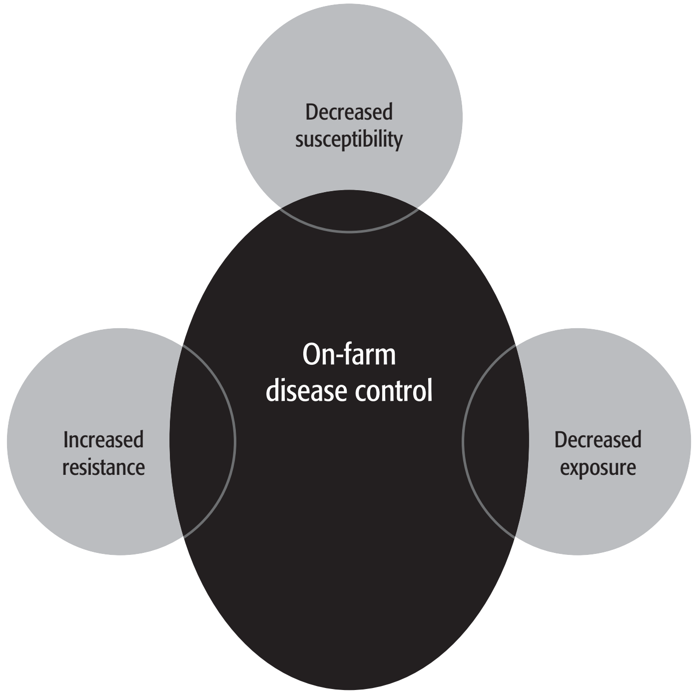
Flock Management

The cheapest and most effective means of disease control is using biosecurity to decrease disease exposure.

Producers should maintain individual flock health records. In the event of a disease outbreak these records provide invaluable information. Production records should include feed intake, production parameters, morbidity and mortality counts, and veterinary and diagnostic laboratory reports. Any additions to or removal of birds from the flock should be recorded and their health records should be kept in the flock records.

All-in, all-out is the best method of poultry production to minimize disease transmission between different ages of birds. Incoming poultry should be from high health status sources, with documentation of well

Figure 1.
Basic areas of on-farm disease control



defined health monitoring and audit procedures provided by the supplier. Incoming birds should be isolated from the rest of the flock and placed in facilities that have been cleaned and disinfected. Work with the farm veterinarian to determine regular sampling procedures of birds and the environment to monitor for specific diseases, such as avian influenza, infectious bursal disease, or infectious bronchitis.

Once they leave the farm, birds should not return under any circumstances. Damaged eggs, dead birds, litter and manure may carry disease, so should be disposed of promptly and properly.

Feed delivered to the farm must be of good quality and protected from vermin. Finished feed and stored raw materials should be sampled regularly for contamination with pathogens such as salmonella. Water quality should be checked regularly by an accredited laboratory. In-line water filters, ongoing water sanitation (chlorination or peroxide) and a water line cleaning and disinfection program between flocks are recommended.

Disease Recognition

One of the most important factors in controlling disease on the farm is recognizing potentially infected birds. All workers in contact with the flock should be aware of the signs of emerging disease syndromes (Fig. 2).

Once an infectious disease is suspected, it is important that established protocols are followed to deal with an outbreak. Compliance by farm personnel is increased if everyone knows and understands the reasons behind the protocols and their individual responsibility.

Work with your veterinarian to send birds and/or tissue samples promptly to a diagnostic laboratory at the first signs of significant disease.

Figure 2.
Warning signs of a disease outbreak

- ↑ Mortality (> 3% in 1 week or > 0.5% in 24 hours)
- ↓ Production (> 5% in 1 week)
- ↓ Feed or water consumption (> 20% in 1 week)

Preventing Human Transmission

On arrival, farm personnel should park their vehicles only in specified parking areas. Workers should wear clean clothing and dedicated footwear approved by farm management. Clean footbaths containing disinfectant should be placed outside the entries to all poultry houses. Boots should be scrubbed to remove organic matter before they are placed in foot baths. Workers and others should stand in foot baths, not just dip. A sign outlining the foot path procedure should be posted above the bath.

Workers should use and maintain all footbaths they pass and should stay in designated work areas on the farm during their shift or work the flocks from youngest to oldeset and visit flocks with health problems at the end of the chore period. There should be a pair of gloves in each barn for use in that barn only. They should care for the birds in specific order, taking care of clinically normal birds before sick birds on mixed farms or work the flocks from youngest to oldest and visit flocks with health problems at the end of the chore period. They should work with poultry before working with other animal species, especially swine.

Gloves should be used at all times during work. There should be a pair of gloves in each barn for use in that barn only. Workers should disinfect their hands prior to starting work and before and after eating. Alcohol-based hand disinfectants are now widely used and in many situations are superior to hand washing for disinfection. These products are quick and easy to use, and most contain emollients, so they are easier on the skin than frequent hand washing.

Alcohol-based hand disinfectant dispensers should be available at multiple sites on the farm. If hands are obviously dirty, hand washing should be performed first. A 15-second scrub (think of the time that it takes to sing "Happy Birthday") with a bactericidal soap is recommended, but rarely followed in practice. Workers must take care not to re-contaminate their hands by touching the faucet taps. If automatic taps are not available, a paper towel should be used to turn off the taps.

Short, clean fingernails are essential for good hand sanitation because organic material easily accumulates under fingernails. A nailbrush or pick should be used to remove any material from underneath fingernails prior to washing.

Watches cannot be completely sanitized and should be removed before hand washing begins. Rings, if they are plain, can be sanitized if all organic material is removed and the skin beneath the ring is thoroughly washed. A shower in, shower out facility should also be seriously considered.

Employees should not bring visitors on farm without prior approval and should wait 72 hours after traveling out of the country or to a high risk farm before returning to work. They should not own poultry, pet birds or have contact with birds outside of work. They should notify management if visiting exhibitions or sales involving any class of birds. They should not hunt or visit migratory bird sites on a work day prior to coming to work and should have 48 hours downtime after hunting, fishing or trapping. Use extreme biosecurity for vehicles and clothing used for hunting waterfowl.

Barrier precautions, such as gloves, coveralls, masks, and shoe covers should be required for personnel entering disease-affected houses. These items must be removed and disposed of properly to prevent cross-contamination with street clothing. They also must be changed regularly, because contamination may occur even if soiling is not obvious.

Rodent, Insect, and Wild Bird Control

Poultry farms should maintain an effective and audited rodent, insect and wild bird control program (see Chapter 9: Pest Control and Management). Minimize the entry of vermin into poultry houses through good building design and repair. Rodents are known carriers of many poultry diseases and they are the most common reason for re-contamination of a cleaned and disinfected poultry facility. They are also commonly responsible for house-to-house spread of infectious disease on a farm. The farm grounds should be free of debris and long grass that provide cover for rodents and insects. The perimeter of poultry houses should have a one metre area of gravel or concrete to prevent rodents from burrowing in. Feed and eggs should be stored in insect and rodent-proof areas. Bait stations should be placed throughout the house and maintained with appropriate rodenticides. Rodenticides should be rotated every six onths to prevent the development of resistance. All houses should be designed to prevent exposure of the flock to wild birds.

Cleaning and Disinfection

Cleaning and disinfection are important parts of the disease control process, and protocols should be in place and reviewed regularly with the farm veterinarian. Clean and disinfect all vehicles entering the farm. Designated parking areas and controlled access zones my be practical solutions for non-farm vehicles. If possible, do not use the same vehicles for transporting birds, feed, manure or other wastes.

Regularly clean and disinfect all crates, containers and other equipment before and after use. Do not move any equipment into different poultry buildings without cleaning and disinfecting it first. At depopulation at the end of a production cycle, thoroughly clean and disinfect all buildings and equipment, including ducting, drains and air inlets, fan housing, fan blades and fan louvers. Remove all surplus feed, dead birds, ltter and as much other organic material as possible. Clean the house of organic matter with a high pressure sprayer with warm water containing a detergent/disinfectant.

Heating the house during washing improves the removal of organic matter. Wash the upper portions of the building before the pit. Flush and sanitize the water lines. When dry, the house should be disinfected or fumigated and allowed to dry again before repopulation. For additional security the barn can be fumigated.

It is important for farm personnel to understand why certain cleaners and disinfectants are being used and how to use them properly. Improper use of these products may result in disease outbreaks.

Detergents and abrasives facilitate the removal of dirt, manure and other debris. Disinfectants are chemicals which kill bacteria, bacterial spores, fungi, yeast, protozoa or viruses. Just as is the case with antimicrobials, some disinfectants are broad in spectrum, whereas others have a relatively narrow spectrum of activity. Not all disinfectants kill all pathogens, so changes in disinfection protocols may need to be made in the face of an outbreak.

An ideal disinfectant has rapidly lethal activity against a broad spectrum of pathogens, a low surface tension for ease of spread, activity in the presence of organic matter, low toxicity to birds and humans, not be corrosive, and be economical to use. Some disinfectants are ineffective in the presence of organic matter, such as manure, bedding or feathers, so thorough cleaning is required before using these products. An antiseptic is essentially a disinfectant which can be applied to skin or mucus membranes of humans or animal without causing toxicity. Therefore, an ideal antiseptic is similar to an ideal disinfectant, but must not be irritating to the skin, be hypoallergenic, not be absorbed to any significant extent across the skin, and have pleasant aesthetic properties. Frequently the sole difference between a disinfectant and an antiseptic is dilution.

Both disinfectants and antiseptics can be generally classified into broad groupings based on their mechanism of action or chemical structure.

Alcohols

Ethyl alcohol and isopropyl alcohol at dilutions of 70% by weight in water rapidly kill bacteria and some viruses and are used as antiseptics and disinfectants. Isopropyl alcohol has a more rapid killing action against vegetated bacteria than does ethyl alcohol.

Methyl alcohol (grain alcohol) is not a good disinfectant or antiseptic and is not a suitable substitute for ethyl or isopropyl alcohols.

Alcohols have no residual effect, and are active only while in direct contact with the bacteria or virus. A contact time of between 1 and 30 minutes is required to kill most organisms. Topical application of the alcohols as antiseptics to humans or animals is not toxic. However, oral ingestion of ethyl alcohol causes life-threatening central nervous system effects. Ethyl alcohol and isopropyl alcohol in effective concentrations are flammable and volatile. They should be used in well ventilated areas and kept in sealed containers.

Aldehydes

Glutaraldehyde and formaldehyde are both potent and broad spectrum disinfectants and fumigants. They are toxic to humans and animals, so they must not be used as antiseptics. They are active against most bacteria, fungi, yeast, many viruses and some bacterial spores. These products are also temperature dependent. Using them at temperatures under 20°C may require additional time and/or concentration to obtain the desired results.

Gluteraldehyde

(Metricide®, Metricide® 28, Metricide Plus 30®, Metrex) is supplied as 2.5-3.4% alkaline solutions for disinfection of equipment. Some vegetative bacteria are killed within minutes of exposure to glutaraldehyde, but 10-20 minutes of contact with 2.5% glutaraldehyde is necessary for broad spectrum action.

As the glutaraldehyde solution ages, the contact time required for killing increases. By 28 days in use, bacteria contact times greater than 1 to 2 hours are often necessary for disinfection. Unfortunately it is now well established that glutaraldehyde is an occupational hazard of significance for people exposed to it.

Formaldehyde

Formaline™ (Vétoquinol) is a general disinfectant and can be used as a fumigant to decontaminate all surfaces of a building, if the building can be tightly sealed. Adding potassium permanganate to the Formaline™ solution causes a reaction that releases formaldehyde gas. Profilm® is a time-release formaldehyde fumigant for poultry houses. Formaldehyde has a broad spectrum of activity and is highly effective as it kills most bacteria and fungi; however it must be used carefully due to the irritating fumes and potential explosiveness.

Formaldehyde gas is one of the few agents effective against coccidiosis and cryptosporidiosis. The facility must be completely depopulated and the building must be sealed for 24 hours. Do not enter until it has been thoroughly ventilated.

Formaldehyde is classified as a probable human carcinogen by the U.S. Environmental Protection Agency. Formaldehyde can cause allergies, and is part of the standard patch test series.

Chlorhexidine

Although seldom used on poultry farms, chlorhexidine (Hibitane®, Wyeth) is a disinfectant and an antiseptic with a wide spectrum of activity against vegetative bacteria and viruses, but it is not active against spores or fungi. Chlorhexidine has a rapid bactericidal action, with a significant decrease in bacterial numbers within one or two minutes of contact time when used as a hand or pre-surgical disinfectant. Chlorhexidine also has residual action which decreases the rate of recontamination of surgical sites or hands when compared to other surgical scrub solutions.

Chlorhexidine has little toxicity to humans and animals. Chronic or repeated exposures to chlorhexidine containing surgical scrub solutions have been reported to cause skin reactions in some people.

Chlorine

Free chlorine in solution is an effective disinfectant, rapidly killing bacteria, many spores, fungi, algae and viruses. Household chlorine (bleach) is inexpensive and widely used as a disinfectant at a 1:10 dilution (5.25% sodium hypochlorite). A final concentration of 2 ppm of free chlorine should be measured at the furthest point in the waterline to ensure effectiveness.

Commercial chlorine disinfectants are normally made into a solution by adding water to salts of hypochlorites. Sodium hypochlorite is the most commonly used salt, as it is stable at an alkaline pH, but at an acid pH it releases chlorine, resulting in its disinfectant properties. The concentration of chlorine resulting in solution is a function of the concentration of sodium hypochlorite and the pH of the solution. Therefore labelled recommendations must be followed closely in order to provide a final solution which is an effective disinfectant.

DM CID and DM Clean (Merial), Dupont™ Chora-A-Foam™, Dupont™ Liquid Tray& Egg Wash (Vétoquinol) are approved for cleaning eggs, plastic trays and boxes. Chlorine disinfectants are extremely irritating to tissues and should not be used as antiseptics.

Workers should be careful in preparing, using and disposing of chlorine disinfectants. Sodium hypochlorite loses activity on exposure to air and light, so new solutions should be prepared frequently. Chlorine adheres to organic matter and becomes unavailable, so proper cleaning is mandatory before disinfecting. Chlorine is also corrosive and bleaches fabrics.

Iodine

Free iodine in aqueous solution (Barn-Storm Iodine Cleaner Sanitizer, Ostrem; Biodine, Dominion; Premise Disinfectant, WestAgro) is effective against bacteria, bacterial spores, yeast, fungi and most viruses. Iodine is also active in alcoholic solution (known as tincture of iodine). Alcohol solutions of iodine lose their potency rapidly on exposure to air, both through evaporation of the solvent and through loss of the iodine (which is a volatile molecule).

Alcoholic preparations of iodine are also drying to skin and irritant in nature. Exposure of animals to an aqueous iodine solution or tincture of iodine can cause central nervous system depression and suppression of thyroid hormone production. These disadvantages of iodine have been largely overcome by formulation with active carrier agents such as polyvinyl pyrrolidine (PVP).

Formulations of iodine with PVP and other similar polymers are collectively known as the iodophors. PVP in aqueous solution above a critical concentration forms aggregations known as micelles. Iodine dissolves into the micelles, and then it is slowly released as free iodine into the aqueous solution for disinfectant. Therefore, if PVP iodine preparations are diluted below the critical micellar concentration, the reservoir for iodine is lost and the volatile free iodine is therefore depleted and there is rapid loss of activity.

Iodophors are popular as surgical scrub solutions and as antiseptics. Their popularity results from their extremely broad spectrum of activity, low toxicity, stability and the low propensity for bacteria to develop resistance. However, iodines and iodophors are corrosive to metal instruments. In comparison to chlorhexidine the iodophors have a slower bactericidal action. Therefore, the use of iodophors for hand disinfection requires more care. Unless there is an adequate period of contact between the iodophor and the skin, skin bacterial numbers will not be sufficiently reduced. Nevertheless, the iodophors are useful in formulations of surgical and hand scrub solutions.

Merbromin

Merbromin (Antisep 2%, Vetoquinol) is a topical antiseptic approved for minor wounds on poultry. Also known as mercurochrome, merbromin's antiseptic qualities were discovered by Johns Hopkins doctor Hugh H. Young in 1919. The chemical soon became popular among parents and doctors for everyday antiseptic uses. The United States Food and Drug Administration (FDA) removed it from the "generally recognized as safe" and into the untested classification to effectively halt its distribution in the United States in 1998 over fears of potential mercury poisoning. It is still readily available in Canada and most other countries.

Figure 3.
Survival of pathogens in a contaminated environment

Disease Organism	Survival Time in Contaminated Environment
Infectious Bursal Disease	Months
Coccidia	Months
Duck Plague	Days
Fowl Cholera	Weeks
Coryza	Hours to Days
Marek's Disease	Months to Years
Newcastle Disease	Days to Weeks
Mycoplasma	Hours to Days
Salmonella	Weeks
Avian Tuberculosis	Years

Oxidants

Oxidant disinfectants include hydrogen peroxide, potassium monopersulfate and potassium permanganate.

Hydrogen Peroxide

Hydrogen peroxide undergoes a complex chemical reaction, forming highly reactive hydroxyl radicals which attack cell membranes. Commercially available preparations of 3% hydrogen peroxide are relatively stable and effective when used on inert surfaces, but contact must occur for as long as 20 minutes to have anti-fungal activity. A 25% hydrogen peroxide/5% paracetic acid product (Hyperox, Vétoquinol) is available as a poultry house disinfectant and can be used in foot baths.

Accelerated Hydrogen Peroxide

Accelerated hydrogen peroxide (Peroxigard™, Bayer Animal Health) is a surface cleaner and disinfectant approved for use in veterinary hospitals and animal care facilities. It has rapid disinfectant action, killing bacteria and viruses within five minutes of contact. Diluted solutions are stable for up to four weeks.

Potassium Monopersulfate

Potassium monopersulfate (Virkon®, Vétoquinol) has a broad spectrum of activity against bacteria, viruses and fungi. For most pathogens, only 10 minutes of contact time is required for disinfection. Virkon® is available as a powder or as tablets and is mixed prior to use.

When used in a foot bath or for other purposes, diluted Virkon® remains stable for only two weeks. It is not corrosive and has a low toxicity. It can be applied manually, sprayed or fogged in poultry houses. It has good detergent properties; however a thorough pre-cleaning is still best prior to any application. Avoid contact of the powder to skin or eyes or inhalation of the powder.

Potassium Permanganate

Potassium permanganate (Germe-Zone®, Dominion) is an antiseptic for internal and topical use in poultry. It can be administered in drinking water or used as a strong solution for topical treatment of wounds and eye irritations. Alone, it is not a good disinfectant; it is primarily used for pretreatment to minimize chlorine usage and by product formation. It is available as an oxidizing agent to be used with formaldehyde (Potassium Permanganate, Vétoquinol) for poultry house fumigation.

Phenols

Phenol and phenol-containing compounds (1-Stroke Environ®, Steris; Beaucoup, Ecolab Healthcare; DuPont™ Neutrafoam™, Vetoquinol; Environ® LpH®, Steris; LpH ag®, Steris; Multi-phenolic Disinfectant, Bio Agri Mix) are coal-tar derivatives that are rapidly bactericidal and virucidal. These disinfectants have fallen into disuse since the development of more potent and more efficacious agents. Nevertheless many phenol-containing disinfectants are still used principally as toilet sanitizers and as floor detergents. These products often have high esthetic qualities including pleasant odour and lack of contact irritation. For most species, diluted phenols present minimal toxicity. However, cats are extremely sensitive to phenol induced toxicity, showing signs of seizure and coma.

Quaternary Ammonium Compounds

The quaternary ammonium compounds (Clinicide, Bimeda-MTC; Coverage 256®, Steris; DuPont™ 904,Vétoquinol; Proquat™, Engage; Quatsyl®-D Plus, Pfizer; Rocco, Vétoquinol are rapidly bactericidal. Quaternary ammoniums are one of the only compounds in which active advancements in development have occurred taking them from first generations all the way to fifth generations. With the increase in generations the efficacy of the compound has increased greatly to the point today that it is one of the products used extensively in the poultry industry. The advanced quaternary ammoniums normally have good detergent properties like potassium monopersulfate, and can be sprayed and fogged on. However, as like all disinfectants, a good preclean is crucial for best results. One other important quality is that they are biodegradable, making them safer to use for animals and the environment.

Quaternary ammoniums have some antifungical activity, but are not very active against bacterial spores or viruses. Their activity is markedly reduced by the presence of organic matter, therefore thorough cleaning is required before their use. However, some quaternary ammonium compounds are inactivared by some soaps or soap residues, so if soaps are used to assist in the removal of organic material, a thorough rinsing must take place before any quarternary ammonium compound is applied..

Despite their continued wide availability and clean smell, their narrow spectrum and poor efficacy in the presence of organic matter make them the least desirable of the available disinfectants. Furthermore, these are the only disinfectants against which transmissible resistance has been identified this plasmid mediated resistance may be linked to resistance genes against multiple antimicrobials.

Practical Biosecurity: Traffic Control

Introduction

Biosecurity (a system of reducing the risks and consequences of introducing disease into a population) is a widely discussed topic in the poultry industry. The concepts are relatively simple and there are numerous reports and studies, which clearly show the cost benefits of implementing these systems. Despite the recognition that good biosecurity systems are an essential component of successful poultry operations and the foundation for future success/failure avoidance, they are seldom implemented properly. Many farms have implemented most of the important components of the biosecurity system such as: farm location, farm layout, bird placements, controlling pests, properly immunizing their birds and cleaning and disinfecting barns. Despite the obvious success in these areas, the most difficult and often least “secure” component of the biosecurity system on a poultry farm is controlling human traffic. Humans are the most important factor in the transmission of infectious agents of poultry in the context of modern commercial poultry operations (A). While natural factors may contribute to the introduction of diseases to a poultry facility, it is often human traffic, which effectively distributes the pathogens between facilities resulting in a disease outbreak.

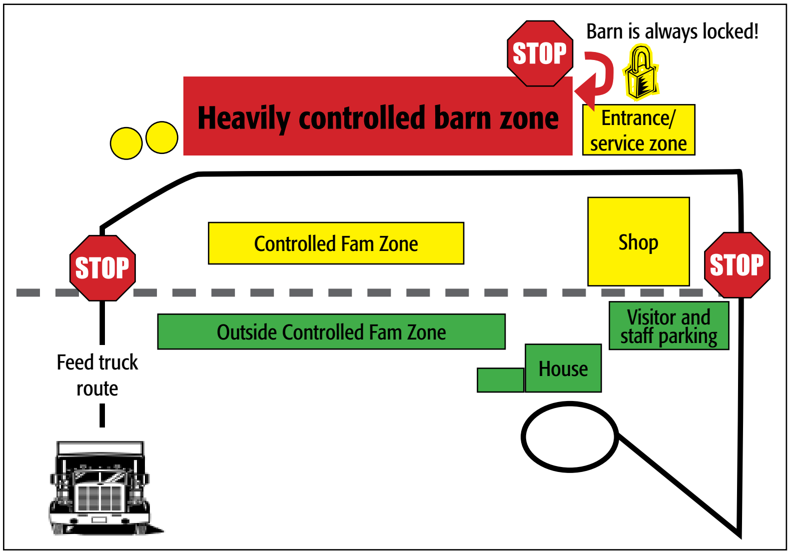


Figure 4. Basic zones for traffic control

If human traffic on the farm poses such a high risk, then why is it the least well managed aspect of many biosecurity programs? The answers likely vary for each operation but undoubtedly, human nature is part of the challenge. People tend not to like to change their patterns of behavior, seldom follow rules that aren't enforced, and simply forget what they are supposed to do sometimes. Controlling human traffic on the farm is the sole responsibility of the owner. It is the responsibility of the facility owner to put in place a system to develop, teach and police a program for controlling human traffic on the farm. A good biosecurity system for controlling human traffic on the farm must be written down, clearly communicated, easy to follow, understood by all visitors, workers and employees, and reviewed on a regular basis. If people are not following a biosecurity program on a farm it is because they do not understand it and require education, or that they do not care about the rules and should not be there.

Biosecurity traffic control programs must be:

- written down
- easy to understand
- easy to follow
- understood by all employees
- clearly explained to visitors as soon as or preferably before they arrive
- enforced
- reviewed on a regular basis

Figure 5.
Creating zones in a service vehicle

Creating Traffic Control Zones

One of the most difficult but important aspects of building a practical biosecurity traffic control plan is creating zones on the farm to designate control measures (such as Outside, Control area and Heavily controlled area). Every farm is different and will require customized biosecurity traffic control zones and categories for the program. Because these categories and zones are created for each specific farm situation it may seem at first like drawing a line in the sand. In fact drawing a line on a map or painting a line on the floor of the service room helps to make these zones visible and easily identified. Once a zone or category is created then the control measures can be put into place, which make that zone/category a meaningful part of the program.

The following steps are required for a poultry farm traffic control biosecurity program:

- create traffic control zones for the farm
- evaluate visitor risk categories and implement control measures.

Step 1: Creating control zones for a poultry facility

An aerial photo of the farm or a diagram is helpful in determining the natural borders for biosecurity zones. The zones must be clearly marked with signs and ideally should have a physical barrier, which stops people long enough for them to read the signs and learn what you want them to do next. Signs should be clear and tell the visitor exactly what to do. Examples of clear signs include: Stop and phone this number for access. Spray tires and proceed to feed bins. Please report to house. etc.

Maps are very helpful in ensuring that people go to the right place; there is no such thing as too easy when it comes to instructions. Regular service visitors should be provided with a schematic of the farm as well as instructions on how to enter and leave the facility. Remind all service personnel that these are the rules for doing business with your farm and that they must be followed. If you are unable to provide a visitor with instructions prior to arriving on the farm then have them meet you outside the control zone in the visitor parking area, at the house or at another building. Remember! Your house should be outside the controlled zone so you and your family must take the same precautions as visitors when entering the control area. Try to eliminate common areas where farm workers and visitors can mingle without having changed boots and coveralls. Make sure that visitor parking and service areas are safe, remembering that people may be wearing plastic boots.

Checklist

✓ Signs used to direct traffic and instruct visitors
✓ Physical barriers (gates and fences) used to control traffic
✓ Transition areas between zones clearly marked
✓ Use dedicated boots and coveralls for workers in each barn
✓ Ensure that hand washing and sanitizing are followed
✓ Foot baths:
  - must be big enough to step into
  - must be clean and maintained with fresh disinfectant
  - only work on visibly clean boots
  - work best when used together with changing into dedicated barn boots
✓ Barn door is always locked!

Table 1. Biosecurity Risk Assessmen: Poultry Service Personnel, Neighbours and Staff

Check most appropriate box	Low Risk		Moderate Risk		High Risk	
Number of farm visits per day	One farm, little or no animal contact.		Occasionally visits more than one farm per day. Minimal animal contact.		Visits many farms and processing plants .	
Protective Clothing	Wears sanitized shoes or boots. One pair of coveralls per site.		Wears sanitized boots and clean coveralls. If clean may not change coveralls.		Does not wear protective clothing or the same clothing between farms.	
Leaves materials or borrows supplies	Materials and supplies away from bird and feed areas.		Materials and supplies in areas of minimal bird or feed contact areas.		Materials and supplies may be left in bird or feed contacts areas.	
Bird Ownership	Does not own birds at home.		Similar species but a different production type.		Owns and/or cares for a similar species and production type at home.	
Contact with potentially infected birds	Minimal or no contact with potentially infected animals.		Contact with healthy birds and avoids contact with potentially infected animals.		May own or be exposed to many birds of unknown health status.	
Work in bird contact areas	Does not work in areas with highly susceptible birds.		Minimal exposure to high risk birds and only with protective clothing.		Works with highly susceptible birds. Little precautions.	
Biosecurity knowledge	Understands and promotes biosecurity for industry.		Exposed to biosecurity principles but is not an advocate.		Little appreciation for biosecurity and does not view it as an industry issue.	
Foreign Travel	Does not travel out of the US or Canada.		Limited travel outside of US or Canada without bird contact.		Travel to foreign countries with bird contact in those countries.	

* Modified from: Table 2.Biosecurity: A Practical Approach. Wolfgang DR.)

Step 2. Visitor risk assessment and categorization and implement control measures

The farm owner and staff are responsible for all visitors and service people they allow on the farm. It is important not to assume that service personnel, veterinarians and suppliers understand what your expectations are in terms of biosecurity. Professional service people and crews will have a written farm visit biosecurity protocol that they follow and they will be happy to share that with you. An effective program relies on good communication. Some service workers such as electricians may not have a protocol in place for visiting farms if they do not do farm calls on a regular basis but may have been on another farm immediately before yours and will require you to instruct them on how to access your facility.

There are three aspect of establishing visitor risk assessment and control measures.

- Assess the risk that the visitor poses to the operation
- Outline the steps required for visitors/workers on the farm
- Evaluate the protocol followed by the visitor

Visitor Risk Assessment

When evaluating the risk that a visitor may pose to your operation it is important to consider aspects such as their understanding and attitude toward proper biosecurity, their contact with other birds/farms, how long it has been since their last farm visit (down time), what steps do they follow to protect your farm. See Table 1.

Visitors can then be categorized and managed as:

- **High Risk Visitors**
  Action: (avoid unnecessary visits, suggest an offsite visit, prevent or limit access to controlled farm area and barns, increase down time before visit, implement additional precautions ie. clean vehicle and disinfectant tires, review biosecurity protocol, supply farm traffic control program, if necessary disallow visit)
- **Moderate Risk**
  Action: (avoid unnecessary visits, review biosecurity protocol, supply farm traffic control program, discuss risk factors, suggest additional precautions)
- **Low Risk**
  Action: (avoid unnecessary visits, review biosecurity protocol, supply farm traffic control program, discuss and reduce risk factors)

Remember, a practical program is based on controlling traffic not eliminating it.

Checklist

✓ Limit farm visits to essential calls
✓ Assess the risk level of all visitors and workers
✓ Visitors should only visit on scheduled times
✓ If a visitor, crew member or worker rates as a high risk, take appropriate measures to manage that risk
✓ Managing visitor risk may include delaying or refusing a visit
✓ Provide all visitors with clear instructions on how to enter and move around the farm
✓ Ensure that all visitors sign into the visitor log book

A specific example of this concept is to designate a change area for workers on the farm. A farm worker arrives at the farm, parks in the designated area (outside the control zone) and enters the shop via the back door. There is an area in the shop with a fridge for lunches, a table and lockers for off farm clothes. The worker washes his hands. The worker leaves his off-farm clothes in the locker and changes into farm supplied work clothes kept in another area. There is a bench on top of a painted line on the floor which separates the outside from the control zone. The worker sits on the bench and puts on his farm work boots which are on the other side of the bench. The boots have yellow paint on them which helps him remember to leave them on the controlled farm zone side of the yellow painted line on the floor. The worker is now in the controlled farm zone and ready to work.

Steps required for visitors/workers

The visitor sign in is the first and most important step of all. The visitor sign in should take place outside the controlled farm zone or at the border to it (in our example, at the house or the entrance to the shop). The goal of the sign in book is to help in a trace back or trace forward of all visitors in the event of a disease outbreak as well as to assess the risk each visitor represents to the farm. Many people feel uncomfortable "interrogating" their visitors about where they have been but filling in the questions in the sign in book is an easy way to start the conversation about biosecurity. Most importantly, risk assessment must occur before the visitor is given access to the barns. If you determine after the visitor is in the barn that they are very high risk or have not taken an important step (such as cleaning their vehicle after visiting a farm with a disease problem).

Sign in book checklist

- ✓ Visitor's name, contact numbers and company affiliation
- ✓ Reason for visit
- ✓ Last stop (date and time)
- ✓ Last bird contact (date and time)
- ✓ Precautions taken between farm visits

History
Washing hands putting on gloves
Clean boots / over-boots
Clean coveralls
Hairnet
Mask

Evaluating Visitor Biosecurity Protocol

Evaluate the zones established in the serviceperson's vehicle

Conclusions

Limit accessibility to the farm location; locate lockable gates away from farm buildings. Control all vehicle traffic on the farm and keep traffic to a minimum. Routes through the facility should be one way. Fences and barriers are very effective ways to direct on-farm traffic, but can be expensive to install. Driveways should be paved or gravel and well maintained.

Keep a log of all authorized visitors and exclude all unauthorized visitors. Vehicles which must enter should be spray disinfected at the farm entrance. Secure entries to houses with locks. Workers and visitors should stay in houses only as long as necessary to minimize exposure of the birds. Any visitor who must go into the barn should put on clean (farm-supplied) coveralls, boots or boot covers, gloves (or wash hands), hair nets and mask.

Implementing any of these suggestions reduces the risk of disease entry. Each additional step implemented further reduces biosecurity risks. Producers need to review and update protocols regularly. By adopting and maintaining biosecurity protocols, individual producers will benefit from reduced economic losses associated with a disease outbreak on their farm. The entire poultry industry benefits as biosecurity protocols promote healthier poultry production and effective infectious disease containment.

Review Questions

1. What are the three most important considerations when setting up a good on-farm disease control program?

2. What on-farm management practices should be part of a biosecurity program?

3. What is the difference between detergents and disinfectants?

4. Why is it necessary to change disinfectants after a disease outbreak?

2 Prudent Use of Antimicrobials and Drugs in Poultry Production

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Poultry production in Canada depends on antimicrobials and other drugs to protect the health of birds. Even with the best farm management and disease prevention programs, producers still need to treat and control disease in flocks. To maximize the efficacy of medications and to protect the human food supply, producers need to work with veterinarians to diagnose disease accurately, make appropriate management changes, and use antimicrobials and other drugs judiciously.

The human food supply has never been safer and more nutritious. In developed countries, most human health problems related to food are simply from consumption of too much food (for example, obesity, arteriosclerosis, Type 2 diabetes). But bad news sells, and the media is quick to hype food issues such as animal welfare and food safety.

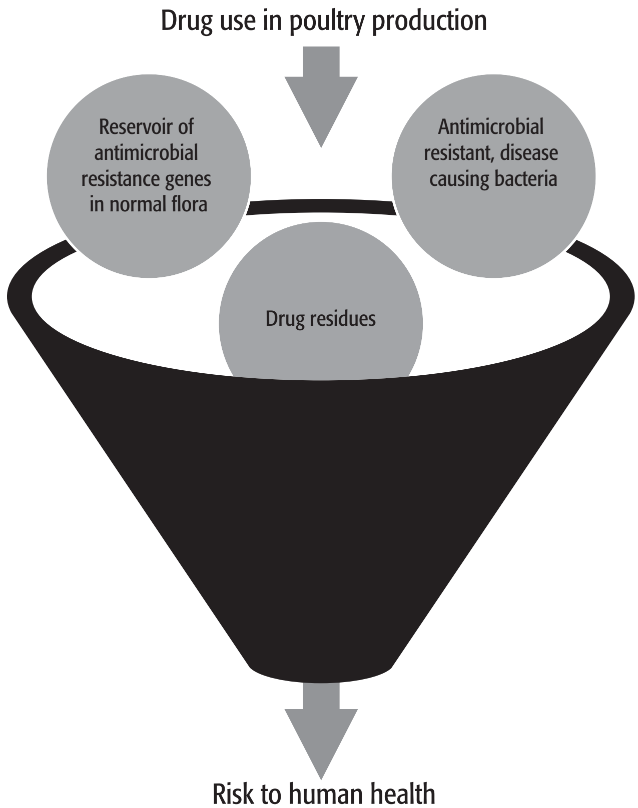
Consumers are concerned about the use of antimicrobials, hormones and pesticides in food-producing animals. With a high standard of living and adequate disposable income, consumers can afford to be selective about their food supply and the major retailers are responding to their concerns. Drug residues and antimicrobial resistance from foods of animal origin are major areas of consumer concern (Figure 1).

The Antimicrobial Use Issue

In poultry production, the greatest consumer concerns are over the use of antimicrobials, especially sub-therapeutic antimicrobials in feed and water for disease prevention or growth promotion (Figure 2). The impact of antimicrobial use in animals on human health is still being debated by scientists, but information is accumulating that raises concerns about food safety and the impact on human health.

Bacteria are able to evolve rapidly because they are genetically versatile. Under ideal conditions, they can double their number in less than 20 minutes. When an animal is treated with an antimicrobial,

Figure 1.
Consumer concerns regarding the safety of poultry products.



Whenever an animal or human is treated with antimicrobials, there is some degree of selection for resistant bacterial populations.

selective pressure is applied to all bacteria exposed to the drug. Bacteria that are susceptible to the antimicrobial are killed or put at a competitive disadvantage, while bacteria that are able to resist that antimicrobial have a survival advantage and are able to outgrow the more susceptible bacteria. If even one in a billion bacteria is able to survive exposure to an antimicrobial by becoming resistant, its descendants quickly reproduce and become the dominant population. Thus, whenever an animal or human is treated with antimicrobials, there is some degree of selection for resistant bacterial populations. Selection depends upon the type of antimicrobial used, the number of individuals treated, the dosage regimen, and the duration of treatment.

More concerning and more difficult to measure is the impact of antimicrobial resistance reservoirs in the normal bacterial flora. Exposure

Figure 2.
Antimicrobials approved for poultry

Growth Promotion	Arsanilic acid Bactracin Bambermycin Chlortetracycline	Erythromycin Neomycin Lincomycin Oxytetracycline	Penicillin Salinomycin Sulfamethazine Tylosin
Prophylaxis	Bacitracini Ceftiiofur Chlortetracycline Erythromycin Gentamycin Lincomycin	Neomycin Nitrofurazone Oxytetracycline Penicillin Spectinomycin Streptomycin	Sulfaguanidine Sulfamethazine Tetracycline Tiamulin Tylosin Virginiamycine
Therapy	Ampicillin Apramycin Chlortetracycline Ceftiofur Erythromycin Florfenicol	Gentamicin Lincomycin Neomycin Ormethoprim Oxytetracycline Penicillin	Spectinomycin Sulfadiazine Sulfamethazine Tetracycline Tylosin Virginiamycin

to antimicrobials selects for resistance genes in the commensal (non-pathogenic) bacterial populations. While not harmful to the bird, these bacteria serve as a reservoir of resistance genes. These genes can move between pathogenic and non-pathogenic bacteria on mobile elements known as plasmids. Many of the plasmids responsible for antimicrobial resistance carry genes that code for resistance to more than one antimicrobial. From gut bacteria, it is common to isolate plasmids that determine resistance to five or more antimicrobials. Consequently, the use of any one of the antimicrobials selects for resistance to the others.

Therefore, it is vital to limit antimicrobial use in animals and humans to those situations where they are truly needed. This may be the area in which veterinarians have the least influence, as many antimicrobials can be purchased and used without a prescription or veterinary involvement. However, a veterinarian is the most qualified consultant to suggest alternative solutions (for example, vaccination, sanitation, nutrition) that can significantly reduce on-farm antimicrobial use.

The Bacteria of Concern

The major bacterial pathogens found on poultry products that are known for antimicrobial resistance are *Salmonella* spp., *Enterococcus* spp., *E. coli* and *Campylobacter jejuni*. The majority of human cases of campylobacteriosis and salmonellosis are caused by contaminated food. If a significant percentage of *Salmonella* or *Campylobacter* become resistant to the antimicrobials used to treat these infections in humans, there will be a significant impact on human health.

The Canadian Integrated Program for Antimicrobial Resistance Surveillance (CIPARS) monitors trends in antimicrobial use and antimicrobial resistance to generate antimicrobial resistance information from farm to fork. Reports have been produced annually since 2002 and have already impacted antimicrobial use in the poultry industry. The publication of CIPARS findings resulted in restricted use of ceftiofur (a third generation cephalosporin used in veterinary medicine and closely related to ceftriaxone, a third generation cephalosporin used in human medicine) in Quebec chicken hatcheries.

Drug Residues

The Canadian Veterinary Drugs Directorate (VDD) approves veterinary drugs and establishes the acceptable concentrations of drug residues in animal-origin food products. The Canadian Food Inspection Agency (CFIA) monitors meat, poultry, eggs and honey for residues of drugs and chemicals. The Codex Alimentarius Committee on Residues of Veterinary Drugs in Foods is a subsidiary body of the World Health Organization and the Food and Agriculture Organization. This Codex committee facilitates world trade in agricultural commodities through the establishment of internationally recognized standards, codes of practice, guidelines, and recommendations that are based on the consensus of expert scientific opinion. A primary function is the establishment of internationally acceptable concentrations of veterinary drugs in food animal products.

Before any drug can be approved in Canada for use in a food-producing animal, the pharmaceutical sponsor must provide an extensive toxicological evaluation of the drug and its metabolites. This ensures that drug residues in food products do not harm consumers. Based on the results of toxicity tests, the VDD establishes an acceptable daily intake (ADI). The ADI represents a level of daily intake of a drug or chemical which, during an entire lifetime, appears to be without appreciable risk to the health of the consumer.

The ADI is used to determine the maximum concentration of a marker residue in edible tissues, honey, milk, or eggs that is legally permitted or recognized as acceptable; this is known as the maximum residue limit (MRL). The MRL is calculated such that daily intake of food with residues at the MRL results in a total daily consumption of residues in quantities at or below the ADI.

Because of differences in consumption factors, MRLs and drug label withdrawal times may differ between countries, even though ADIs are equivalent. Canadian MRLs can be found at http://www.hc-sc.gc.ca/dhp-mps/vet/mrl-lmr/mrl-lmr_versus_new-nouveau_e.html. Pharmacokinetic studies and tissue depletion studies are then performed to establish the approved drug withdrawal time (WDT). Drug manufacturers administer the label drug dose to a number of animals and perform sequential slaughter to measure tissue drug concentrations. The WDT is determined by identifying the time that is required for drug concentrations in tissues to fall below the MRL.

When approved veterinary drugs are administered according to their label directions, the prevalence of violative drug residues in animal products should be less than 1%. Residue violation rates greater than 1% indicate that a drug has been used in a manner inconsistent with label directions.

Medicated feeds are a frequent cause of residue violations in market hogs and poultry. The most commonly detected residues are antimicrobials and coccidiostats. Adherence to medicated feed WDTs may be burdensome, inconvenient, and expensive in that nonmedicated feed must be provided during the withdrawal period and this requires changing feed programs and containers for a short time at the end of the feeding period. Difficulties in co-ordinating feed deliveries and changes in marketing schedules ephasize the fact that producers and feed suppliers must work very closely together.

Lack of treatment records or failure to adequately identify treated animals can also lead to insufficient withdrawal periods and violative residues. When drugs are administered to animals at dosages greater than those specified in the labeling, or when drugs are used in species for which they are not approved, the prescribing veterinarian is responsible for withdrawal recommendations.

Lack of treatment records or failure to adequately identify treated animals can also lead to insufficient withdrawal periods and violative residues.

When using drugs in an extra- label manner in food animals in Canada, veterinarians should contact the Canadian global Food Animal Residue Avoidance Databank (CgFARAD) for withdrawal recommendations. Veterinarians can call 1-866-CGFARAD (1-866-243-2723), send email to cgfarad@umontreal.ca or go to www.cgfarad.usask.ca to submit a request for information.

Store vaccines in the refrigerator with the correct temperature

Prudent Use Guidelines

Production of safe and wholesome poultry products is the goal of everyone involved in the poultry industry. The following guidelines should be considered when contemplating drug or chemical use on the farm.

1. **Use all antimicrobials, even those purchased directly through or on prescription from a veterinarian, within the confines of a valid veterinarian-client-patient relationship (VCPR).**

   The accepted definition of a VCPR includes the following conditions:

   - The veterinarian has assumed the responsibility for making clinical judgements regarding the health of the animal(s) and the need for medical treatment, and the client has agreed to follow the veterinarian's instructions.
   - The veterinarian has sufficient knowledge of the animal(s) to initiate at least a general or preliminary diagnosis of the medical condition of the animal(s). This means that the veterinarian has recently seen and is personally acquainted with the keeping and care of the animal(s) by virtue of an examination of the animal(s) or by medically appropriate and timely visits to the premises where the animal(s) are kept.
   - The veterinarian is readily available for follow-up evaluation, or has arranged for emergency coverage in the event of adverse reactions or failure of the treatment regimen.
   - When it is not possible to make a direct clinical evaluation, the diagnosis should be based on past experience, on knowledge of the farm's usual health status, and historical and/or ongoing susceptibility testing.

   Veterinarians should work with poultry producers to use antimicrobials and drugs prudently regardless of how the products were obtained. All new antimicrobials for use in poultry are approved as prescription-only products because of the need for proper use of antimicrobials through precise diagnosis and correct treatment to minimize animal suffering and maximize efficacy, and to reduce antimicrobial resistance and prevent drug residues in food. However, many older antimicrobials and drugs are available for over-the-counter sale to producers. Regular, close veterinary involvement assists producers with informed advice and guidance on judicious drug use.

2. **Use preventive strategies, such as appropriate husbandry and hygiene, routine health monitoring, and immunizations, whenever possible. Consider other therapeutic options before antimicrobial therapy.**

Antimicrobials should never be used in place of proper animal husbandry and hygiene programs. Disease control reduces the need for antimicrobial use. These programs should include on-farm biosecurity measures, hygiene and poultry house disinfection procedures, probiotics to establish "good" bacteria in birds, good farm management and record keeping, ideal stocking rates, and vaccination.

Preventative disease programs based on vaccination strategies reduce disease outbreaks in poultry. The poultry industry is the leader in novel vaccination procedures for immunization of large numbers of animals. Breeder and meat production flocks can be monitored for protective response to vaccinations.

All-in-all-out production minimizes the presence of multiple ages of flocks on farms and helps in disease prevention. Biosecurity programs on poultry farms prevent disease introduction. In the face of a disease outbreak, management adjustments in environmental temperature, ventilation, and litter moisture can help minimize the impact of the infection in the flock. Supportive therapy with vitamins and electrolytes can be utilized in some cases.

After the ban on in-feed antimicrobials in the European Union, producers were forced to find a way to deal with necrotic enteritis. They found that the addition of enzymes acting on carbohydrates and the addition of probiotics helped birds develop an adequate intestinal bacterial flora and reduced the incidence of necrotic enteritis. Reduced dietary levels of protein and added amino acids improved house hygiene and animal health. Feeding whole wheat stimulated skeletal muscle activity and reduced moisture in bedding. The feeding regimens employed were developed through close collaboration between the feed industry and the farmers. Strong emphasis was also placed on improving animal environment because many diseases, including necrotic enteritis, have a multifactorial background.

3. **Extra-label antimicrobial and drug use (ELDU) must be prescribed by a veterinarian and only in accordance with the Food and Drugs Act and based upon sound scientific evidence.**

No drug can be marketed unless its quality, safety, and efficacy have been demonstrated. Therefore, first choice therapies should be products approved for the type of poultry and the indication on the medication label. When no suitable product is approved for a specific condition or species, or the approved product or its dose is known to be clinically ineffective, the choice of an alternative product or dosage regimen should be based on the results of valid scientific studies and demonstrable efficacy for the disease and species concerned. Certain drugs are banned for use in food-producing animals and must not be administered under any circumstances.

4. **Optimize dosage regimens for antimicrobial and other drug use using current pharmacological information and principles.**

For the on-label use of an antimicrobial, the most accessible source of information is its label and the product insert. The choice of the right antimicrobial or drug needs to take into account pharmacokinetic parameters, such as bioavailability, tissue distribution, apparent elimination half-life, and tissue kinetics to ensure the selected drug reaches the site of infection. Consideration is given to the available formulations and to the route of administration.

Veterinary continuing education programs and technical updates from service veterinarians help keep poultry veterinarians and producers up to date on current drug and vaccine information. If prescribing a drug in an extra-label manner, the veterinarian is responsible for providing a withdrawal time sufficient to prevent violative food residues or any residue that presents a risk to public health.

Correct temperature 2–8°C (35–46°F)

In situations where ELDU is necessary, the Canadian gFARAD can recommend appropriate withdrawal periods. Prolonged administration of antimicrobials in feed and water should be avoided, as most of the concerns regarding antimicrobial resistance are associated with antimicrobial resistance reservoirs in the birds' normal bacterial flora.

5. **Antimicrobials considered important in treating serious infections in human or veterinary medicine should be used in flocks only after careful review and reasonable justification. Consider using other antimicrobials for initial therapy.**

Health Canada recognizes that all available antimicrobial drugs are important. However, some drugs are considered more important than others in the treatment of serious bacterial infections, and resistance development against those antimicrobials might have more serious consequences in human health.

Health Canada uses pre-defined criteria to group antimicrobials into different categories based on the implications of resistance to

Category I: Very High Importance

These antimicrobials are considered of very high importance in human medicine. They meet the criteria of being essential for the treatment of serious bacterial infections. There is limited or no availability of alternative antimicrobials for effective treatment if resistance emerges to these agents.

Carbapenems	Monobactams
Cephalosporins (3rd & 4thGeneration)	Nitroimidazoles
Fluoroquinolones	Oxazolidinones
Glycopeptides	Penicillin/β–lactamase inhibitor combinations
Glycylcyclines	Polymyxins
Ketolides	Streptogramins
Lipopeptides	Drugsto treat tuberuculosis

Category II: High Importance

These antimicrobials are used to treat a variety of infections including serious infections and for which alternatives are generally available. Bacteria resistant to drugs of this category are generally susceptible to Category I drugs.

Aminoglycosides	Macrolides
Cephalosporins (1st& 2nd Generation)	Penicillins
FusidicAcid	Quinolones
Lincosamides	Trimethoprim/sulfamethoxazole

Category III: Medium Importance

Antimicrobials in this category are used for treatment of bacterial infections for which alternatives are generally available. Infections caused by bacteria resistant to these drugs can, in general, be treated by Category II or I antimicrobials.

Aminocyclitols	Phenicols
Aminoglycosides (topical)	Sulphonamides
Bacitracin	Tetracyclines
Fosfomycin	Trimethoprim
Nitrofurans	

Category IV: Low Importance

Antimicrobials in this category are currently not used in human medicine.

Flavophospholipols	Ionophores

these drugs to human medicine. Generally, antimicrobials with a broad spectrum of antibacterial activity lead to development of resistance in non-target bacteria more rapidly than those with a narrow spectrum because they exert selection pressure on a greater number of bacteria. Therefore, where an appropriate narrow spectrum agent is available (for example, bacitracin), it should be selected in preference to a broad spectrum agent (for example, ceftiofur).

6. **Use culture and susceptibility results from the flock and from CIPARs nationally to aid in antimicrobial selection.**

The susceptibility of bacteria to specific antimicrobials can vary between flocks. Periodic culture and susceptibility testing provides historical data on which to base empirical treatment. Susceptibility tests are intended to be a guide for the veterinarian, not a guarantee that an antimicrobial will be effective in therapy. The effect of the drug depends on its ability to reach the site of infection in a high enough concentration, the nature of the disease process, and the immune responses of the bird.

The effect of the drug depends on its ability to reach the site of infection in a high enough concentration, the nature of the disease process, and the immune responses of the bird.

Ideally, the susceptibility profile of the disease-causing pathogen should be determined before therapy is started. But in disease outbreaks with high death losses and/or rapid spread of the disease, treatment may need to start before susceptibility results are obtained. The antimicrobial susceptibility of the suspected pathogen should still be determined, so that if the initial treatment fails, an appropriate second treatment can be selected.

Antimicrobial susceptibility trends should be monitored over time, and such monitoring used to guide on-farm treatments. This can be done for the individual flock and can be compared to national results from the Canadian Integrated Program for Antimicrobial Resistance (CIPARs, www.phac-aspc.gc.ca).

7. **Antimicrobial drugs are only effective against bacteria and they should not be used for treatment of non-bacterial diseases, such as uncomplicated viral infections.**

Every effort is made to address disease outbreaks with other disease management strategies prior to the initiation of antimicrobial therapy. Veterinarians should use their professional knowledge and clinical judgment to decide whether viral infections are or are likely to involve a superimposed bacterial infection. Viral, fungal and other non-bacterial infections are not treated in poultry with antimicrobials. Mortality and morbidity are closely monitored;

diagnostic evaluations are performed to confirm bacterial involvement prior to antimicrobial therapy.

8. **Minimize exposure of poultry to antimicrobials by only treating ill or at-risk birds and treating only for as long as needed.**

Due to the costs of drugs, veterinarians and producers monitor antimicrobial treatments closely to minimize use in flocks. Theoretically, infections should be treated with antimicrobials only until the bird's immune defence is able to fight off the infection, but that period is often difficult to determine precisely. Morbidity and mortality are used to base clinical judgments as to duration of therapy. Limiting the duration of treatment to the minimum required for a therapeutic effect minimizes the exposure of the bacterial commensal bacteria. However, if the treatment period is too short birds that appeared to have improved may relapse. It is then more likely that the pathogens involved in the relapse episode are less susceptible to the antimicrobial.

In some cases, if a number of birds in a flock show clinical signs of disease, both sick and healthy birds will be treated with therapeutic levels of an antimicrobial. This is intended to cure the sick birds, reduce the spread of the disease, and prevent the disease from developing in birds exposed but not yet showing clinical signs. Such strategic medication may be appropriate in precisely defined circumstances, but should be part of an integrated disease control program and regularly re-evaluated. The use of antimicrobials in the absence of clinical disease or should be restricted to situations where past experience indicates that the flock may develop the disease if not treated.

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9. **Minimize environmental contamination with antimicrobials and other drugs whenever possible.**

Unused antimicrobials and other drugs should be disposed of properly. Also some antimicrobials may be environmentally stable in litter. If the antimicrobials are not bound in an inactive form, environmental exposure contributes to human exposure and may contribute to resistance development. Consideration may need to be given to disposal methods that will not recycle resistant organisms to humans or animals.

Avoid environmental contamination with other drugs as well. Many poultry coccidiostats contain arsenicals, and there is consumer concern over the extent of environmental contamination with arsenic from poultry litter.

10. Use accurate records of treatment and outcome to evaluate treatment protocols.

Record keeping is a vital part of on-farm food safety programs. Production records including dosage regimens, medication costs, antimicrobial susceptibility information and treatment outcome should be kept for future reference. Periodic review will identify any changing antimicrobial susceptibility patterns. Outcome records greatly assist with designing future antimicrobial treatments.

The implementation of these general prudent use guidelines will reduce the development of antimicrobial resistant bacterial pathogens and commensals in poultry and lessen human health risks from the on-farm use of antimicrobials and other drugs.

Review Questions

1. How do bacteria become resistant to antimicrobials?

2. Is antimicrobial resistance a problem in Canada and, if not, could it become a problem?

3. What can poultry producers do to help avoid or minimize the development of antimicrobial resistance?

4. What is a frequent cause of residue violations in market hogs and poultry?

5. How can we minimize the use of antimicrobials on our farms without affecting production efficiency?

6. How effective are antimicrobial drugs against viral infections?

3 How Drugs Work

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Introduction

It is important to understand the basics of how drugs work so that they can be used safely and effectively on your farm.

The following discussion is focused on antimicrobials but also applies to other types of medications given to poultry.

Every drug is labeled for specific species, conditions, doses and durations of treatment which correspond to specific withdrawal periods. Any use of a product in any way different from the label dose is off-label use and requires a veterinary prescription.

When we look at these labels it is easy to wonder why they can't be more user-friendly and general. The reason for the specificity of label requirements is that the actions of different products depend on a number of biological, chemical and microbiological factors. Any product which can help can also cause harm if incorrectly used. In some cases, the desired therapeutic dose and the toxic dose for an antimicrobial can be very close. What you need to know? The most you can gain from the following information is a basic explanation for the details underlying the treatments that are recommended to you. The least you should take away from this chapter is that the way that drugs work is complicated by a number of factors and that poorly informed treatment choices or mistaken delivery can be dangerous to the health of your flocks, the health of your business and may cause a risk to food safety and contribute to antimicrobial resistance development.

The Nature of the Drug

Most antimicrobials are derived from naturally produced compounds found in nature. Nature is a competitive environment; even at the microscopic level organisms are competing with each other for survival. To protect themselves many bacteria, yeast and fungi produce chemicals which damage or slow the growth of their competitors. Scientists have been collecting these organisms and their unique chemical products to develop antimicrobials for use in human and animal health since penicillin was discovered by Scottish scientist, Sir Alexander Fleming in 1928. The way these compounds work to kill (bactericidal) or slow the growth (bacteristatic) depends on their microbial targets and how they act on the victim microbe. The target of the compound results in some antibiotics having a narrow spectrum of microbes that they affect while other will have a broad spectrum of activity. The following table shows characteristics of antimicrobials commonly used in poultry production.

Antibiotic	Activity	Damages bacteria by	Spectrum of activity*	Pathogen Example*	Disease Example
Penicillin G	Kills	Cell wall synthesis blocking	Gram positive bacteria	*Staph. aureus*	*Staph. arthritis*
Neomycin	Kills	Protein synthesis blocking	Gram negative bacteria	*Psuedomonas sp.*	*Psuedomonas* infection
Amoxicillin	Kills	Cell wall synthesis blocking	Broad	*E. coli*	*Colibacillosis*
Apramycin	Kills	Protein synthesis blocking	Gram negative bacteria	*E. coli*	*Yolk sac infection*
Tetracycline	Effects growth	Protein synthesis blocking	Broad	*Pasturella multocida*	*Cholera*
Sulfonamides	Effects growth	Folic acid synthesis blocking	Broad	*E.coli*	*Colibacillosis*
Bacitracin	Effects growth	Cell wall synthesis blocking	Gram positive bacteria	*Clostridium sp.*	*Necrotic enteritis*

* These are general categories. Bacterial resistance to these antibiotics varies with type of poultry, geographical area and farms.

The deciding factor in making a treatment choice will often be the antibiotic sensitivity pattern of the bacteria isolated from your flock. You will not usually be given a sensitivity pattern for bacteriology from your flock as there are many other details you must know before choosing a drug from the list on the report. A sensitivity pattern will be reported as sensitive, intermediate or resistant for a panel of antibiotics. In some cases the drugs listed as resistant will be an option and those listed as sensitive will not be a good choice because of the following factors.

The Nature of the Beast

There are many factors which influence the suitability of an antibiotic for a specific treatment. The first is the ability of the bird to absorb the antibiotic (if it is given by water or feed). Injection of antibiotics is seldom used in modern poultry production with the exception of targeted administration at the hatchery level to chicks and poults. In some cases injection may be used in valuable birds which are easily handled (for example, turkey or chicken breeders).

To be properly absorbed, orally administered antimicrobials must survive the water or feed delivery system, be ingested and survive the low pH of the gastric stomach of the bird, reach the intestine and be taken up into the blood stream. Some antimicrobials (for example, neomycin, bacitracin) are not absorbed and have their activity at the intestinal level only.

Under-dosing a flock is also a risk that should be avoided as it can result in treatment failure and contribute to the development of antimicrobial resistance.

Once absorbed by the bird the drug will end up in specific compartments of the body; this is called the volume of distribution. Some products have a high volume of distribution which means that they will spread out in many tissues in the body, while others will concentrate in specific tissues such as the lungs. It is important that the antibiotic reaches the site of infection to enable a successful treatment.

With absorption and distribution under control we must ensure that the medication reaches the bird at the required dose and for the required duration. As a general rule one should stop any water treatment while administering an antibiotic in the water. Chlorination is usually not a problem but acidification of water while medicating can damage the antimicrobial (penicillin, tetracycline) or cause them to precipitate out of solution (sulfonamides). If the antimicrobial doesn't get to the bird there is no chance of absorption or distribution to the target tissues!

Label dosing recommendations are usually based on a water concentration required to give a therapeutic dose at a predicted water consumption/kg of live weight. As water consumption can vary significantly with temperature it is important to take this into account when setting doses for the treatment.

Your veterinarian may advise different dosing regimens depending on the disease, the product being used and the environmental conditions. As a general rule, the medication should be made available at least over a period long enough to allow access to all birds in the barn (minimum four hours) and stock solutions or bulk tank should be prepared daily for the duration of the treatment. Slowly walking the barn as throughout a treatment period will encourage birds to get up and drink. Be careful not to over stimulate a flock during treatment especially when using bell type drinkers or birds may spill a significant amount of medication.

Under-dosing a flock is also a risk that should be avoided as it can result in treatment failure and contribute to the development of antimicrobial resistance. Recording daily water consumption is a useful tool when making medication calculations.

The dosing strategy and length of treatment will often depend on the nature of how the product works in body of the bird and the level of product required to kill the bacteria. Some antimicrobials just need to reach a certain peak concentration (concentration-dependent killers) in the blood or tissues to kill the invading bacteria while others need to reach a steady concentration and stay there (time-dependent killers). These characteristics of the antimicrobial and the bacteria causing the infection will determine the length and dose of treatment. Generally antibiotics which affect growth of bacteria require longer treatments.

Antibiotic	Method of delivery	Absorption	Volume of distribution	Type of killer	Toxicity
Penicillin G	water	easily inactivated	kidney, liver, lung	Time	very low
Neomycin	water	little oral absorption	not absorbed	concentration	low
Amoxicillin	water	good	kidney, liver, lung	Time	very low
Apramycin	water	first 4 days then little	kidney, liver, lung	concentration	low
Tetracycline	feed or water	rapid and good	widely distributed	Time	low
Sulfonamides	feed or water	rapid and good	widely distributed	Time	high
Bacitracin	feed	none	none	Time	low

Toxicity and Withdrawal Times

Every medication has a certain toxicity range although some (penicillin, for example) are very low. However, if penicillin residues were to occur in eggs and meat of treated flocks this would be a major food safety issue. A significant proportion of the human population is allergic to the penicillin.

For some medications there is a small difference between the therapeutic and the toxic dose. You must be particularly careful with these products (for example, sulfonamides) ensuring that you dose according to water consumption and rule out any possible interactions with medications in the feed (ionophores, for example).

Reminders

1. Remember that some products are not compatible and one must take into account all medications in the feed and water when planning a treatment.
2. A common mistake that is made when starting a treatment is forgetting to open the water line after setting up the medicator.
3. Have you calibrated your medicator? Don't assume that the dosing rate listed on the dial is accurate.
4. Calculate how much medication you will need each day and for the whole treatment and keep track of what you give to make sure you are on track. It never hurts to check you math twice.

The last and most important consideration when planning to treat a flock with antimicrobials or any medication is to ensure that you will meet the required withdrawal time. Withdrawal time management is the foundation of residue avoidance for protecting the food chain and your business.

If there is a feed or medication error you should contact your veterinarian immediately to request a withdrawal time recommendation. It is better to delay shipping your flock or eggs than to risk having violative residues in your product. Not only is the whole industry and consumer confidence at stake, but you risk having your product destroyed without compensation. The withdrawal time will be clearly indicated on the product label or provided on your prescription if you are using an off-label treatment. Withdrawal times apply to all medicated feeds so make sure that you have changed completely to a withdrawal feed before you begin the withdrawal countdown. Some feed and water medications have a label claim for 0 days withdrawal and will have this stated on the product. Do not assume that if a withdrawal time is not listed that it is 0. Remember that the label claim must be followed exactly (species, condition, dose, duration of treatment and all warnings) for the withdrawal recommendation to be valid. When using products off -label the maximum residue limit becomes 0 parts per million or parts per billion (whatever the most sensitive test available for measuring zero is). When it comes to the responsible and successful use of medications knowledge is power.

Review Questions

1. Antimicrobials are either bactericidal or bacteriostatic. What do those terms mean?

2. Give an example of an antimicrobial that has a broad spectrum of activity and one that does not.

3. What are the dangers of using excessive amounts of antimicrobials?

4. Are there any potential problems which might result from using levels of antimicrobials that are lower than those recommended by your veterinarian?

5. If antimicrobial residues were found in meat or eggs what do you think might have caused this to happen?

4 Principles of Antimicrobial and Medication Use

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Introduction

Antimicrobials and other medications are used in poultry production to prevent and treat disease and to improve production performance. Consumers and regulatory bodies have a great deal of concern about the use of veterinary medications and feed additives in poultry production. The use of these products has sparked considerable public debate specifically regarding the development of antimicrobial resistance and the potential for chemical residues in the products offered to consumers.

Beyond consumer and regulatory concerns using the right product, in the right way, at the right time is the foundation of good management. Long term use of products for the control of chronic conditions can result in resistance to antimicrobials which have real impacts for the farm. Using products without knowing what condition is causing the problem can result in the worsening of the condition you are trying to remedy, a cost with no benefit, possible antibiotic resistance issues and contribution to the perception of irresponsible use. The poultry industry must recognize these concerns and deal with them appropriately so as to ensure its success into the future.

Who, What, When, Where, and Why

Who

The target audience for this material is poultry producers and farm managers. The people responsible for administering medications and making treatments decisions must understand the fundamentals to do this properly. Proper decision-making requires knowledge and training. When new workers join your operation they should be given access to material like this program and should be trained in the standard operating procedures for your farm, including all medication and vaccine use protocols. There should be treatment protocols for every product you keep on your farm which include the when, where, why they are to be given. The other who in this process should be your veterinarian, who can help you to develop and review your protocols.

What

Knowing what products to use requires you to know exactly what disease or parasite challenge your flock is facing. Once you have an understanding of the challenge you are facing choosing the right product to overcome that challenge is the next step.

There are a number of different classifications of products available for use in poultry flocks. Each of these products must have a drug identification number (DIN) which indicates that the product is registered with Veterinary Drugs Directorate of Health Canada. Disinfectants will also have a DIN but are not to be administered to or used around birds outside of the label recommendation.

Over the counter (OTC) products are products which can be purchased at a Production Animal Medicines (PAM) outlet. These products must be used in the exact way they are labelled. The label recommendation will indicate the species and type of bird the product can be used for, the route, dose and duration of treatment, the condition to be treated for and the withdrawal time that must be met before the flock is used for egg or meat production. If an OTC product is used in a way that is not described on the label then it is being used in an extra label manner and requires a veterinarian prescription. In many cases extra label drug use (ELDU) will require extended withdrawal periods. If a withdrawal time is not stated that does not mean the withdrawal time is 0 days or hours.

Veterinary prescription drugs are products which must be prescribed by a veterinarian. A veterinary prescription will provide all of the same information given in a label: species, type, route, does, duration, condition being treated and withdrawal time.

Veterinary biologics are vaccines (viral,bacterial,protozal) and can be either modified-live products or killed. All of these products will have passed safety testing but modified-live vaccines, in particular, can have negative impacts on bird health if used incorrectly or without an understanding of the particular virus and strain. Because of this, all live vaccines are available only through licensed veterinary facilities. All of these products also have a withdrawal time and must be used according to the label.

Did you know?
Lincomycin Soluble Powder is registered for use in broiler chickens for the treatment of necrotic enteritis. Thi product can only be used in turkey flocks with a veterinary prescription and will have a longer withdrawal time than the 24 hours required for chicken flocks.

Withdrawal times are based on registered maximum residue limits (MRLs). A Maximum Residue Limit is a level of residue that could remain safely in the tissue or food product derived from a food-producing animal that has been treated with a veterinary drug. This residue is considered to pose no adverse health effects if ingested daily by humans over a lifetime.

There are two problems with choosing the wrong treatment: first, you are spending money on something that is doing no good and second, you are not using the treatment or corrective action that will fix your problem.

When

Once there is an understanding of what conditions are being treated or vaccinated for and the right product has been chosen and acquired the decision of when to give the product must be made.

The timing of administration of medications and vaccines is an important factor in successful and prudent use of these products. In general treatments are given in response to a disease challenge (therapy), or in advance of a known or expected challenge (metphylaxis).

> The cost of the treatment must be weighed against the effect of treatment.

Therapeutic treatment should be initiated in response to the identification of a specific disease challenge. Simply identifying a disease in a sample of sick or dead birds from a flock does not necessarily indicate the need for a treatment. In some cases the disease responsible for the mortality can be secondary to an initial challenge, such as another bacterial, viral or parasitic challenge.

There must be an expected cost benefit to any treatment and, therefore, the cost of the treatment must be weighed against the effect of treatment (the predicted savings of birds, eggs or weight gain directly from the treatment in question). Predicting losses can be difficult and relies heavily on knowledge of the specific disease as well as the proportion of the flock at risk (the susceptible population).

It is easy to forget that even in a flock of birds which are all the same age and from the same source that there are subpopulations of smaller and larger birds, healthier and less healthy birds as well as the fact that within a given barn the environment experienced in one area of the barn may be very different from other areas of the same barn.

When a problem starts in a flock under your care you always have the choice to make a simple decision to a complex problem (the trial and error school of thought) or to make an informed decision as part of a systematic approach to treating and ultimately preventing disease. To make the best decision for a therapeutic treatment of a flock, keep good production records so you know what is normal in your operation.

When you are concerned about an increase in a problem, mortality or a decrease in production:

1. Collect a representative sample of birds with the problem, observe where in the barn the problem is occurring.
2. Save the sample for your veterinarian or submit it to your local diagnostic service
3. Based on the diagnosis and status of the flock you can make a treatment decision with your veterinarian. In some cases immediate treatment will be prudent and in others it may make sense to wait for a bacterial culture and antibiotic sensitivity result.
4. Follow-up evaluation of environmental, management or other risk factors such as potential underlying viral diseases should be done.
5. Preventative treatment may be required if the suspected risk factors for the disease challenge cannot be identified and addressed.

Remember:
if you have to initiate a treatment before you have seen your vet or submitted birds take a sample to ensure that culture results can be used. Birds dying after even a day on treatment may not provide a sample from which the bacteria causing the problem can be grown.

Preventative Treatment (Metaphylaxis), such as routine deworming, is used to protect flocks from an ongoing disease challenge or as part of a health program. You have probably heard it said that an ounce of prevention is worth a pound of cure. While the exact conversions are not known in many cases this concept is true. Both targeted and long-term preventative treatments are usually more cost-effective than therapeutic treatments for specific diseases.

A common example of effective metaphylaxis is the use of feed additive antibiotics such as bacitracin and virginiamycin to prevent necrotic enteritis (NE) in broilers and turkeys. While it would be possible to wait for your flock to break with NE, signalled by increased mortality, before treating there are production and welfare concerns associated with not preventing disease. Obviously, allowing birds to die from and become sick with a disease, which is likely to occur and easily prevented, is irresponsible and has serious welfare implications. From a production perspective, allowing diseases to occur before treating not only results in increased mortalities but also in losses from subclinical (not visible) disease such as decreased weight gains, increased feed conversions, and decreased egg production, hatchability, quality.

The concept of subclinical disease is often described using the iceberg analogy where the clinical disease (dead or visibly sick birds) is represented by the tip of the iceberg and much larger body of the iceberg is the subclinical (decreased performance and health) effects occurring below the surface where they cannot be seen.

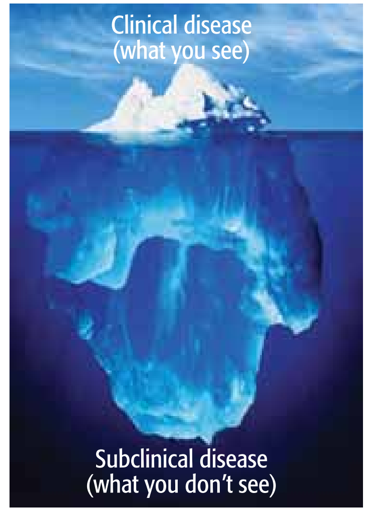
One of the important aspects of why metaphyaxis tends to be more effective at controlling certain diseases is that you are administering treatments to a normal flock of birds. Unlike a therapeutic treatment situation where the birds are already affected, with meatphylaxis we are able to evenly dose birds according to normal activity, feed and water intake. Even when a therapeutic treatment is properly designed and administered, we know we will continue to lose recently affected birds as they will not be consuming adequate amounts of feed or water to get a therapeutic dose of medication. After a therapeutic dose is delivered the medication will take time to reach the affected body system of the bird and reach levels high enough to kill or prevent pathogens from growing.

With preventative treatments the goal is to reach the body system with a protective level of medication before the bird is clinically ill or to disrupt the pathogen before it can cause too much damage, as with parasite control.

After reading about the obvious benefits of preventative treatment one might feel that it should be used all the time. However, there are some risks associated with preventative treatments which over time can have negative impacts on an operation. Nature is designed to adapt and the same is true of the pathogens that affect our poultry flocks. If we do not carefully evaluate, rotate and administer preventative treatments we can select for pathogens which are resistant to the medications we are using.

Once pathogens on a farm develop resistance to a medication we lose that medication as a tool to keep the birds healthy and this may contribute to bigger problems for other parts of the industry, the food chain and our environment. The best way to avoid a high stakes game with resistance problems is to make certain that there is really a challenge to protect against, define, understand and monitor that challenge and then work closely with your veterinarian and nutritionist to make a plan which is regularly reviewed.

The goal of successful and sustainable poultry production is to reduce and control risk factors for disease challenges with non-medication methods wherever possible. By providing optimal environments, high quality nutrition and management we can avoid the cost and risk of many treatments.



Where

The where of medication use is obviously where the birds are – but this is a good place to discuss where you can source the medications that you need. There are businesses with Production Animal Medicine (PAM) licenses which allow them to sell and distribute a number of medicines (over the counter products), pest control products and disinfectants for use on poultry farms. PAM outlets are licensed by the province under the regulations of the Livestock Diseases Act (Alberta), and should have their license clearly visible to their clients.

Registered veterinary practices and pharmacies can sell these products in addition to prescription drugs and vaccines regulated under the Federal Food and Drug Act (Canada), Veterinary Profession Act (Alberta) and Pharmacy Act(Canada). Registered Feed Mills can prepare medicated feeds under the Feeds regulation (Canada).

There are many products with similar sounding names and different formulations of the same products so it is important to make sure you buy what has been recommended to you. Be careful not to substitute products accidentally as different manufacturers of the same products may have different label recommendations, including doses, species and withdrawal times. If you are not sure about a product you have purchased check with your veterinarian before you give it to the birds.

Reminders:

- Only a licensed veterinarian can make diagnoses and treatment recommendations.
- You must follow the label instructions or prescription for all products used on your farm
- Keep only the medications that you use regularly on the farm and only as much as you will need (storing medications from bulk buys often result in losses from expiry and damage)
- Any medication given to your flock must have a Drug Identification Number (DIN).

Treating symptoms will work sometimes but it is like randomly replacing parts in your vehicle when it is not working properly.

Why

This is one of the most important questions we can ask in any aspect of poultry production: Why are we doing what we doing? When making treatment decisions, asking and knowing why is the essence of responsible and effective use of medications. The wrong answers to why a specific treatment or dose is being given are that birds started dying or because they looked sick. We established earlier that making the right treatment decision requires us to know what specific disease or challenge we are treating.

Mortality, lameness, respiratory signs and loose droppings are all symptoms of disease, they are not diseases. Treating symptoms will work sometimes but it is like randomly replacing parts in your vehicle when it is not working properly. To continue with that analogy, if you call a professional mechanic and describe the funny noise your vehicle is making they will no doubt tell you that you need to bring it in rather guessing at the problem that is causing the sound. If you call a friend or colleague and describe to that person the sound your vehicle is making they may have had a similar experience and share some advice. You are left with the decision of who to listen to and what to do. Most of us will decide to bring our vehicle in to the mechanic, if not at first, then eventually.

The length of time we take to get professional advice on important issues will often determine how much the outcomes of those issues and our decisions cost us. The difference between getting advice from people you know and professionals who fix those problems for a living is that the professional knows better than to give advice without enough information. Professionals have reputations to protect, are accountable for the advice they give, and will charge you for advice because that is what they do for a living.

Free advice is often worth what you pay for it, so be careful who you go to for advice on important issues such as the health of your flocks. At the end of the day the problems you are facing are your responsibility and if you make a decision based on inadequate information or bad advice the consequences will still be your responsibility. So, to understand the problem, make a treatment plan, implement the treatment plan and review the outcome.

Understand the Problem

- To know when something is wrong you need to know what is normal for your operation; record keeping and production data analysis will help you do this. Many problems develop over time and become more severe in successive flocks.
- Create a list of what has changed in the time period immediately before the problem started.
- Write down your observations: exactly what is the problem, when it started, where it is occurring, what group of birds are affected, is there a group of birds that are not affected?
- Contact your professionals for support you will need to get advice about what samples will be needed (water, feed, birds, blood samples etc.)
- Analysis, testing and interpretation of results will reveal the exact problem or indicate the need for more or different testing

Make a Treatment Plan

- Ideally, after you know exactly what problem you are facing, the professionals who helped you to find the answers will have advice on exactly what treatments or corrective actions are needed. Remember that the corrective actions will often not involve the use of any medications, vitamins, vaccines or antiparaciticides.

- Sometimes your professional support will advise immediate corrective actions when you describe the problem and will confirm the suspected problem later (suspected toxicity, reportable diseases).
- The plan should be written down, specific (for example, product, dose, mixing instructions, length of treatment, withdrawal time).
- You may end up with differing opinions on the best way to approach your problem. It is usually best to implement one strategy in its entirety than to combine parts of a number of strategies.

If you feel that you do not have a thorough understanding of a problem you are facing with flock health and production rely on the support of the professionals you work with – and if you do not have a team of professionals, you may want to start making those connections.

Implement the Treatment Plan

- Do exactly what you have planned. If you are delegating the plan confirm that the employees understands exactly how and what they are to do (written instructions are so important for avoiding mistakes and can be invaluable in problem solving).
- If any changes are required to implement the plan make sure that you change them on the original plan.
- Stick with your plan and stay the course. A sure way to fail is to keep changing your strategy.

Review the Outcome

- When you have completed your plan review the outcome: was it successful? What did it cost?
- If your treatment plan was not successful you may need more information to understand the problem or need to try another strategy.
- Regardless of the outcome of your treatment plan a progressive operation will want to make a prevention plan to avoid the problem that was encountered. An example of a prevention plan is to reduce risk factors for the disease on your farm through changes to your production system, biosecurity plan, facilities, and management.

Having a systematic approach to making a treatment plan will improve success, avoid failure and reduce the stress of facing problems. We hope that these guidelines help you in decision making about treatments you will administer to the flocks in your care. If you feel that you do not have a thorough understanding of a problem you are facing with flock health and production rely on the support of the professionals you work with – and if you do not have a team of professionals, you may want to start making those connections. An ounce of prevention is worth a pound of cure.

Review Questions

1. Discuss the difference between over the counter products and products provided by a veterinarian.

2. What are subclinical diseases and how might they affect your bottom line?

3. How should one assess the potential of a preventative treatment?

4. What factors should one consider when evaluating the results of a treatment?

5. Should the poultry industry strive towards using less medication and, if so, how would we do that?

5 Diseases of Poultry

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Introduction

Most people have some knowledge of bacteria, viruses, and other microorganisms. It is common to have a general understanding that they are very small, bad things that cause diseases. We sometimes refer to catching a bug, though few diseases have anything to do with insects. Although many microbes are pathogenic (they produce disease), the majority do not cause disease. All animals, including poultry, have a population of bacteria that normally inhabit the gut and aid in digestion and production of some of the vitamins their bodies need. Microorganisms are also used in the production of foods, such as yogurt, cheese and bread. Microorganisms are involved in processes such as decomposition of dead plant and animal matter, and form part of the food chain in soils, lakes and rivers. They help maintain the delicate balance in the environment.

There are several terms that are used, such as microbes and germs, and the terminology can cause some confusion. The term microbe or microorganism will be used here to include bacteria, fungi (yeasts and moulds), protozoa, and viruses. We will focus on the characteristics of these organisms, and look at how they cause disease. Some common infectious poultry diseases will be discussed to illustrate the main categories of microorganisms. This chapter is not intended to be an exhaustive list or in-depth discussion of specific poultry diseases. There are many excellent poultry references that can provide detailed information on all of the infectious diseases of poultry.

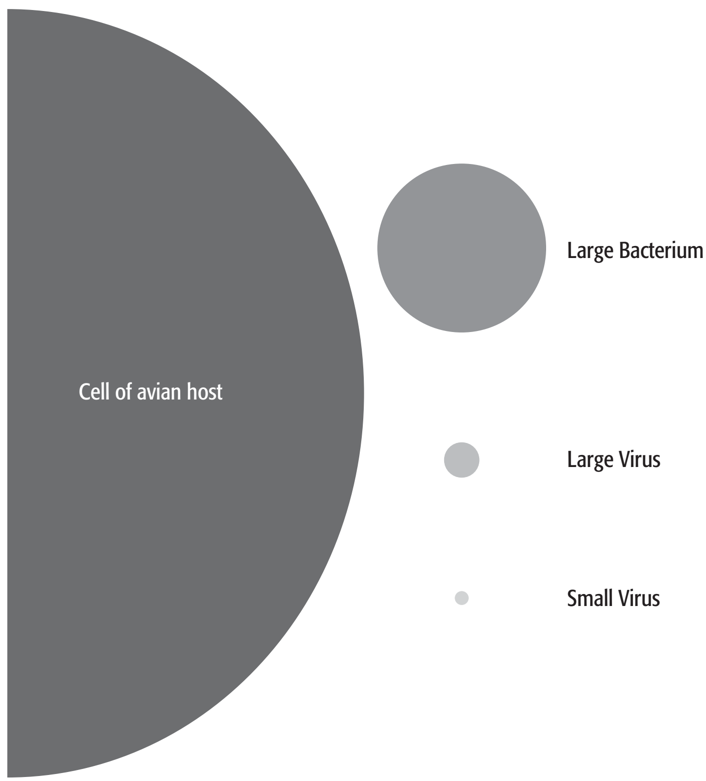
In this chapter, the focus will be on disease-producing microorganisms, particularly those important in poultry production. Some multicellular parasitic organisms including worms and surface parasites, which are not micro organisms, will also be discussed briefly since these parasites affect poultry and require treatment and control. Knowing the size and structure of bacteria, viruses and other microorganisms is important because these factors influence how we diagnose, treat, and prevent the diseases they cause, and how we can clean or disinfect the environment they inhabit.

Size of Microorganisms

Microorganisms are small – microscopic, as the name suggests. Many bacteria are about 1/1000 of a millimeter in length, so 1000 bacteria lined up end to end would only cover one tiny tick on a ruler. Another analogy that has been used is that if a single cell in the body were magnified to the size of a human, a common large bacterium would be about the size of a football. A large variety of virus would be about the size of an AA battery, and a small virus would be about the size of an aspirin tablet.

Most bacteria can be seen with a microscope, while viruses are smaller than a standard microscope can detect. Protozoan parasites also vary in size. Some are smaller than the cells of a host, and may invade inside a cell to infect it. Other protozoan parasites are much bigger than cells, and typically attach to the outside surface of a cell or a group of cells.

Figure 1
Size of microorganisms compared to host cells. The size of a cell is represented by the circle on the left. Common bacteria are small enough that many average-sized bacteria would fit inside a single cell. Viruses are much smaller than bacteria.



Microorganism Structure and Reproduction

Bacteria

Bacteria are simple, single-celled organisms, and represent what most people think of when they consider germs or microorganisms in general. Bacteria have cell walls and their genetic material (DNA) is not enclosed in a nucleus as it would be in the cells of higher organisms. Different types of bacteria take a number of shapes, including bacillus (rod-like) coccus (round or berry-like) or spiral (corkscrew or curved). Individual bacteria may form groups into pairs, chains, clusters, or other structures. The shape and group type are both used to classify bacteria.

Bacteria normally reproduce by fission, splitting into two new organisms (Fig. 2). This process often takes as one to three hours, while in some it may be less than an hour and in other species of bacteria it can take more than 24 hours. The time for the reproduction process can also vary depending on environmental conditions such as temperature. When a bacterium such as *E. coli* reproduces by doubling every 20 minutes, a single organism can increase to over a million organisms in only seven hours. In ten hours the population would be a billion.

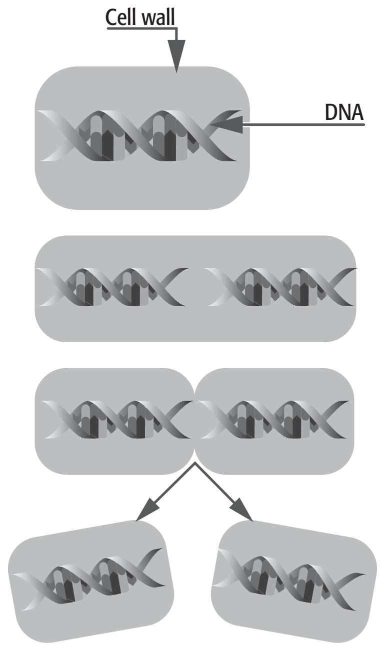
It is easy to see why a bacterial infection can overwhelm a host quickly if immunity and other factors do not prevent it. Some bacteria reproduce by processes such as budding, where a new small outgrowth of the cell wall enlarges and then separates. Other bacteria form into long filaments, and reproduce by producing chains of spores at the tips of the filaments. These spores are often highly resistant to environmental conditions that would normally kill other bacteria, such as drying, heat, sunlight, and even disinfectants.

Antibiotics typically attack one of the stages involved in the reproductive or metabolic processes. Different antibiotics target different processes or structures, so, for example, the production of cell walls may be blocked, or protein production is inhibited, or the replication of DNA is affected, or production of essential metabolites is prevented.

Fungi

Fungi (singular: fungus) comprise a large group that includes mushrooms, moulds, and yeasts. Their cells have genetic material enclosed in a nucleus by a membrane. Fungi can be single-celled, or form large multicellular structures such as mushrooms that look somewhat like plants. Yeasts are solitary single-celled organisms much larger than bacteria. Moulds form multi-celled colonies with branching, intertwining filaments that create the fuzzy-looking structures we recognize on old bread or fruit. Fungi reproduce both asexually by

Figure 2
Bacterial reproduction by fission. (Adapted from Figure 6.11 in Tortora, Funk and Case, *Introduction to Microbiology*, page 169).



budding, or sexually by forming spores that result from the fusion of two nuclei of opposite strains. Anti-fungal drugs with mechanisms of action similar to antibiotics are used in humans and some animals, but typically are not used in poultry due to common adverse effects including toxicity and food residue concerns.

Protozoa

Protozoa are single-celled organisms that have their DNA enclosed in a membrane. They often have hair-like projections or other means of movement. This group also includes amoebas that move by using extensions of their cell wall and internal structure called pseudopods or false feet. The protozoa of interest in this chapter are those that are parasitic and take their nutrients from their host's living cells.

The reproduction of protozoa may be simple asexual budding or splitting, or sexual either by a straightforward exchange of DNA or in a manner similar to fertilization with sperm and egg. Some protozoa, including coccidia in poultry, have a very complex cycle of reproduction involving both sexual and asexual phases. In some parasites such as avian malaria, these stages may occur in different hosts.

Drugs are available for treatment of many protozoan diseases, but the parasites often develop resistance to the medications, so medications must be alternated or rotated, and new drugs must be continually developed and introduced.

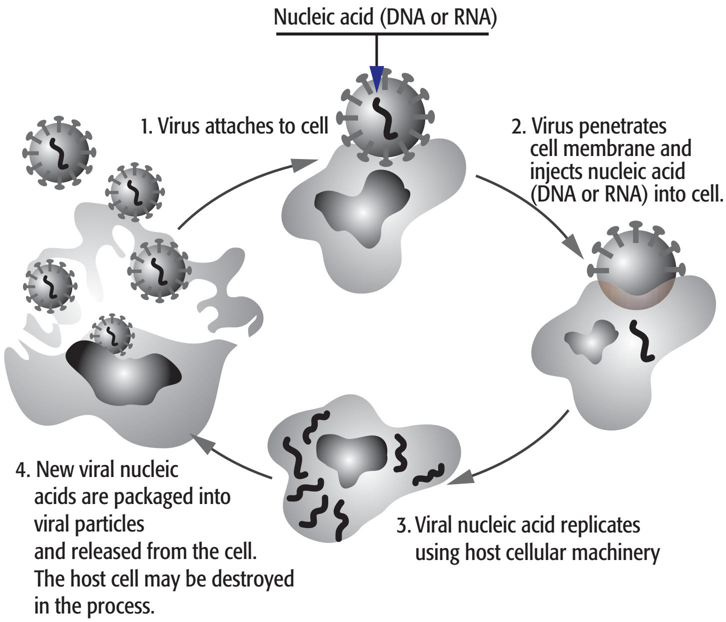


Figure 3
Viral Replication. The virus attaches to the cell, loses its coat if it has one, penetrates the cell and injects its DNA or RNA. It then uses the host cell's systems to create new viral nucleic acid, package the nucleic acid with new proteins to make virus particles, and then the new viruses are released from the cell.
Source: Encarta (http://encarta.msn.com/media_461520267/Viral_Replication.html)

Viruses

Although bacteria represent the classic idea of germs, viruses have recently been in the news much more, with emerging diseases such as Avian Influenza and West Nile Virus becoming understood as threats to humans and domestic livestock. Viruses are different from the other infectious organisms discussed here because they are essentially a package of non-living genetic material, either DNA or RNA. Viruses have to enter a host cell to reproduce. Viruses can be of many shapes, including round, polyhedral, square, spiral or rod-shaped. The genetic material is covered by a protein coat, and in some types of virus the whole structure is further covered by an envelope of protein which may have surface spikes.

To reproduce, the virus must attach to the surface, lose its coat and then enter a living host cell (Fig. 3). It must then take over the cell's genetic machinery to cause the host to produce more viral genetic material and protein and assemble new virus organisms. The new virus particles are then released from the cell. Some types of viruses may remain in the cell for some time before becoming activated, often when immunity in the host is suppressed.

Because viruses are so different in structure and in their method of reproduction inside host cells, antibiotics that are used against bacteria are not effective against them. Treatment in the case of most viruses in poultry is not practical, so efforts are focused on prevention. Few anti-viral drugs are approved, and against only very few diseases, mostly in humans. The structure of viruses also makes many of them much more resistant to disinfectants than other microorganisms are. Preventive measures include vaccination of birds to induce immunity against the virus and implementation of biosecurity measures to reduce the chance of exposure to viruses.

Biofilms

It is worthwhile to briefly discuss biofilms, which are communities of microorganisms that are attached to a solid surface. The organisms that make up a biofilm can be of a single type or of multiple species of bacteria and sometimes fungi, in a mucous or slimy matrix with protein. These mats of cells can become many layers thick, and the bacteria and fungi in them are protected from detergents and disinfectants by the matrix surrounding them.

In agricultural settings, biofilms have been associated with persistent contamination of drinkers, water lines, feeders, and other barn equipment, and of equipment in hatcheries. Biofilms may also be found on wet, smooth surfaces in clean environments, like stainless steel table tops in food preparation areas.

The likelihood of biofilms being present makes proper cleaning and disinfection of equipment and barns a critical step. An improperly removed biofilm can harbour bacteria that may continue to be involved in a cycle of infection and reinfection.

Multicellular Parasites

A number of much larger, multi-celled parasite organisms also infect poultry. While they are not germs or microorganisms, the group that includes endoparasites such as intestinal worms and external or ectoparasites such as lice or mites must be mentioned in this chapter because various pharmaceutical products are used to control them. Though the antiparasitic products are not antibiotics in the traditional sense of the word, the issues, problems and concerns that arise with these products bear many similarities to the issues that arise with products used for bacterial infections.

Endoparasites include roundworms, tapeworms, and flukes. These worm parasites are sometimes known as helminths. Roundworms, also known as nematodes, are the most numerous and the most problematic group of internal parasites. They can infest large numbers of birds and cause considerable illness and death in the flock. Tapeworms may infect large numbers of birds raised outdoors, while flukes are largely a problem in ducks and geese that have access to ponds since they require a snail intermediate host.

Ectoparasites which affect the skin and feathers of their avian hosts, include lice, mites, and fleas. While the production of modern poultry flocks indoors has changed the types of parasites found, they can be serious and persistent problems on poultry farms. Because they can be a troublesome pest, these parasites often require control measures such as various insecticides which are applied to the birds themselves as well as the litter, nests, walls, and roosting areas. Ectoparasites can easily be transported from farm to farm on equipment, egg flats, or on supplies, equipment or tools of repair and service personnel.

Effects of Microorganisms

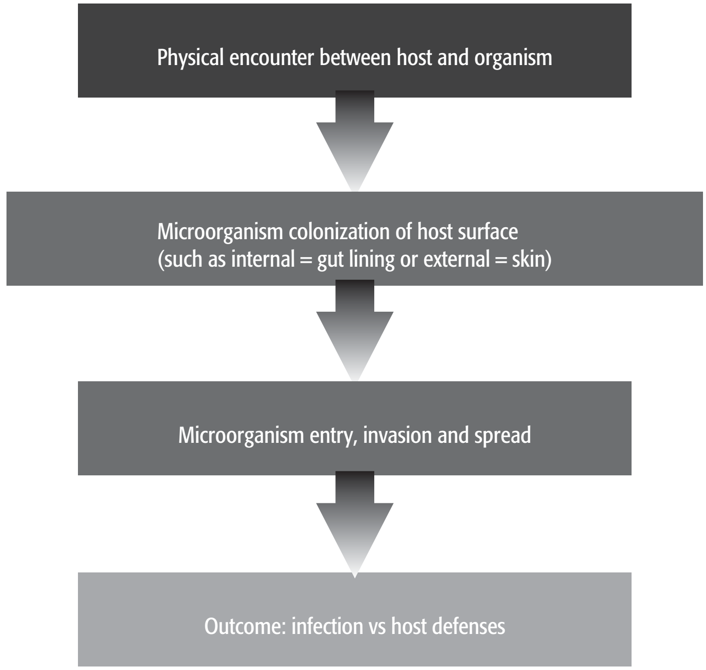
The ability of a microorganism to produce disease in a susceptible individual is known as pathogenicity. Some bacterial organisms always cause disease and are obligate pathogens. Others are more opportunistic and may exist in the environment, on the skin, or elsewhere in the host, and cause disease only when the conditions in the host permit invasion, such as reduced immunity or other pre-existing illness.

Virulence is the relative ability of a microorganism to invade, reproduce, and cause damage in a host. Often it is measured by the number of organisms that it takes to cause infection. A highly virulent organism may need only a few present to infect, and a less virulent bacterium may have to be present in thousands or millions to take hold. But in a somewhat confusing alternative use of the term, we also use virulence in relation to severity of disease. So we commonly say that a virus that causes severe disease that often leads to death is highly virulent.

Virulence is related to a number of abilities that the microorganism has to enter, invade and reproduce (Fig. 4). The first is the ability to resist engulfment or phagocytosis by the host's immune cells. Some bacteria have the ability to produce substances that are toxic to white blood cells and others produce chemicals that prevent the attraction of other defense cells. Another requirement of many bacteria, fungi or viruses is to attach to the surface of host cells prior to infection. Thus, pathogens of this type have surface attachment structures that enable this process.

Pathogens must reproduce after attachment, and some have the ability to even live inside host defender white cells (immune cells), and reproduce inside the immune cell. Much of the disease related to microbial infection is related to the secretion of toxins, either ones

Figure 4
General stages of microbial-host interactions.
Adapted from: Bailey and Scott's *Diagnostic Microbiology*, Figure 3-1, p. 27.



secreted from the bacterial cell itself (exotoxins), or ones that make up part of the cell wall of the bacterium (endotoxins) and are released when the organism is attacked and broken down by the host immune cells. Some types of toxins aid the microorganism in breaking down the host cells to enable spread of the infection into new tissues.

Viruses have a number of cytopathic (cell-damaging or killing) effects that are unique. Cell lysis (breakdown) occurs when the virus kills the cell as the virus particles are released following the takeover of the cell's machinery to produce new virus. This cell death obviously causes immediate damage to the host organ or tissue affected. Some viruses cause the host cells to produce surface markers that attract a host immune response against its own infected cells. Other viruses induce transformation or conversion of host cells into cancer cells. An example of this type of infection in poultry is Marek's Disease.

The pathogenic effects of fungal infections, known as mycosis, are related both to the invasion of tissues by the branching filamentous growth, and through release of toxins they produce. Much of the tissue damage related to mycotic infections is caused by the effect of the immune system trying to attack the fungus in the body.

Protozoa cause damage to host cells through both their presence and their waste products. Some invade host cells, reproduce within them, and cause them to rupture to release the new parasites. Others cause damage by attaching to host cells and ingesting cell fluids. In many cases the symptoms of the disease in the host are related to the host's immune response to the parasite.

The endoparasitic organisms such as worms have varying effects, depending on the site of infection, the number of worms present, and their means of reproduction and movement within the body. Parasites may cause loss of blood or tissue fluid due to feeding activity, local immune responses, or physical damage such as scar tissue formation in the organ or tissue. Many parasitic worms move from one part of the host's body to another during development; this migration can cause damage to the tissues it moves through. In animals with higher numbers of parasites the damage they cause is typically much more severe.

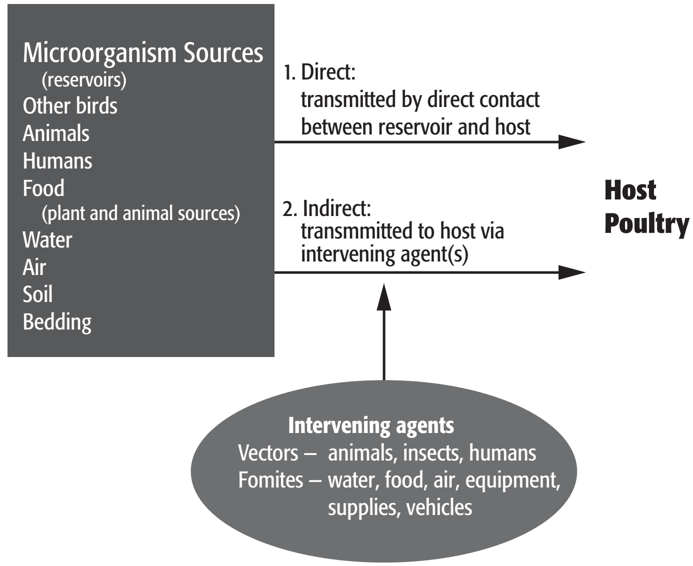
Transmission of Disease

Poultry are inevitably exposed to microorganisms because they are found throughout the environment. The location in which the disease-causing organisms may be found is referred to as the reservoir (Fig. 5). Reservoirs of disease in poultry may include other poultry, other farm livestock, wild birds or animals, food products, water, the air, soil or bedding or even humans. Viruses such as Newcastle Disease and Infectious Laryngotrachitis may be carried as far as 5 km by winds. Alternatively, transmission between poultry may be transovarial – from hen to chick in the egg as it is fertilized and formed. This is also referred to as vertical transmission. Mycoplasmosis, pullorum disease, and Inclusion Body Hepatitis can be transmitted this way. Transmission may also be on the egg surface, from the hen's vent (cloaca) or from nest box litter, such as with *E. coli* and *Salmonella*. Infections carried on the surface of the egg may also be transmitted into the brooding and rearing facility.

Another means by which the infection gets from the source to the host may be by direct contact. Wild birds or rodents infected with bacteria such as *Salmonella* may enter a barn and shed bacteria that may infect the poultry housed inside. Direct contact between susceptible and infected, shedding reservoir birds can occur in multi-age units and commonly spreads diseases like salmonellosis, coryza, mycoplasmosis, infectious laryngotrachitis, and pasteurellosis.

Water or food contaminated with bacteria can also be a direct means of transmission. Direct transmission between birds is referred to as "horizontal" transmission. Alternatively, the contact could be indirect, with the infectious microorganism transmitted via an intervening agent. These can either be vectors, which are living animals, insects or birds

Figure 5
Summary of microbial reservoirs and modes of transmission to poultry
Adapted from: Bailey and Scott's *Diagnostic Microbiology*, Figure 3-2, p. 27.



that carry the disease from a reservoir to the host, or fomites, which are non-living carriers that move the organism to the host. Avian Influenza is known to be transmitted between poultry flocks by the movement of wild waterfowl as biological vectors. Insects such as beetles and house flies can act as vectors of diseases such as salmonellosis, coccidiosis, and campylobacter. Fomites which would commonly be a concern in poultry operations are the equipment or vehicles used for delivery of chicks, or to load grown birds.

Zoonotic Disease Transmission

Humans can become infected with a number of diseases of poultry. The term zoonotic is used to describe a disease of animals or birds that infects, or is shared with humans. The most serious concern is for people who are very young, elderly, or those with an immune system that is weakened by illness, an immune-suppressing treatment of a disease, or an organ transplant. However, serious cases of farm workers becoming infected with poultry diseases have been well documented. Often the infection does not cause severe symptoms in the birds, and in some cases no bird illness is seen at all. The organisms commonly involved in zoonotic infections are the serious food-borne infections like *Salmonella*, and *Campylobacter*.

All farm workers should be aware of the possibility of contracting a zoonosis during work with livestock and poultry, and take routine precautions such as proper hand washing. Farm staff who have an immune-suppressing illness or who have family members with a condition of this sort should consult both their veterinarian and their family physician to discuss safe work practices and precautions to avoid zoonoses.

Important Infectious Diseases of Poultry

There are far too many infectious diseases of poultry to allow a full discussion of all of them in this chapter. Many good references are available that provide information on diagnosis, treatment and prevention. It is useful here to list and briefly describe a number of important diseases that are examples of bacterial, fungal, viral, protozoan and endo- and ectoparasite infections of poultry in western Canada. This is not a comprehensive list. Readers should consult other references for more detailed information on these and other infectious diseases. Diseases are listed roughly alphabetically by their most commonly used name.

Bacterial Diseases

Botulism

Botulism is caused by the spore-forming bacterium *Clostridium botulinum.* The classic effects, which include paralysis are a result of an exotoxin produced by the bacterium, rather than by an infection itself. This disease may affect poultry, wild waterfowl, livestock and humans. Because the bacterium forms spores which persist in the environment in soils and are resistant to many disinfectants, it can be difficult to eliminate. The bacteria are most likely to reproduce and produce toxin in conditions that provide a moist, warm environment or the absence of oxygen, such as in decaying plant material, poorly managed compost, or stagnant pools. Disease occurs in birds when the toxin is ingested in contaminated water or by consuming insects contaminated with the toxin.

Erysipelas

Erysipelas is a disease caused by a bacterium, *Erysipelothrix rhusiopathiae.* Among poultry, it most commonly affects turkeys, but it also causes swine erysipelas and is a known zoonotic disease. A number of reports indicate that Erysipelas can occur in birds that are exposed to pig manure or are housed in improperly decontaminated former swine housing areas. It seems to affect toms more frequently than hen turkeys, possibly because it can be introduced through skin wounds caused by fighting. But it can also be transmitted to hens, possibly through insemination techniques. It is most common in birds several months old. Although this bacterium does not form spores, it is fairly resistant to environmental extremes. It can be inactivated by sufficient contact time with proper concentrations of disinfectant.

E. coli

Colibacillosis**,** caused by *Escherichia coli* (*E. coli*) includes a range of syndromes, from severe rapidly fatal infections to much more chronic infections with low mortality. Some strains of *E. coli* are normal non-disease-producing inhabitants of the gastrointestinal tract, while other strains are very virulent. Navel infections, acute septicemia (blood infection) in young turkeys, and air sacculitis in young chickens often result from infection with this bacteria. Typically, young growing birds are more likely to be affected. Infections usually enter via the respiratory system or the gastrointestinal system and may stay in those locations or quickly move past these into the blood, causing an infection that is rapidly fatal. Treatment is frequently ineffective. Prevention includes management practices to reduce stress and improve air quality, humidity and temperature stability. Efforts to improve sanitation are also commonly introduced.

Omphalitis is an infection of the unhealed navel and usually the yolk sac in the abdomen of the young chick. The common cause is contamination of the egg with disease-causing *E. coli* from manure. This may occur due to introduction of bacteria into the hen during artificial or natural insemination, leading to infection in reproductive organs. Other potential causes of the bacterial contamination of eggs include eggs laid on the litter and eggs which are poorly washed. Modern incubators have ideal conditions for not only chick embryo development but also bacterial development on the shell, which eventually can penetrate the shell, continuing to grow using the eggs' contents for nutrition, and eventually the egg explodes and contaminates the entire content of the machine. Bacteria can then be shed directly into the egg during formation. Some embryos die before hatching. Others hatch but have persistent infection leading to swollen abdomen, and wet, dirty navel areas. Chicks with mild infections may show only poor growth and no other obvious symptoms.

Fowl Cholera

Fowl Cholera (Pasteurellosis) is caused by the bacterium *Pasteurella multocida*, which is a very common pathogen in domestic fowl, waterfowl, wild birds, livestock, rodents and even pets. This bacterium is not related to the cause of cholera in humans. *Pasteurella multocida* has been known to be shed by pigeons and sparrows that gain entry to barns, and to be tracked on shoes or other fomites. Fowl Cholera causes symptoms, typically in young birds, including loss of appetite, lameness from joint infection, difficulty breathing, and diarrhea. In acute forms, no symptoms may even be observed before birds are found dead. Treatment can control losses, and vaccines are available, but biosecurity measures are recommended to prevent the disease. These include control of vermin, all-in/all-out management with sufficient down time, proper cleaning and disinfection, and prompt disposal of dead birds. Mixing of birds from different flocks or of different ages is dangerous since non-symptomatic reservoir birds can spread the disease.

Fowl Typhoid and Pullorum Disease

Fowl Typhoid is a disease caused by *Salmonella gallinarum*, and is unrelated to typhoid in humans. It affects most domestic and wild fowl, waterfowl, game birds, and pigeons. Pullorum Disease is caused by a closely related organism, *Salmonella pullorum.* Both diseases can be transmitted vertically through the egg by transovarian infection. These infections are quite rare in North America but occur worldwide. Typically Pullorum infection causes severe symptoms in young chicks and poults, while Fowl Typhoid affects older birds, but the opposite can occur.

Therefore, control must focus on starting with disease-free flocks. When breaks in biosecurity occur and disease is introduced, use of antibiotics can reduce death and disease.

Salmonella Infections Including Septicemia

Infections with Salmonella organisms such as *S. enteriditis* in very young birds often result from contamination of eggs with organisms that cause a severe, acute blood infection resulting in rapid death before other symptoms occur. In older birds, infections may result in poor appetite, diarrhea, huddling and poor egg production. Fertile eggs produced by infected chickens may have surface bacterial contamination that perpetuates the infection cycle. Outside sources may include contaminated feeds, insect vectors and mice. Even people have been implicated in infecting birds when proper sewage handling does not occur. This is an example of a zoonosis where the human is the source of an animal infection.

Infectious Coryza

Infectious Coryza is an acute respiratory disease of chickens, caused by *Haemophilus paragallinarum*. It tends to be more severe in mature birds, and results in poor growth and reduced egg production. It affects primarily the nasal passages and trachea and causes facial swelling, mucous discharge, and swollen wattles. Birds may breathe with their mouths open. A large percentage of a flock may be affected, but mortality is generally low. Chronically infected or healthy carrier birds are often the reservoir of this disease and it can spread from group to group in multi-age or multi-barn flocks. Practices such as buying chicks or spiking flocks with males from sources of unknown health status are risky. It is not transmitted in the egg.

When a flock is infected, depopulation is necessary, followed by cleaning, disinfection and allowing the barn to remain vacant for several weeks. Vaccines are available, and treatment is possible with antibiotics under the supervision of a veterinarian since resistance to antibiotics can occur in this bacterium and sensitivity testing is often advised.

Mycoplasma

Mycoplasma causes a number of important infectious diseases in poultry. These bacteria are unique because they do not have a cell wall as most other bacteria do. This makes them resistant to many common antibiotics whose target is bacterial cell walls. *Mycoplasma gallisepticum* causes chronic respiratory disease in chickens and infectious sinusitis in turkeys. It causes coughing, nasal discharges and respiratory distress, and causes sinus infections in turkeys. It has been reported in some wild birds including ducks and geese. This bacterium does not survive well outside a living host, so most infections are introduced with birds, or on fomites such as dust or feathers. Multi-age flocks may be more prone to the disease. Infection can also be transmitted vertically between generations via the egg. Therefore, control must focus on starting with disease-free flocks. When breaks in biosecurity occur and disease is introduced, use of antibiotics can reduce death and disease. Vaccination is also an option in some situations.

Another type of *Mycoplasma* is specific to turkeys. Egg-borne infections of *M. meleagridis* result in decreased hatch due to embryonic death, and in chicks that survive the hatch, air-sac infections, skeletal abnormalities, and poor growth are common. Eradication programs have focused on testing and slaughter of infected flocks, and on antibiotic dipping of eggs to reduce incidence in outbreak situations.

Mycoplasma synoviae is another form of *Mycoplasma* that causes upper respiratory infection and can then spread to other systems, resulting in joint infections. Chickens affected may have pale combs, lameness and slow growth. Swollen joints become evident, and respiratory signs may be observed. Breast blisters, enlarged liver and spleen are also observed. Similar signs occur in turkeys. With this type of *Mycoplasma*, as with the others, prevention through sourcing from disease-free flocks is much more effective than treatment with antibiotics or other types of prevention such as vaccination.

Necrotic Enteritis

Necrotic enteritis is commonly referred to as rot gut, or crud. It is caused by a spore-forming bacterium called *Clostridium perfringens.* As in botulism, which is caused by a related bacterium, the effects of this microbe are due to the production of toxins. And like botulism, the source of the infection may be soil, contaminated feed or litter, and manure. It probably occurs in small numbers in the gut of normal poultry. However in certain conditions, it grows and reproduces rapidly and the toxins produced cause severe gut damage. The conditions that encourage necrotic enteritis may include certain types of feed and damage to the gut from other infections such as coccidia, or parasitic worms.

Affected birds quickly show severe depression, diarrhea, ruffled feathers, and birds may be simply found dead. In outbreak situations, treatment with antibiotics in the water may be effective. Prevention focuses on reducing the exposure to dirt floors that may be contaminated, and avoiding some high grain feeds or increasing fibre.

Many physicians and poultry veterinarians recommend that poultry workers receive annual human flu vaccines to reduce the rare possibility of contracting a human flu virus and exposing it to an avian flu strain.

Viral Diseases

Avian Influenza

Much information is available regarding avian influenza (AI), so readers who want in-depth information should consult one of many good references. Influenza is caused by a virus that has forms that affect humans, horses, pigs and various bird species. Avian influenza was historically initially recognized in its Highly Pathogenic (HP) form and was known as Fowl Plague, Fowl Pest, or other more local names. Low pathogenic avian influenza is also recognized and is probably more common than the highly pathogenic form of influenza. Some large outbreaks of HP-AI in North America have occurred over the years, but the recent outbreaks of HP-AI in Asia and Europe and of less pathogenic forms in British Columbia and Saskatchewan have focused attention on this disease, mainly due to the potential human public health significance.

Generally, influenza viruses inhabit host species, and transmission occurs most easily with other hosts of the same species. But influenza has also demonstrated the ability to cross to other species. Migratory waterfowl are suspected of being the main culprits in transmitting the disease that has recently spread across Asia. Over 300 human cases of HP-AI have occurred between 2003 and 2007, mostly in Asia and a few African and Eastern European nations, with approximately 200 deaths. In almost all cases, the infection of humans with HP-AI was due to contact with poultry and very few of these human cases were contracted from other humans. But the big public health concern is that if the infection occurred at the same time as the person had a human influenza virus, the two viruses could recombine to form a highly pathogenic virus that would readily transmit between humans.

It is believed that the major pandemics of human influenza in the past century originated from birds, including the Spanish Flu in 1918-19, the Asian Flu 1957-58 and the Hong Kong Flu in 1969-69. Influenza viruses are classified by two surface proteins Hemaggutinin (H) and Neuraminidase (N), each of which has numerous types designated by number. The highly pathogenic strain that has been of recent concern in Asia is designated H5N1.

Avian influenza viruses in poultry can cause very mild symptoms, including coughing, sneezing, rattling breathing, decreased egg production, huddling, ruffled feathers and other non-specific signs. Highly pathogenic strains can cause sudden severe illness and symptoms including tremors, inability to stand, or progress quickly to death with no early symptoms. It can spread very quickly through a flock. Prevention includes biosecurity measures to avoid any contact with wild waterfowl, including controlling movement and cleaning of equipment, clothing, and manure management. Avoiding contact with pigs is advised, due to the concern about virus mutation if pigs are also infected with swine influenza. Many physicians and poultry veterinarians recommend that poultry workers receive annual human flu vaccines to reduce the rare possibility of contracting a human flu virus and exposing it to an avian flu strain.

Fowl Pox

Fowl Pox is a true Pox virus, (unlike human "chicken pox" which is a herpes virus related to cold sores in humans). Fowl Pox does not affect mammals, but is a disease of commercial poultry as well as pet birds and wild birds. It causes wart-like nodules on the skin of the comb, wattles, eyelids or other exposed skin areas. In the wet form, it can cause yellow flaky-appearing cankers on the inside of the mouth, trachea and esophagus. It can be severe and causes trouble breathing, drinking and eating. It does not usually cause death, but can severely set back laying and growth. The virus can be stable in the environment, and scabs from infected birds can fall into the litter and contain infective virus particles for a long time. Vaccines are available for prevention, but there is no treatment for birds infected with the virus.

Inclusion Body Hepatitis

Inclusion Body Hepatitis (IBH) is caused by an adenovirus, which is a type of virus particularly resistant to degradation in the environment. IBH has been a problem in recent years in some broiler barns in western Canada. It tends to be present in most barns and causes low level losses of between 2 and 4 percent, most often at about 21 days of age. Sick birds crouch, are ruffled, and mostly recover within 48 hours though a few die. In occasional cases it causes high death rates in birds between one and two weeks of age, and these outbreaks are usually due to vertical transmission through the egg from breeder flocks.

When outbreaks occur between two and four weeks of age, the transmission is usually bird-to-bird, or from barn-to-bird. Sometimes IBH is secondary to a problem like chilling, or follows another infection such as infectious bursal disease. There is no commercially available vaccine in Canada so autogenous vaccines have been made for breeder flocks but not for broilers. Prevention of other predisposing problems such as ventilation failure and other preventable infectious diseases is therefore important.

Infectious Bronchitis

Infectious Bronchitis is a highly contagious viral disease that affects the respiratory tract. The disease is characterized by wheezing or rattling breath sounds, coughing, sneezing, poor weight gain, loss of feed efficiency, and predisposition to other infections such as air sacculitis. The disease spreads very rapidly and standard sanitation measures seem to do little to prevent spread. It can be transmitted through the air, on clothing, equipment, poultry crates, or on vehicles. In young broiler flocks, mortality may be high, while in older birds, they may not die, but feed efficiency and growth drop significantly.

Laying hens may stop laying entirely, and then partially recover and lay small soft-shelled eggs. They may not ever resume economical laying. In areas where Infectious Bronchitis is common, vaccines may be used to decrease the risk of outbreaks, but the vaccines may cause mild symptoms of the disease and may reduce productivity in birds after vaccination.

Vaccine use must be considered carefully and on a risk-assessment basis. Treatment of infected birds is not possible, though increasing barn temperature may be of some help.

Infectious Bursal Disease

Infectious Bursal Disease is another acute, highly contagious disease of young chickens. It targets immunity-producing cells in an outpouching (bursa) of the cloaca or vent. The virus is very resistant to environmental degradation, and can last for months in a barn after infected birds are removed. It is resistant to heat and disinfectants, so it is hard to eliminate from a contaminated barn. Infectious virus has been found in mealworms collected from the litter in barns several weeks after the disease occurred, so insects may play a vector role in transmission.

The virus is easily spread by any means that carries contaminated water, feed or bird droppings from one barn to another. The incubation period of the virus is very short, and up to 100% of exposed birds will die within five to seven days in the most severely affected flocks. Prior to death, they may develop diarrhea, trembling, ruffled feathers, and dehydration.

No treatment is effective. Prevention focuses on immunization. Having healthy, vaccinated breeder flocks helps to ensure that chicks have immunity passed to them in the egg. Vaccination after hatching is often employed to protect broilers. Farmers should develop an individual plan in consultation with their veterinarian, based on the needs and conditions specific to their farm.

Infectious Laryngotracheitis

Infectious Laryngotrachitis (ILT) is caused by a member of the herpes virus family that affects chickens. It is highly contagious, and causes an acute respiratory disease with nasal discharge, coughing, gasping and open-mouthed breathing in severe cases. Loss of body condition and decreased egg production occur. Up to 100% of a flock may be affected, and as many as 20% or more may die, with the remainder recovering in about 2 weeks. The virus may persist in chickens and re-appear and begin shedding when the birds are stressed by relocation or onset of laying. It can become an ongoing problem in backyard or fancier flocks. Transmission on contaminated equipment and litter is common, but egg transmission is not known to occur.

No treatment is effective, and although vaccines have been used successfully, depopulation is commonly employed to control spread. In Alberta the disease must be reported to the Chief Provincial Veterinarian under the Livestock Diseases Act. The virus is easily inactivated by cleaning agents and disinfectants, so proper cleanup of contaminated carcasses, feathers, litter, and feed, and effective decontamination will prevent transmission to subsequent flocks.

Lymphoid Leucosis

Lymphoid Leucosis is the most common of a group of viral diseases that causes transmissible tumours in chickens. It tends to affect adult chickens, but forms occur in turkeys and game birds. It does not affect humans. The virus can be transmitted between chickens by feces or vertically in eggs, and by blood-sucking insects or even during injections for vaccination against other diseases. Tumours produced by this virus are typically found in the liver and spleen of affected birds. The virus does not survive long outside the bird and is easily inactivated by disinfectants.

Treatment is not possible, and no commercial vaccine is currently available. Prevention focuses on eradication of the disease from primary breeding flocks to prevent vertical transmission from hen to chick.

Adherence to good biosecurity procedures at all times is vital to prevent spread of diseases such as Newcastle Disease if it ever should occur, since it could potentially be carried far and wide prior to diagnosis and intervention.

Marek's Disease

Marek's Disease is another viral disease that causes transmissible tumours, primarily of nervous tissue but also of other organs. It is caused by a very different virus than the one that produces Lymphoid Leucosis, but it has a number of similarities in its effects. The Marek's Disease virus is a herpes virus.

The symptoms of the disease vary widely, and there are a number of syndromes associated with this infection. The signs generally relate to damage to nerves, so they may include problems with walking, breathing, and vision. The symptoms most obviously recognizable may be weight loss, paleness, diarrhea or other signs related to inability to feed or drink properly. Marek's Disease virus can be transmitted both by direct contact between chickens and by indirect contact. The virus concentrates in feather follicles and is shed in feathers and their dust (dander). The dust can travel throughout barns on air currents, and the virus can survive for a long time in the environment, so proper cleanup is difficult.

Control and prevention strategies depend on both biosecurity and vaccination. Treatment of infected birds is not effective, but vaccines are successfully used to control Merek's Disease, and genetic resistance in certain strains of poultry is useful in reducing susceptibility.

Newcastle Disease

Newcastle Disease is a widely variable virus with strains that can cause severe diseases as well as others that are much milder. The most severe form is known as Exotic Newcastle Disease (END) and while there have been no cases of this virus in Canadian poultry since the early 1970s, the disease does occur in wild birds including cormorants. END is a Federally reportable disease under the Health of Animals Act, so any suspected cases must be reported to the Canadian Food Inspection Agency.

This virus causes respiratory symptoms such as difficulty breathing, nasal discharge, gasping or coughing, intestinal symptoms including diarrhea, and nervous symptoms of drooping wings, circling or paralysis. Drops in egg production or increases in thin-shelled eggs may be early signs. Sudden death can occur. Transmission occurs by contact with diseased birds or their manure, feathers or discharges. It can be spread by workers on equipment or vehicles.

In Canada, the control program involves eradication of infections via depopulation. Adherence to good biosecurity procedures at all times is vital to prevent spread of diseases such as this if it ever should occur, since it could potentially be carried far and wide prior to diagnosis and intervention.

Fungal Diseases

Aspergillosis

Aspergillosis is caused by a fungus (mould) called *Aspergillus,* and occasionally other mould species. It can affect most animals, including poultry, and is found on rotting wood, vegetation, litter or feed. The mould can be inhaled by poultry from these sources, and if exposure is great enough, the mould can begin to grow in the airsacs, lungs and trachea of the bird. It causes respiratory difficulty, loss of appetite and death if it is widespread. It is not contagious between birds but can occur in “outbreaks” when a flock is exposed to extremely mouldy litter or feed.

There is no treatment for affected birds, so prevention must focus on avoiding mouldy feed and litter, and cleaning barn areas to avoid conditions that promote mould growth.

Candidiasis

Candidiasis is caused by a yeast form of fungus called *Candida albicans*. It is sometimes called thrush, or Crop Mycosis. *Candida* is a common and normally non-disease causing organism that lives on the skin and in the gut. Infection with this yeast is more common after prolonged or inappropriate antibiotic use has caused an upset of the normal bacteria in the gut. Most poultry and livestock can also be infected from poorly cleaned water troughs or on mouldy corn-based feeds. In chickens and turkeys, this organism tends to grow in the crop, stomach (proventriculus) and gizzard, causing white, cheesy lesions.

The disease can be prevented by avoiding conditions that favour *Candida* growth, such as through proper cleaning of drinkers with disinfectant. Treatment of infected birds can be attempted with antifungal agents in the feed or water.

Mycotoxicosis

Mycotoxicosis is itself not truly an infectious disease. It is a disease caused by a toxin produced by a fungus that may be in the feed or water. *Aspergillus*, mentioned above, is one of the many fungi that may produce toxins. Toxins produced by fungi may be extremely toxic to humans, animals and birds. At low levels in poultry feeds these toxins may produce effects that are very non-specific, such as poor growth, reduced egg production or reduced feed conversion. At higher doses, these toxins may cause a wide variety of symptoms, including diarrhea, reproductive changes, convulsions, and death. Hundreds of different toxins produced by moulds have now been identified.

Treatment begins with removing the mouldy feed and replacing it with fresh feed. Prevention depends on eliminating the sources of contact with mouldy feeds, improving feed production and storage practices, regular cleaning of feed bins, and adequate ventilation of poultry housing to reduce humidity.

While most infections are mild and cause only low mortality, the potential for large outbreaks and high mortality forces most producers to routinely use anticoccidial drugs.

Protozoan Parasites

Blackhead

Blackhead is a disease of poultry that affects turkeys, chickens and other poultry. It is caused by a parasite called *Histomonas meleagridis* and is sometimes referred to as Histomoniasis. The parasite invades the cecum, multiplies, enters the blood stream and then invades the liver. Its life cycle is associated with both cecal worms and earthworms as vectors, and therefore contact with poultry yard soil is often a contributing factor.

Chickens seem to be more mildly affected than turkeys, and may act as a reservoir of infection that spreads to turkeys. Affected birds become drowsy, drop their wings, develop yellow feces, and may develop a bluish tint to the skin of the head (hence the name "blackhead"). Birds may have mild symptoms and poor productivity, or can have severe infections and high flock mortality.

Prevention and control focus on reducing the cecal worm parasites that act as vectors, rearing birds indoors to reduce soil contact, and preventive treatment with antiparasitic drugs. Control of coccidia is also known to be an important factor, since the damage to the ceca and spread of *Histomonas* to the liver is much worse when both parasites are present.

Coccidiosis

Coccidiosis is a very common disease that affects poultry worldwide wherever they are raised. It is one of the most costly diseases due to the need for prevention and treatment. It is caused by a number of different species of the genus *Eimeria*. Coccidiosis causes diarrhea, poor growth, and variable levels of mortality. It usually causes more severe disease and higher death rates in younger birds.

Because it has a short life cycle and high reproductive rate, it is particularly important in environments with high populations and exposure to manure, such as in broilers housed on litter with thousands of birds in a barn. It can cause devastating illness and death rates if not controlled. Immunity develops in birds after infection and recovery, but immunity does not provide protection against other species of *Eimeria,* and infection with several species at once is common. Different species of the parasite infest specific sections of the intestines and ceca of affected birds.

While most infections are mild and cause only low mortality, the potential for large outbreaks and high mortality forces most producers to routinely use anticoccidial drugs. Fortunately, birds' immunity to the parasite develops quickly, which limits further infection and makes the infection self-limiting in a flock. Infected chickens may shed oocysts (eggs) of the parasite in their feces for several weeks. The oocysts can be spread mechanically by people, equipment, animals, insects, wild birds, and dust. They may remain viable for long periods but are somewhat susceptible to drying. They are resistant to common disinfectants. Outbreaks tend to be more severe in wet, humid weather than in hot, dry weather.

New barns may be free of infection for the first flock placed, but infection of birds when the parasite is eventually and inevitably introduced often produces a severe outbreak of disease. Birds housed in cages are much less susceptible to infection due to greatly reduced exposure to feces that carry oocysts, unless there is accidental fecal contamination of feed or water.

Endoparasites

In most commercial poultry farms, worm infestation with nematodes (roundworms) or cestodes (tapeworms) is much less significant than in the past when birds were more commonly housed outdoors. Backyard or small farm flocks often have worm problems but commercial flocks can still have persistent problems. Control includes the use of antiparasitic medications and environmental improvements including changing litter, and reduction of common intermediate hosts such as beetles, slugs and snails. Control of worm parasites focuses on removing manure through sanitation measures and use of medications to kill the parasite in affected birds.

Ascarid Worms

Large intestinal worms of the Ascarid family are commonly found in chickens and turkeys around the world. Worms of this type may be found in the manure of affected birds, and can reach 2 to 6 cm in length. In severe infestations, the birds may be droopy, emaciated and have diarrhea, with reduced productivity or even death

Insecticides for control of lice must be applied to the birds themselves, since lice spend their life cycle entirely on the bird.

occurring in some cases. The eggs of this parasite are present in bird manure, and common cleaning agents and disinfectants do not kill the eggs, so contamination of the environment is the main means of exposure of birds.

Capillaria, Heterakis and other Nematodes of the Gastrointestinal Tract

Several species of Nematode worm affect chickens and turkeys, and others may also affect ducks, geese or other birds. *Capillaria* is also known as Thread Worm. *Heterakis* is sometimes referred to as Cecal Worm. The main importance of this worm is not the damage it causes as a parasite, but that it is thought to be a vector for Histomoniasis (Blackhead) parasites. A number of other related species of nematode worms, including *Strongyloides*, *Trichostrongylus*, and *Subulura* have similar life cycles, and affect different parts of the digestive tract. Depending on species, these worms range from 1mm to several cm in length. Symptoms of infection may include emaciation, diarrhea and death in cases where large numbers of worms are present in a bird.

Gapeworms

Gapeworms, *Syngamus tracheae,* are also known as redworms as a result of their reddish colour or tracheal worms, because of their common location in the host bird. They affect the trachea (windpipe) and small air passages in the lungs. The characteristic open-mouth gasping breathing pattern of infected birds is easily recognized. The parasite affects chickens, turkeys and other related birds such as grouse and pheasants as well as geese. Transmission may either be directly from bird to bird, or via an intermediate earthworm or snail host. Young birds are usually most severely affected, and numbers of worms in the trachea may cause suffocation.

Like other nematode worms, prevention of gapeworm focuses on denying birds access to earthworms and to contaminated soil. Backyard or farmyard flocks are more commonly affected than commercial flocks, and can be a source of infection for the commercial birds.

Tapeworms

Tapeworms are small, flattened and segmented worms, whose segments break off and may appear as white “rice grains” in affected birds’ feces. The worms themselves may be very small, or up to several cm in length if found in the intestinal tract of birds. The birds become infected by eating an intermediate host such as a beetle, fly, grasshopper, earthworm or snail. The intermediate host in turn becomes infected by ingesting eggs in bird manure. Control in poultry focuses on preventing birds' access to flies, beetles and other pests that can act as intermediate hosts.

Ectoparasites

External, or ectoparasites of poultry include lice, mites and ticks. These parasites can vary in importance from mild pests that make birds uncomfortable, to those that can cause anemia due to blood sucking, or severe irritation and damage to the skin that devalues the carcass at harvest.

Lice are small insects that feed on the surface of the bird host. All lice in birds are chewing lice and do not suck blood. Lice tend to be host species-specific, meaning that lice of chickens tend not to attack turkeys. Lice eggs (nits) are attached to the feathers of the host bird. The young lice hatch and reinfest the bird, or move to a new bird in close contact. Different types of lice prefer to attach in different locations on the bird's body, and infestations may be so heavy that the small lice on the skin may appear like scales or moisture droplets. In severe infestations, have reduced feed intake, lose weight, and drop egg production. Louse infested chicks can die. Birds should be checked every two weeks throughout the barn to identify infestations early before effects become severe. Insecticides for control of lice must be applied to the birds themselves, since lice spend their life cycle entirely on the bird.

Mites can be either blood-sucking or burrowing parasites. The Northern Fowl Mite is the most common ectoparasite of poultry in most of North America. Because they suck blood, they produce a blackening of feathers, and scabbing and crusting around the birds' vents. Birds lose productivity, and feed conversion becomes poorer. In severe cases, anemia and death can occur. They can be found on the birds during the day or night, and are more dense when barns are cooler in the winter. Mites can be introduced from infected hatcheries, on trucks or crates, on equipment, personnel, or with wild birds.

The Chicken Mite is a common ectoparasite. It is also known as the red mite. It is more common in warm months. These parasites suck blood and can cause anemia and even death in severe cases. Poor productivity, poor feed conversion, and hen refusal to lay in nest boxes in broiler breeder houses can be noticed. The mites can be found in cracks and between slats in barns, or under clumps of manure.

Mites can survive in cracks and crevices in barns in the absence of birds for several weeks. Therefore, insecticides used for control must be used on both the birds themselves and applied to the litter, nests, walls, and roosts. Birds should be monitored frequently to help diagnose infestation early and prevent transmission to other barns, or other farms on personnel, equipment or vehicles. Affected barns should be treated again at cleanout.

A number of other types of mites occur in poultry. Some affect specific parts of the bird's body. Some burrow in the skin; others attack the nasal passages or air sacs internally. Ticks also occur, particularly in back yard or range-housed birds. They can transmit tick-borne infectious diseases in some parts of the world, including parts of North America.

Review Questions

1. What are the main differences between bacteria and viruses?

2. Name two infectious diseases of poultry that can also affect humans.

3. What are the main factors which cause the spread of avian influenza and how can we prevent it from becoming a major problem?

4. Some microorganisms are described as being more virulent than others. What does that mean?

5. Which of the diseases discussed are most significant to Alberta producers?

6 Principles and Methods of Vaccination

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Regardless of the type of poultry you are involved with, a high performing flock is generally the result of the flock being healthy. There are a multitude of factors which help maintain a healthy flock. These factors include: genetics, cleanout and disinfection, downtime, stress, biosecurity, management (appropriate quantity and quality of water, feed, light and air and adequate space allowance) and vaccination programs.

Disease causes decreased performance, either through immunosuppression, with a decreased ability to fend off primary pathogens and secondary bacterial infections, or manifested by a loss of appetite, a reduction in egg production, failure to gain weight for age, and higher mortality and morbidity, all of which affect your bottom line. Reduced performance is not the only cost associated with disease: treatment can be expensive.

Vaccines are very common in the poultry industry: but what exactly are vaccines and how do they work? There are two main types of poultry vaccines – live vaccines and killed or inactivated vaccines.

A live vaccine is, by definition, a non-virulent form of a micro-organism or virus used to elicit an antibody response that will protect the inoculated organism against infection by a virulent form of the micro-organism or virus. Live vaccines do not prevent infection of micro-organisms or viruses but instead attempt to prevent expression of disease caused by these micro-organisms or viruses.

Live vaccines are attenuated which means they are less pathogenic to the target species being vaccinated. Although attenuated live virus vaccines are less virulent, they are still capable of stimulating an immune response in the bird without causing illness. Live vaccines create a short and quick antibody response that is not sustained for long periods of time and therefore does not protect the birds for long periods. However, repeated use of similar live virus vaccines has demonstrated a quicker, higher antibody response that lasts longer after subsequent applications.

Priming is often used to describe the first application of a certain vaccine while boosting refers to the subsequent use of similar vaccines.

A killed or inactivated vaccine is by definition a vaccine containing an agent that has been treated in such a way that it can no longer replicate in the host. Killed vaccines may contain one or more antigens within an adjuvant. An adjuvant is a carrier for the vaccine designed to stimulate the immune responses over longer periods of time with mimimal tissue reaction. The most common adjuvants used today contain water and oil which is effective for both carrying the killed vaccine agent and stimulating the immune cells within the target animal. Killed vaccines are designed to release antigen over extended periods of time and stimulate high levels of antibodies for protection of the birds for longer periods and, as is the case with breeders, to pass on high levels of Maternal Derived Antibodies (MDA) to protect their progeny.

Whether administering live or killed vaccines, do not vaccinate sick or stressed birds. Doing so will cause additional stress on the birds and can potentially compromise the immune system. Immunosuppressed birds have severely decreased capacity to combat infectious agents.

Immune system

There are two types of acquired immune processes: passive immunity and active immunity. Passive immunity is passed from the hen through the yolk to the chick/poult while active immunity is stimulated through direct exposure of the disease agent (vaccination, for example). The goal for both is to stimulate immune cells to fight infection. The acquired immune system activates B cells (humoral immunity) which are derived from the Bursa to produce antibodies. These antibodies are produced when the bird is exposed to either a vaccine or a wild organism. Vaccine-induced immunity provides cells with memory to prevent expression of the disease by the virus in question.

Cell mediated immunity is elicited from another form of cells called T cells. T cells are derived from the thymus and fight off infection by destruction of the invading organism through digestion and acidification. Vaccines induce both cell mediated (T cell) and humoral (B cell) immunity.

Vaccination programs

Due to the ever-increasing farm size and the proximity of one farm to another the disease status in any given location is constantly evolving. More virulent strains of pathogens have and may continue to emerge in all aspects of poultry. Therefore no single vaccination program will be suitable for all farms in all areas. Vaccine recommendations may change

More virulent strains of pathogens have and may continue to emerge in all aspects of poultry. Therefore no single vaccination program will be suitable for all farms in all areas.

as new information regarding bird immunity and disease comes to light.

There are many factors to consider when deciding on a vaccination program. These factors include: the age and type of birds, the diseases present on the farm and in the region, the virulence and serotype of the disease agents, and the age at which the birds are susceptible

If a vaccination program is not designed properly a number of problems can occur. First, maternal antibodies must be taken into consideration when devising a vaccine schedule; otherwise there is the potential for vaccine interference with the MDA. This is the case with IBDV (infectious bursal disease virus). MDAs play an important role in the bird's ability to generate immunity and prevent disease. However, if the MDA are too high (vaccine given too early) you will have a decreased response of the vaccine, effectively rendering the vaccine ineffective.

A vaccine program with improper timing can result in decreased vaccine efficacy. For example the timing between live and killed vaccines is crucial. Too many vaccines administered in a short period of time can cause stress on the bird, bird health issues and/or a reduction in perfomance. The program must have the proper strains of viruses for the particular area.

For most poultry diseases we vaccinate against there are a number of different strains available from a number of vaccine manufacturers. It is important to choose a vaccine that best suits your needs. If you use a vaccine in a way that is not supported by a label claim this can also render the vaccine ineffective and can leave a flock open to that particular disease – for example, using CAV vaccine in the water which is not on the label. There are numerous points of consideration when devising a vaccine program or changing vaccine types or even changing the timing within a program. Consult your veterinarian before making any changes in your program.

If you use a vaccine in a way that is not supported by a label claim this can also render the vaccine ineffective and can leave a flock open to that particular disease – for example, using CAV vaccine in the water which is not on the label.

Storage, transport and purchase of vaccines

Proper administration is just as important as the timing of vaccination. We are attempting to vaccinate the entire flock, not to prevent infection, but to prevent disease. In any vaccinated flock a certain percentage of the birds may not be adequately vaccinated and thus remain susceptible to disease. If a large percentage of the birds are protected, the virus shed from the infected bird is less likely to find another susceptible bird to infect and eventually the threat of spread of disease is drastically reduced. Therefore, the fewer birds that are susceptible, the less likely a field challenge will result in severe disease within the flock.

A well designed, well timed and soundly executed vaccination program coupled with good management, nutrition and biosecurity will go a long way in maintaining a healthy and productive flock.

Extreme care must be taken to ensure the vaccines are handled properly and delivered appropriately so that each bird may receive an immunizing dose. Strict attention to detail can mean the difference between protected birds and those that are susceptible. Read the information supplied with the vaccine vials, administer it properly and pay close attention to withdrawal times.

For a vaccine or antibiotic to be truly effective it is critical that it is purchased, transported and stored properly.

Vaccines and antibiotics should be purchased only through a veterinarian or a licensed establishment. Purchase only products recommended by your veterinarian, and make sure they are approved for use in poultry. Make sure to check the expiry dates of the vaccines or medicines.

When transporting and storing vaccines and antibiotics, follow the directions on the label. Live vaccines retain their quality up to the end of their shelf life when stored in a refrigerator at a temperature of 2–8ºC (35–46ºF). The livability of the vaccines can be affected negatively when they are not kept in a well maintained refrigerator at the correct temperature.

Be aware of expiry dates and discard any products that are outdated.

Before using any vaccine or antibiotic write down the serial number and expiry date. Record keeping is crucial should there every be a problem with a vaccine or antibiotic.

Vaccines administered properly, at the correct time and with the appropriate antigen content, do not guarantee 100 percent protection. However, a well designed, well timed and soundly executed vaccination program coupled with good management, nutrition and biosecurity will go a long way in maintaining a healthy and productive flock.

Drinking Water Vaccination

Introduction

Wherever possible, today's large poultry operations prefer to use mass application techniques for vaccination with live vaccines.

Even though these techniques involve application to thousands of birds at one time, the goal is the same as that for individual bird vaccination: deliver a minimum of one dose of vaccine to the target organ of each bird. Not only does the dose of vaccine have to be adequate, but it must be alive when it reaches the birds in order to replicate and induce an immune response.

Under practical conditions our aim is to vaccinate the highest possible proportion of birds in a flock. This prevents the proliferation of a field pathogen on a farm and thus minimizes the effects of a particular disease.

Mass application through the drinking water offers the following advantages:

- lower labor costs
- minimal bird stress
- stimulation of mucosal immunity

Although vaccination via drinking water would seem to be the least labour-intensive it is certainly not the simplest and fastest method when done correctly.

Its main disadvantages are:

- inconsistencies of vaccine dosage depending on water consumption
- the potential for some birds to receive no vaccine at all
- incomplete coverage of the flocks can result in rolling post vaccination reaction due to repeated bird to bird transmission

The four most common methods of delivering vaccines through water are by:

- automatic dosing systems
- pumping vaccine solution from a vaccine tank into the water system
- pouring of vaccine solution into bell drinkers
- using overhead gravity flow tanks

Although vaccination via drinking water would seem to be the least labour-intensive it is certainly not the simplest and fastest method when done correctly. This is the method that requires the most mental and physical preparation in order to achieve good, uniform vaccine response in the whole flock. There are quite a few precautions that need to be taken for vaccination to be effective and reliable.

Major concerns in drinking water vaccination

Live vaccines are quite stable as long as they are in freeze-dried form and stored in the refrigerator. When the vaccines are dissolved in the drinking water the virus or bacteria can be inactivated by several factors. Everything possible must be done to keep as much of the virus or bacteria contained in the vaccine alive and to ensure that all birds have the chance to consume enough vaccine.

Live vaccines are particularly susceptible to:

- ultraviolet light: avoid exposure to sunlight
- heat: avoid prolonged exposure to high temperatures (e.g. vaccine vials left by a window). The drinking water should be fresh (8-15°C)
- heavy metals: do not use materials or drinking water containing these. Use plastic buckets or containers for vaccine preparation.
- chlorine: do not administer vaccines in drinking water containing chlorine (if chlorine can be smelled or tasted, the level is definitely very high)
- disinfectants and detergents: make sure that all materials are free from traces of these
- organic matter (litter, feed etc): make sure that all materials and drinkers are clean
- moisture: do not use the contents of damaged vials. Do not break the seals on the vaccine vials until you are ready to prepare the vaccine

Preparation of vaccine vials

Vaccine vials should be prepared in an office or on a clean bench or desk, free from residues of sanitizers or disinfectants. If these conditions cannot be met, covering the required surface with a clean paper tissue or plastic bag is adequate.

The floor of the entrance area of a shed is not acceptable for vaccine preparation because of the dirt and disinfectant residues with which vaccine vials can come into contact.

Vaccine vials should be opened under water. Alternatively de-mineralized water can be injected into the vial to dissolve the vaccine.

When opening vaccine vials use clean hands (free of sanitizer/ soap residues) or disposable gloves.

Use clean dedicated materials for preparing the vaccine

Materials

Only clean, dedicated materials must be used for vaccination. Do not use the same bucket or measuring jug for adding disinfectants to drinking water and vaccine stock solution. Residues of disinfectants or other chemicals are capable of killing vaccine viruses or bacteria at a very low level.

Protection from inactivation

Use correct handling, storage and mixing of the vaccine, however, all of these efforts can be quickly spoiled by an improperly maintained or operated water system. Sanitizing products in the water such as chlorine, ammonia compounds or acidifiers like citric acid, together with residual sediment in the water lines and filters will inactivate the vaccines. These sanitizing products and the sediment (bio film) in the water system can bind with or destroy vaccines. Failure to rotect the vaccine may lead to partial protection of the flock.

Check the quality of drinking water on a regular basis. pH values which are too high (>7.5) or too low (<6.0) can have a negative effect on the efficacy of the vaccine virus or bacteria.

Simple testing strips are available to test chlorine and pH levels in the water. These may also be used to test swimming pool water.

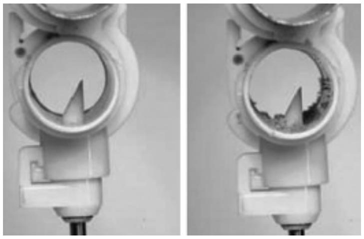
Chlorine levels as low as one ppm (1 gram per 1,000 litres of water) or contamination with heavy metals can lead to inactivation of the vaccine virus. Oxygenated water has a strong antimicrobial effect. Therefore, the oxygenating system should be switched off at least 48 hours before vaccination.

Use of stabilizer and dye in the drinking water

Tablets

There are commercially available effervescent tablets that neutralize chlorine levels (up to 5 ppm) in drinking water. They also contain a blue dye, which makes it possible to monitor vaccine administration and distribution in the drinking water. One tablet of Vac-Safe (Intervet, for example) is required to treat up to 100 litres of water.

Dissolving Vac-Safe in a bucket for automatic dosing system



Clean and dirty nipple line

Skimmed milk/skimmed milk powder

When using skimmed milk powder it should be added at a rate of 2.0 g skimmed milk powder per litre of water or 2.0 litres of skimmed milk per 100 litres of water. Once the milk or milk powder is added to the water it should be left to stand for 15-20 minutes (to neutralize the chlorine) before using it for reconstituting and administering the vaccine. Skimmed milk powder can form lumps which may block the drinking water system. It is therefore essential to stir the solution until these lumps disappear completely.

When skimmed milk or skimmed milk powder is used, it is not easy to see the distribution of vaccine in the drinking water. Vac-Safe tablets make the water more visible even when lights are dimmed in a shed.

Vaccine tank

When using a vaccine tank to vaccinate the flock, make sure the vaccine tank is clean, free of residues. It should be possible to close the tank, preventing dirt to come into the tank. Volume calibration should be visible outside of the tank. Writing the volume levels on the outside of the tank with a marker can be a useful tool.

Automatic dosing system

Automatic dosing systems need to be cleaned and rinsed out before use. Calibrating and regular maintenance of the automatic dosing system is necessary to check if the dosing percentage is still as is set.

Filters

Filters must be removed or bypassed before vaccination. Slime and dirt build-up on filters can concentrate undesirable disinfectants, minerals etc. on the surface of the filter, which may inactivate the vaccine.

Nipple lines

Nipple lines can become dirty due to debris that originates from the header tanks or by the build up of slime and dirt.
This slime and dirt can be caused by:

- calcium (high hardness of water)
- usage of different disinfectants
- usage of vitamins, minerals and other additions in the water

Therefore, it is essential to clean and sanitize these lines properly during the cleanout period using power flush and appropriate sanitizing materials.

Keep all nipple lines horizontal, since variation in the height of the line can create air blockages. This will ensure that birds have equal chances to consume vaccinated water everywhere in the shed.

Bell drinkers

If organic matter gets into the drinkers it is usually a mixture of litter and feces. This cocktail can change the pH of the water in the drinkers and can adversely affect the vaccine. If the flock is under medication, residues of drugs or their metabolites in the feces can also change the pH conditions.

Shavings or other litter material can act as weight and keep the valves closed preventing vaccinated water flowing down into the drinkers.

Dirt in the drinkers can also absorb the vaccine causing it to stick to the bottom or side of the drinker bowl. A certain proportion of the vaccine thus remains in the drinker instead of being consumed by the birds. This will lead to an uneven immune response and poor flock protection. It is always advisable to clean the drinkers on the morning of vaccination **(do not use sanitizer or disinfectant.)**

Distribution of vaccine

As well as problems surrounding the quality of the drinking water there are various problems linked to the extensive range of drinking water installations available. For example, there are some systems which are difficult to drain and retain substantial volumes of chlorinated water in their dead spaces.


Bell drinkers

Dead spaces

Depending on the type of drinker system, up to 10% of the vaccinated water can remain in the dead spaces of the system and therefore is unavailable to the birds. In certain types of header tanks there is residual water under the level of the outlet pipe. This means there is always some vaccine left in the tank once vaccination is finished. It is important to keep that in mind when planning drinking water vaccination. The manifold of the water system can also contain substantial residual water. Residual chlorinated water in the dead space of nipple lines can be detrimental to the vaccine virus; the system must be drained completely before allowing vaccinated water to enter the drinker lines.

Emptying the water lines.

Raising the water lines.

Check drinking water for blue dye indicating that vaccine solution has reached the end of the nipple line.

If drinker lines are not drained before vaccination the residual water in them can not only neutralize the vaccine but also slow its distribution. In such cases, birds at the front of the shed may consume enough vaccinated water whilst those at the end of the shed may receive no vaccine at all. It is therefore essential to allow birds to drink only after the drinker lines have been drained and then primed with vaccinated water.

Problems with cage systems

One of the difficulties associated with vaccination of caged pullet flocks is over-consumption of the vaccine solution by birds at the inlet end of the water line. Birds further down the water line may not receive vaccine solution, which results in uneven vaccination of the flock.

This can be a particularly acute problem when the flock is excessively thirsty at the time of vaccination or when the vaccine volume is insufficient.

A remedy to this problem can be to close the water system for the night, let the birds drink all the water from the lines and prime the lines with vaccinated water before lights come on in the morning. This way all the birds have an equal chance to take the vaccine as long as the header tank contains enough water for the duration of vaccination.

Depending upon the water system design, water lines of different cage batteries may not fill up at the same time. The result of this unequal filling rate is that exposure time to vaccine solution is not equal throughout the house, leading again to uneven vaccination.

Each house needs to be evaluated individually to determine the best approach towards vaccination.

Further factors affecting outcome of water vaccination

Water consumption

Water consumption is influenced by breed, type of feed, ambient temperature, length of water withdrawal time, lighting program and type of drinker system. Guideline information can be obtained from tables in books from, for example, breeder companies, but for accurate information one needs to check water meter readings or water levels in the header tanks.

If in doubt a trial vaccination can be done one day or two days before the actual vaccination day, to establish the volume of water consumed within the two hour period that vaccination is planned. This one can determine the exact volume of water required for vaccination. A trial vaccination is an opportunity for detecting and rectifying any flaws in the process.

Digital water meter to measure water consumption

The amount of water needed for vaccination

This depends principally upon the age of the birds. Mixing the vaccine in an adequate amount of water is essential for a uniform and desired immune response. If too much water is used, birds do not consume their portion of the vaccine within the allowed time, yielding weak and inconsistent titers. If too little water is used more dominant birds or the ones nearest the drinker system over-consume leading to uneven uptake and uneven immune response among birds in the same house.

As a general rule for every 1,000 broilers, 1,000 doses of vaccine should be dissolved in 1 to 1.5 times the litres of water as the age of the birds in days to a maximum of 40–45 litres/1000 birds.

So if a flock of 40,000 broilers is 21 days old on the moment of vaccination, you need 21 x 40 x 1.5 = 1260 litres of water (100 litres is 26.42 US gallons).

Advised water quantity needed when vaccinating broilers (1.5 litre/1000 birds)

Age (days)	Number of birds (x 1000)				
	20	40	60	80	100
7	210	420	630	840	1050
14	420	840	1260	1680	2100
21	630	1260	1890	2520	3150
28	840	1680	2520	3360	4200

For layer pullets at an ambient temperature of 21ºC the following volumes can be used as guidelines for drinking water vaccination.

Age (days)	Water intake per 1000 birds	
	Litres	Gallons (Imperial)
21	21	4,6
28	28	6,2
35	35	7,7
42	42	9,2
49	45	9,9

Adding the vaccine solution in a vaccine tank

The following data can be used as a guide for broiler breeders for vaccination at 21ºC ambient temperature.

Age (weeks)	Water intake per 1000 birds	
	Litres	Gallons (Imperial)
2-3 weeks	25	5.5
4-6 weeks	35	6.6
7-10 weeks	45	9.9

These volumes are guidelines only and accurate volumes need to be established on an individual flock basis.

For birds on lighting programs (for example, layer pullets or broiler breeders), vaccine may be given after a feeding and water withdrawal period or with the first water in the morning.

This eliminates the need for a withholding period. The choice of method depends on management practices on a given farm.

Drinking space

We must ensure that each bird has enough drinker space to consume sufficient vaccinated water at the same time. Nipple drinkers are associated with less water wastage and also less social competition for drinking sites when birds are allowed to drink after the withdrawal period.

In the case of bell drinkers, if existing numbers are not enough to ensure adequate drinking space for all birds, (and therefore prevent uniform vaccine uptake) additional drinkers should be installed for the period of vaccination.

Advised drinking space for birds

	Bell drinkers (cm per bird)	No of birds per	
		Drink nipple	Drink cup
Rearing Birds			
Layer (floor housing)	0.6	10	12
Layer (cage housing)	-	2 nipples or cups available	
Layer breeder	1	10	12
Broiler breeder	1.5	8	10
Broilers	0.6	Max 15	Max 35

If the drinker system is based on bell drinkers and the header tank cannot be used it is essential to have enough manpower on the farm to carry vaccinated water to each drinker as quickly as possible to prevent birds fighting for water and spilling vaccine.

Time of water withdrawal

As a general guideline all vaccinated water should be consumed within two to three hours. To facilitate this, water has to be withheld from the birds for a period of time prior to vaccination.

Trial results with a blue dye in the water suggest that the ideal length of water withdrawal for vaccination of broilers is 1 to 1.5 hours. This can be used as a guideline for other types of poultry also. Ambient temperature and age must be carefully considered when establishing water withdrawal times. If birds are made excessively thirsty they will fight for the water leading to uneven uptake and spillage of vaccine.

Timing of vaccination

Vaccination early in the morning is recommended since this is when birds will exhibit peak activity, such as the first feeding period. Therefore a peak water consumption can be measured.

Birds fighting for water

Exposure time to vaccinated water

Two factors must be taken into consideration when determining the length of exposure time required completing successful drinking water vaccination of a flock.

First, increased exposure time to the vaccine solution gives more birds the opportunity to drink. On the other hand the time

Scoring crop and tongue staining in the house

should be limited since the titer of reconstituted vaccines generally starts to decline after two hours. Virus stability in water should be considered when developing water vaccination protocols.

Controlling the vaccination process

To check the vaccination process, Vac-Safe can be used. When using Vac-Safe or blue dye tablets birds that have consumed enough vaccine solution can be clearly identified. The blue dye temporarily stains the tongue and crop of the birds.

The intensity of tongue and crop staining varies depending on the amount of vaccine solution consumed. The intensity of tongue staining is related to the protection offered by vaccination.

Newcastle Disease (ND) challenge of vaccinated birds, having different degrees of tongue staining, has demonstrated that birds with more intensely stained tongues were better protected against challenge than those with lightly stained tongues. The Vac-Safe can also be used in 'trial' vaccinations to evaluate vaccination technique or to check the water system.

For monitoring the distribution of vaccine in the drinking system and for neutralizing the chlorine in the water one Vac-Safe tablet per 100 litres is sufficient. One tablet also gives staining of crop and tongue. To gain a reasonably accurate picture about vaccine uptake, pick up 50 birds from each corner of the shed and score tongues and crops for staining. It is best to check the birds for crop and tongue staining immediately after the vaccination. If vaccination has been done correctly, at least 90% of the tongues and crops will be colored blue.

Tongue staining test score +

Tongue staining test score ++

Auditing of the vaccination process

To improve the vaccination process a vaccination audit can be carried out. Auditing will highlight which steps contribute to a successful vaccination. Based on the audit the vaccination process can be further improved.

Crop staining test score ++

Methods for Individual Bird Vaccination

Eye drop, wing web and injection are three different methods of vaccine application which require handling of the birds and individual bird vaccination. Although costly and labour intensive, individual bird vaccination is more accurate and precise in dosing and is the method of choice to deliver certain vaccines.

Eye Drop Vaccination

Eye drop vaccination is the preferred method of vaccination for selected regions in this country that require precision. This method of vaccine application is used primarily for a disease caused by the infectious laryngotracheitis virus. Each bird is given one full dose or drop of vaccine. When applied properly the vaccine disappears into the eye cavity and the bird will blink. The vaccine works on producing local immune antibodies via the harderian gland. It is administered with a blue dye to make it easier to evaluate coverage.

On inspection a properly vaccinated bird will have a blue tinged tongue as a result of the dye. Inspection of 2% of the flock gives management a record of vaccination success. Due to the inherent accuracy, precision and dosing of the eye drop vaccination method one can expect 95% or more of the birds being vaccinated properly with an immunizing dose.

Wing Web Vaccination

Wing Web vaccination is primarily used for fowl pox, avian encephalomyelitis, fowl cholera and chicken anemia virus vaccines. Wing webbing can be done with the use of a special two-pronged needle called a wing web stabber. Each needle in the wing web stabber has grooved section which collects a small amount of vaccine as the stabber is inserted into the vaccine vial. The vaccine vial must always contain enough vaccine to cover these grooves when the stabber is inserted. It is also important to keep the vaccine vials from heating up. Operators accomplish this by putting the vaccine vials in vaccination belts, using a small piece of styrofoam as a holder or at least using gloves to keep the vial away from the heat of your hand.

The bird is presented to the vaccinator, upside-down and head first with the wing spread open exposing the wing web. The needle passes vertically down through both skin layers of the wing web. Care must be taken to avoid hitting muscle or bone or having the vaccine wiped off on the feathers before insertion through the wing web. There is also a single needle wing web gun with a reservoir for vaccine which offers less vaccine spillage and handling.

Although costly and labour intensive, individual bird vaccination is more accurate and precise in dosing and is the method of choice to deliver certain vaccines.

Vaccine monitoring must be done 6–10 days after administration and should show bumps or swelling in the wing web. Bumps and swelling are called “vaccine takes”. Any redness or discharge is indicative of bacterial contamination and a review of administration methods should be done. If there are no vaccine takes the birds were missed. Inspection of 2% of the flock gives management a record of vaccination success.

Once a killed vaccine has been opened it should be used and not carried over to other flocks.

Subcutaneous/Intramuscular Vaccination

Subcutaneous or intramuscular injection is used primarily for administration of killed or inactivated vaccines. Killed vaccines are usually manufactured in 1000 dose (500ml) bottles and administered at the rate of 0.5ml per bird. Birds are picked up and injected in the breast or thigh (intramuscular) or under the skin in the back of the neck, midway between the head and shoulders of the bird (subcutaneous administration). Accurate placement of needle is critical. The needle should be 18-guage with a length of either $^1/_4$ inch or $^1/_2$ inch.

Killed vaccines should be warmed to room temperature at least 12 hours prior to vaccination. Once a killed vaccine has been opened it should be used and not carried over to other flocks. Change the needle frequently (every 500 birds) because frequent needle use can cause excessive bleeders, trauma and pain.

A blue dye can be added to the killed vaccine bottle prior to vaccination to assist in vaccination monitoring when using the subcutaneous method of injecting. If there is a small pocket of vaccine, tinged blue, just under the skin the birds were vaccinated properly. Inspection of 2% of the flock gives management a record of vaccination success.

Spray Vaccination

Spray vaccination of live vaccines to poultry is widely used and is an efficient and cost-effective method for vaccinating large numbers of birds.

This method is effective in delivering live respiratory vaccines to the immune tissues associated with the Harderian gland and the upper respiratory tract. The natural route of infection for many poultry disease pathogens is through the respiratory tract, so good mucosal immunity in this area is critical for the protection of the bird.

Spray vaccination offers the advantages of mass application, requiring less time and labour; it minimizes bird stress while inducing good mucosal and systemic immunity. Through spray vaccination some of the water quality problems associated with drinking water administration are avoided. These problems are the presence of chlorine, dirt or other materials in the drinking water, each of which can negatively influence the liveability of vaccines.

The drawbacks of spray vaccination are inconsistent vaccine dosage and the risk that some birds receive no vaccine at all. The correct method of vaccine application is therefore important. The health status of a flock is important; vaccinate only healthy flocks.

> Spray vaccination offers the advantages of mass application, requiring less time and labour; it minimizes bird stress while inducing good mucosal and systemic immunity.

Factors for successful spray vaccination

Several factors have to be considered for a successful spray application of live vaccines.

- Droplet behaviour
- Impact of droplet size
- Water quality
- Climatic conditions
- House layout
- Vaccination site (hatchery/ farm)
- Equipment used for spray vaccination
- Experience of the vaccinator

Droplet behaviour

The equipment used for spray vaccination breaks down the vaccine solution into droplets. The droplets are propelled into a jet or a cloud to the target organs of the bird. Understanding of how the droplets behave in air is useful.

Between emission from the sprayer and contact with the bird, the vaccine solution is subject to losses. This is due to settlement, evaporation and drift of the droplets.

Factors	Explanation	Solution
Settlement	Loss of vaccine solution due to droplets which land on the ground.	Group the birds together before vaccination.
Evaporation	Phenomenon which affects all droplets between emission and impact. Causes a reduction in droplet size, or when evaporation is high droplets will evaporate completely. Evaporation of droplets is faster if the droplets are small. Ambient temperature (high) and relative humidity (low) enhance evaporation.	Turning off radiant heaters during spraying or vaccinate during the cool part the day. Reduce pressure of spray equipment or use a nozzle with a larger diameter.
Drift	Loss of droplets caused by movement of air. All droplets smaller than 200 microns are susceptible to drift.	Turn off the ventilation during spraying. Close curtains when spraying in open houses.

The smaller the vaccine droplets, the deeper the vaccine virus penetrates into the respiratory tract. The effectiveness of vaccination and type of vaccine that can be used is largely determined by the droplet size in the useful fraction. Droplet size of the useful fractions determines which part of the bird's respiratory tract receives the vaccine. Coarse spray droplets (>100 microns at bird level) will generally settle on the bird and can be used to target the areas around the upper respiratory tract.

Impact of droplet size

In spray vaccination the droplet size determines where the spray is deposited in the respiratory tract. Nearly all the droplets larger than 10 microns will be deposited in the upper respiratory tract, the conjunctivae, the nasal cavity and the upper part of the trachea. Around 80% of droplets of 5 microns will be deposited here as well. Smaller droplets will penetrate deeper into the tract and being deposited in the trachea, the lungs and the airsacs.

Impact of coarse spray (droplet size > 100 microns at bird level)

With coarse spray the impact of the droplets is direct. The droplets emitted should strike the birds around the eyes, in particular,

Figure1.
Behaviour of droplets in air

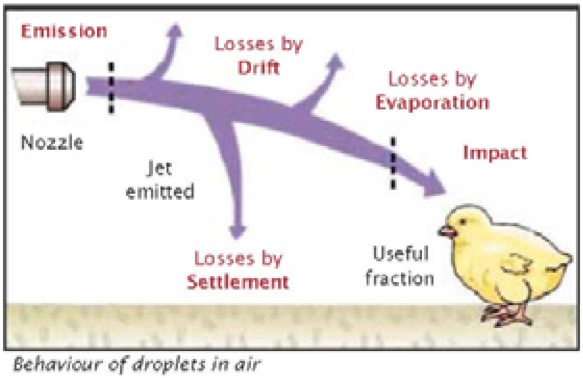
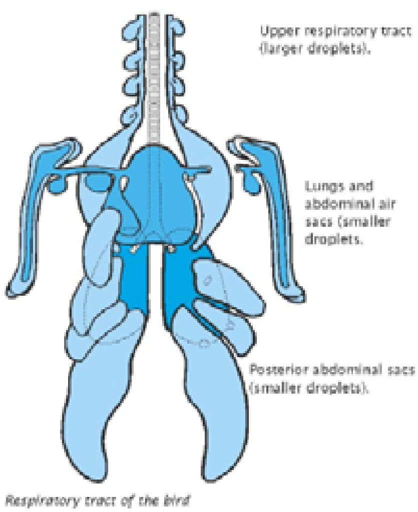


Figure 2.
Respiratory tract of the bird



the nostrils and the beak. Therefore, the jet of a knap-sack sprayer must be aimed towards the head. To make this easier, use an extension lance of sufficient length to reach all the birds including birds turned towards the vaccinator and those which have turned their backs to the spray nozzle.

To achieve maximum coverage in a group of birds it helps if they are grouped together in a corner or along the walls and sprayed twice on a double pass. Because of their size, droplets of coarse spray have a tendency to settle on the ground.

Impact of fine spray (droplet size < 100 microns at bird level)

Impact of the droplets in fine spray is simultaneously direct and indirect. Numerous small droplets remain suspended in the air, are inhaled, and penetrate deeper in the respiratory tract.

Use good quality water to reconstitute the vaccine

To limit losses by evaporation, the spray must be aimed approximately 30–40 cm above the birds' heads in order to surround them with a mist. Numerous small droplets enter the trachea, the bronchi, the lungs and even the air sacs. They are responsible for stimulating an immune response but may cause post-vaccination reactions in birds.

A high ambient temperature can cause problems because the birds hyperventilate with their beaks open. Under such circumstances, the respiratory rate can reach over 170 per minute. This increases the quantity of vaccine droplets inhaled. These may be small enough to penetrate deeply as a result of pronounced evaporation resulting in post-vaccination reactions.

Water quality

The quality of the water used for spray vaccination is important. Due to the small volumes of water used during spray vaccination, all water used for vaccine reconstitution should be fresh, cool and free of certain minerals or chlorine. The presence of certain minerals and chlorine reduces the liveability of the vaccine

The temperature of the water should be between 8–20°C. Excessively hot water reduces the liveability of the vaccine.

A trial run can be carried out to determine the correct water volume required to cover all birds in the hatchery or house. This is dependent on the type of housing and the volume output of the particular spray equipment.

If the volume of water is too high this can result in chilling of the birds, due to the excessive amount of cold water which is sprayed on them. This can be the case when vaccinating day old chicks in the chick boxes at the hatchery or at the farm.

Quantity of water needed for spraying

	Quantity of water needed	Temperature of water
Coarse spray		
Day old chicks at hatchery (hatchery sprayer/cabinet sprayer)	0.1–0.2 litre/1000 birds	8–20°C/46.4–68° F
Day old chicks at farm (knap-sack sprayer)	0.3–0.5 litre /1000 birds	8–20°C/46.4–68° F
Older birds (knap-sack sprayer)	0.5–1.0 litre /1000 birds	8–20°C/46.4–68° F
Fine Spray		
Atomist/Turbo fogger sprayers	0.3–0.6 litre/1000 birds	8–20°C/46.4–68° F
Controlled droplet sprayers (spray fan)	0.1–0.2 litres/1000 birds	8–20°C/46.4–68° F

The above figures are guidelines only.

Climatic conditions

The climatic conditions during vaccination should be optimised in order to enable birds to receive the correct dose of vaccine.

- Reduce or switch off the ventilation system. This will minimise the air movement and prevent drift of the droplets.
- Reduce the light intensity to minimize bird movement.
- Reduce/switch off the heater/cooling system
- Group the birds. This can be achieved by reducing the house temperature by 1–2° 15 minutes prior to vaccination.
- Walking through the house and reduce the light intensity can also cause birds to group together.

In open houses spray during the coolest part of the day and do not vaccinate if there is a strong wind (risk of drift of droplets).

House layout

House layout should be taken in consideration to ensure that all birds receive the correct dose. In a small shed where birds are grouped along the sidewalls the vaccinator should walk with the sprayer slowly up on one side and return on the opposite side. The vaccinator should use a slow side to side motion with the lance of the sprayer or the flexible tube of the atomist or Turbo fogger. The spray should be aimed about 30-40 cm above the head of the birds. The distance between the vaccinator and the side wall should not be more than the range of coverage of the sprayer.

Reduce/switch off the ventilation when vaccinating

Reduce/close the air inlet when vaccinating

Pressurized spray equipment (Desvac)

Cage sprayer used to spray birds in rearing period

In wide houses it is recommended to divide the house into 2–4 metre wide strips and spray the birds within that strip. For this a spraying plan should be drawn up. This ensures that no areas in the shed are left out. Divide the shed into 2–4 metre wide strips utilizing drinker and feeder lines as guides and plan the direction of walking and spraying. An example of a spray plan can be found in annex 3. It is advised in these types of buildings that the vaccinator walks around twice and covers as many birds as possible. Drawing a spray plan in wide houses is recommended. Reduce/switch off the ventilation when vaccinating Reduce/close the air inlet when vaccinating

If spraying for the first time, do a trial vaccination using only water. This ensures that the correct volume of water is used and the correct route through the shed is made.

When equipment requires electric power (atomist, turbo-fogger) roll out the extension cable before vaccination. This prevents pulling the extension cable during vaccination.

Pressurized spray equipment

This equipment consists of a pressure chamber, lance and hydraulic nozzle. Droplet size can be varied by adjusting the nozzle and pressure during operation. Examples of this equipment are the Birchmeier sprayer, cage sprayer and other knap-sack sprayers. This type of equipment will produce a large range of droplet sizes (50–1000 microns), depending on the nozzle and pressure used. In order to vaccinate all the birds, the nozzle must come within 30-40 cm of the head of every chicken in the group. Due to the range of droplets produced, only a small proportion of vaccine can be inhaled by the birds, the remainder is either taken up by the ocular-oral route or falls on the ground. For this reason relatively large volumes of water are required to cover the birds (0.5–1 L/1000 birds). Use fixed pressure spray equipment to reduce the variation in droplet size.

Spray equipment with electric power

The advantage of this equipment is that the spray droplets will travel for 4–5 metres from the device. These systems produce a droplet size of 20–50 microns, and operate with electric power. An extension cable should be rolled out before applying the vaccine. These sprayers can be noisy which can distress the birds.

General recommendation

Contact your local vaccine manufacturer for information regarding the most appropriate spray equipment for each vaccine.

Dedicated materials should be used for spray vaccination.

Nozzle used for coarse spraying (TXVK 18)

Cage sprayers for use of fine or coarse spray

Clean filters of the vaccine equipment after use

Spray vaccination equipment

The majority of spray equipment will produce a spray consisting of a range of droplet sizes. The vaccine used and the age of the birds will determine which equipment is most suitable. Use dedicated materials for spray vaccination (sprayer, bucket, and measuring jug). Residues of pesticides, dirt and chlorine residues negatively affect the liveability of the vaccine.

Coarse spraying (droplet size at nozzle > 100 microns)

Coarse spray is recommended for

- Hatchery spray vaccination
- 1st day vaccination on farm
- First ND vaccination (depending on vaccine)
- IB vaccination
- Spraying birds in production

Fine spraying (droplet size at nozzle < 100 microns)

Fine spraying ensures that the vaccine virus penetrates deeper into the respiratory tract of the birds.

Nozzles

The diameter of the spray hole in the nozzle and pressure influence the droplet size. An uneven droplet size can be caused by a (partly) blocked nozzle.

Maintenance of vaccination equipment

After use of equipment:

- Clean the equipment with warm water. Do not use disinfectants. The filters, lances and nozzles should be cleaned thoroughly.
- Clean the exterior of the machine.
- For knap-sack sprayers, dismantle the nozzles.
- Let the equipment dry before storage.
- Store the equipment in dry place. Leave the opening of the tank unsealed, to prevent growing of moulds.
- Grease knapsack sprayers periodically.

Monitoring spray vaccination

A dye can be used when spraying day old chicks in the hatchery to monitor vaccine coverage. This dye can be used in a hatchery spray cabinet to check if the nozzles are aligned correctly to spray all the chicks in the box. Water-sensitive paper can be used to determine the droplet size of the sprayers. If water-sensitive paper is not available spraying in front of a dark wall or on a light coloured floor surface can give an estimation of the droplet size. The flow rate (litres per minute) of spray nozzles can be monitored by using measuring cylinders.

Review Questions

1. Which of the vaccines used on your farm are live and which are inactivated?

2. What cautions would you give someone new to the poultry industry about handling vaccines?

3. What are the main factors which affect the efficiency of vaccine distribution when using water vaccination?

4. What are the strengths and limitations of the eye drop method of vaccination?

5. What affect do temperatures within the barn and outside the barn have on the effectiveness of spray vaccination?

7 Vitamins, Minerals and other Feed and Water Additives

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Vitamins and Minerals in Feed

All vitamins and minerals in the feed are added as specialized premixes that may be manufactured by the feed supplier, or more often these days by companies that specialize in premix manufacture.

Because they are added in small quantities, they are often referred to as mico-ingredients, being packaged in as little as one kilogram per tonne of feed. Even at just one kilogram, the majority of the premix will actually be a diluent such as wheat shorts or limestone. The diluent suggested for use in the vitamin-mineral premixes is ground corn or wheat shorts (Table 1), both being of medium grind for best results. If the carrier is too coarse, it is not possible to obtain good distribution of the supplements, while too fine a carrier leads to dustiness and caking. For mineral mixes, limestone or kaolin (china clay) make satisfactory carriers.

Where premixes are being stored for relatively short periods of time, the vitamin and mineral premix can be combined. However, where mixes are to be stored for more than 10 weeks in a warm moist environment, it may be advisable to make separate vitamin and mineral mixes, because some minerals can lead to destruction of certain susceptible vitamins.

Vitamin Stability in Feed

Naturally occurring vitamin E is quite unstable, particularly in the presence of fat and trace minerals. However, vitamin E added as a supplement usually is in a highly stable form (for example, a gelatin coated beadlet containing an antioxidant).

Vitamin A in fish oil and pro-vitamin A compounds in yellow corn are easily destroyed in the typical mixed ration. Most dehydrated green feeds are now treated with an antioxidant that helps prevent the destruction of the pro-vitamin A compounds during storage. Today, most poultry feeds contain supplementary gelatin- or starch-coated

Table 1: Vitamin-mineral premixes (without choline)
all premixes should be made up to 1–5 kg by the addition of a carrier such as wheat middlings the amounts shown below are the levels of nutrients to be added per tonne of finished feed.

	CHICKEN				TURKEY			WATERFOWL		
	Starter	Grower	Laying	Breeder	Starter	Grower	Breeder	Starter	Grower	Breeder
VITAMINS										
Vitamin A (M.IU)	10.0	8.0	7.5	11.0	10.0	8.0	11.0	10.0	8.0	10.0
Vitamin D3 (M.IU)	3.5	3.3	3.3	3.3	3.5	3.3	3.3	2.5	2.5	3.0
Vitamin E (T.IU)	30.0	20.0	50.0	70.0	40.0	30.0	100.0	20.0	15.0	40.0
Riboflavin (g)	6.0	5.0	5.0	8.0	6.0	5.0	8.0	5.0	4.0	5.5
Thiamin (g)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Pyridoxine (g)	3.3	3.3	3.3	5.0	3.3	3.3	5.0	3.3	3.3	3.3
Pantothenic acid (g)	15.0	10.0	10.0	15.0	15.0	12.0	15.0	12.0	10.0	10.0
Vitamin B12 (g)	.015	.012	.015	.015	.015	.012	.015	.015	.010	.015
Niacin (g)	50.0	30.0	40.0	50.0	50.0	40.0	50.0	50.0	40.0	50.0
Vitamin K (g)	2.0	2.0	2.0	3.0	2.0	2.0	3.0	1.5	1.5	1.5
Folic acid (g)	1.0	1.0	1.0	1.0	1.0	0.5	1.0	1.0	0.5	0.5
Biotin1 (g)	0.15	0.10	0.10	0.15	0.2	0.15	0.2	0.1	0.1	0.1
MINERALS										
Manganese (g)	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0
Zinc (g)	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
Copper (g)	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Selenium (g)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Iron (g)	50	40	30	40	50	40	40	40	30	30

* Note the values shown are amounts of pure ingredients. All vitamin premixes should contain 125 g Ethoxyquin/kg.

1. Increase if diet contains > 10% wheat.

synthetic vitamin A which is quite stable. The inclusion of antioxidants in the feed helps to retain the potency of vitamins A and E in mixed feed.

Vitamin D_3 is the only form of the product to be used in poultry diets, since birds, unlike other farm animals, cannot utilize vitamin D_2. Vitamin D_3 supplements are available in a dry, stabilized form. These products are reported to be stable when mixed with minerals. Hy-D®, a commercial form of 24(OH) D_3 is also very stable within premixes and mixed feed.

Modern premixes are formulated with stability in mind, and loss of potency today is very minimal even after a few months storage. At most large feed mills, premixes will be used within a few weeks.

While choline is an essential B vitamin, it is usually not added to premixes, but it is added as a separate individual ingredient. The reason for this is that very large quantities of choline are used in comparison to all other vitamins (up to 1kg/tonne) and it is also very hygroscpic. This means it absorbs moisture from the air very quickly, and this can ruin a premix. Choline is therefore kept separate from the premix and added at the same time as the premix during feed manufacture.

While a vitamin supplements is an extremely important part of a well-balanced diet, animals usually have sufficient body stores to meet their requirements for several days. Modern poultry farms receive feed deliveries on a weekly or even more frequent basis. Failure to incorporate the vitamin premix in a delivery of feed will likely have little or no effect on the performance of most classes of poultry, assuming the next delivery contains the vitamin supplement. For breeding birds, this may not be true, especially for the riboflavin, which could well affect hatchability if hens are fed a deficient diet for 5–7 days.

Vitamin C

Theoretically, birds can synthesize all the vitamin C (ascorbic acid) that they require, and so there should not be any need to add it to either feed or water. However, under stress conditions, some believe that supplemental vitamin C is beneficial, with heat stress being the most common reason for application.

The ocean explorers of the 1500s inadvertently discovered the source and role of vitamin C when re-supplying their crews with fresh fruit or even extracts from coniferous trees as a means of combating the dreaded condition known as scurvy. It was not until the 1900s that the so-called anti-scurvy factor was identified. It was called vitamin C simply because the letters A and B had already been allocated to other vitamins. At this time much of the pioneer research work on vitamin C was conducted with guinea pigs since this animal is very sensitive to a deficiency of vitamin C.

Most domesticated commercial poultry species are termed primitive birds on the evolution scale; this means that they have the ability to synthesize vitamin C in a kidney. So-called evolved birds, including most pet birds, have lost this inherent characteristic and so must have a continuous supply of vitamin C in the diet. Because the kidney is the only site of vitamin C synthesis in poultry, general kidney health and metabolism are critical for maintaining blood levels of vitamin C. Mycotoxins, infectious bronchitis and conditions such as urolithiasis in pullets, will compromise vitamin C synthesis in the kidney. Vitamin C synthesis will also be adversely affected by any factor which influences early kidney growth, because vitamin synthesis is a factor of kidney mass.

The need for vitamin C is accentuated under various stress conditions. Application is most common during heat stress or in situations where kidney function is not ideal.

The turkey seems most susceptible to change in blood levels of vitamin C in response to various stresses. Beaktrimming, desnooding and/ or detoeing as well as cold stress of the poult to cause a significant decline in synthesis of vitamin C. The young chick seems less affected by these early stresses, although after initial brooding, exposure to cold stress is reported to reduce vitamin C synthesis.

Plasma Vitamin C levels in birds are very responsive to diet or water supplementation. Such changes are seen within a few hours, and there is a plateau after about 12 hours. When vitamin C is removed from the water or feed, normal blood levels return within 24 hours. This simple manipulation of plasma vitamin C is the basis behind short-term supplementation via the water in response to specific transient stresses.

Vitamin C also plays an important role in bone formation via its effect on vitamin D_3 metabolism. Because of limited vitamin C synthesis by the young birds (less than 14 days) there have been reports of improved bone development in response to vitamin C. Vitamin C given to heat-stressed older laying hens has been reported to improve eggshell quality and under these conditions the beneficial effect of Vitamin C may relate to altered calcium metabolism as much as it does to counteracting the stressor.

Unfortunately ideal conditions seldom predominate commercially and so there is often consideration of including vitamin C in diet pre-mixes and or using water supplements. The need for vitamin C is accentuated under various stress conditions. Application is most common during heat stress or in situations where kidney function is not ideal. These two factors alone are often sufficient reason for inclusion of 100 to 200 mg vitamin C/ kilogram of diet.

In situations of short-term stress water supplementation is often sufficient because plasma levels of vitamin C are quite responsive to supplementation and changes within 12 hours are quite meaningful. There are also reports of water supplementation at 300 to 500 mg per litre being effective in prevention of decline in eggshell quality that is often seen with layers necessarily given saline drinking water. Under these conditions vitamin C is of little use in treating an existing shell quality problem – rather its use prior to the start of production seems an effective preventative measure.

Currently the major use of ascorbic acid supplementation is:

1. under conditions of generalized heat stress,
2. to improve bone integrity of young poults, and
3. to improve eggshell quality of layers.

Of these situations, using vitamin C during heat stress is perhaps the most common application at this time. Some interesting data on diet self-selection by young broilers highlights the apparent need for vitamin C during heat stress. When given a choice of feed, broilers exposed to high temperatures select diets high in vitamin C rather than diets devoid of vitamin C.

Vitamins in Water

Consideration of water intake

In order to medicate birds with vitamins via the drinking water, one must know current water intake and factors that can impact water intake on a daily basis.

Water, is the most critical nutrient that we consciously supply to birds, yet in most instances, it is taken for granted and often receives attention only when mechanical problems occur. The water content of the body is associated with muscle and other proteins. This means that as a bird ages, and its body fat content increases, its body water content expressed as a percent of body weight will decrease.

Water intake of a bird increases with age, although it decreases per unit of body weight. Drinking behaviour is closely associated with feed intake, and so most factors affecting feed intake will indirectly influence water intake. At moderate temperatures, birds will consume almost twice as much water by weight as they eat as feed. Any nutrients that increase mineral excretion by the kidney will influence water intake. For example, salt, or an ingredient high in sodium, will increase water intake.

Similarly, feeding an ingredient high in potassium such as molasses or soybean meal, or calcium/phosphorus sources contaminated with magnesium, will result in increased water intake. Such increases in water intake are of no major concern to the bird itself, but result in increased water excretion and wetter manure.

Table 2 shows average water consumption of various poultry species maintained at 20°C or 32°C. These figures indicate approximate water usage values and will vary with the stage of production, health and feed composition. As a generalization, for any bird up to eight weeks of age, an approximation of water needs can be calculated by multiplying age in days x 6 (e.g. 42 d = 252 ml/d).

In calculating the water needs of egg producing stock, note that water intake is not constant throughout the day, but varies depending upon the stage of egg formation. There is a peak in water consumption immediately following egg laying (usually mid-morning) and again at the time just prior to the end of a normal light cycle. This means that

Table 2: Daily ad-lib water consumption of poultry (litres per 1,000 birds)

		20°C	32°C
Leghorn pullet	4 wk	50	75
	12 wk	115	180
	18 wk	140	200
Laying hen	50% prod.	150	250
	90% prod.	180	300
Non-laying hen		120	200
Broiler breeder pullet	4 wk	75	120
	12 wk	140	220
	18 wk	180	300
Broiler breeder hen	50% prod	180	300
	80% prod	210	360
Broiler chicken	1 wk	24	40
	3 wk	100	190
	6 wk	240	500
	9 wk	300	600
Turkey	1 wk	24	50
	4 wk	110	200
	12 wk	320	600
	18 wk	450	850
Turkey breeder hen		500	900
Turkey breeder tom		500	1100
Duck	1 wk	28	50
	4 wk	120	230
	8 wk	300	600
Duck breeder		240	500
Goose	1 wk	28	50
	4 wk	250	450
	12 wk	350	600
Goose breeder		350	600
These are approximate water usage values and will vary with the stage of production, health and feed consumption.			

water needs must be accommodated during these peak times (around 10–11 am and 6–8 pm) within a 6 am–8 pm light cycle.

The quantities of water in the manure are directly dependent on water intake. Broiler chickens produce excreta containing about 60–70% moisture, while that produced by the laying hen contains about 80% moisture.

Water Quality

Water quality should be monitored with assays conducted at least each six months. Chemical contaminants are the most serious problem affecting water quality. However, poultry usually adjust to high levels of certain minerals after a period of time, and so only in a relatively small number of cases does the mineral content of water significantly affect the performance of a flock. There are certain areas where water salinity is high enough to adversely affect flock performance. In such cases, it may be necessary to remove some of the supplemental salt from the diet. However, this should be done only after careful consideration to ensure that there will be a sufficient salt intake because performance can be severely reduced if salt intake is too low.

Any bacterial contamination of water is an indication that surface water is entering the water supply or that the water lines and systems have been contaminated with biofilms. Waterline cleaning and disinfection should be performed between each flock. An ongoing water sanitation program is critical. Alternatively, the water may be chlorinated to eliminate contamination.

Another problem that can exist with water is a build-up of nitrates or nitrites. Such contamination is usually an indication of run-off from animal wastes or fertilizers leaching into the water system. Although the standard for human water supply is 10–20 ppm of nitrate nitrogen, higher levels can usually be tolerated by animals. Levels beyond 50 ppm need to be present before water is suspected as a factor in the poor performance of poultry. As nitrites are 10 times more toxic than nitrates, and because bacteria in the intestinal tract and in the water supply can convert nitrates to nitrites, levels of these two contaminants in the water supply must be kept to a minimum. Superchlorination of the water will quickly oxidize nitrites to nitrates thereby reducing their toxicity. Before initiating a superchlorination program, check with a local pathologist to ensure a proper level of chlorination in order not to interfere with the performance or efficiency of vaccines or other drugs.

Before initiating a superchlorination program, check with a local pathologist to ensure a proper level of chlorination in order not to interfere with the performance or efficiency of vaccines or other drugs.

Table 3 outlines standards for drinking water in terms of mineral levels. Toxicity and loss of performance will vary with bird age and class of stock, but, in general, these values can be used as guidelines to indicate

Table 3: Concentration of water minerals above which problems may occur with poultry (ppm)

Total soluble salts (hardness)	1500
Chloride	500
Sulphate	1000
Iron	500
Magnesium	200
Potassium	500
Sodium	500
Nitrate	50
Arsenic	0.01
pH	6.0–8.5

the possibility of toxicity with birds consuming such water over prolonged periods.

In the last few years, there has been an interest in the treatment of water for poultry. In large part, this is an attempt to prevent problems of mineral deposits occurring in pipelines, boilers and automatic waterers, rather than preventing actual toxicity problems. Such treatments involve orthophosphates, which sequester calcium and magnesium, thereby preventing precipitation in the water supply. In most situations, these systems will not unduly alter the water composition in terms of the bird's nutritional requirements.

As a last resort, some producers use water softeners, and in these situations, there is some cause for concern with regard to the bird's health. These softeners contain an active column of resin that has the ability to exchange one ion (mineral) for another. Over time, the resin column becomes saturated with the absorbed minerals (usually calcium and magnesium salts) that are extracted from the water, and so must be flushed and re-charged with the donor mineral. In most softeners, this recharging process involves sodium from NaCl. This means that sodium is replacing other minerals in the water, because sodium salts readily dissolve, and will not leave mineral scale in the equipment. The amount of sodium that is pumped into the water supply is, therefore, in direct proportion to the hard minerals extracted from the water. In areas of very hard water, one can expect higher levels of sodium in water reaching the birds, and vice-versa in areas of lower water hardness. Problems in water sodium will likely occur if softener salt use exceeds 40 kg/40,000 litres of water.

Vitamins as Water Supplements

Vitamins are added to water when various stress situations occur. Unfortunately, many such supplements contain too many electrolytes, and, in many situations, they can be harmful.

Layers

Stress and feed intake

Various stresses influence vitamin status of the layer by impairment of either feed intake or digestion or by actually increasing the birds' needs for certain vitamins. Any situation that reduces the birds feed intake will adversely affect the supply of vitamins for metabolism. In growing pullets the common major stresses are beak trimming and vaccination. Studies have shown that pullets eat very little feed for at least 36 hours following beak trimming, and this is usually accompanied by a reduction in growth. All vaccines cause an immunological response, that, in reality, is a very mild form of the disease. Again, feed intake may decline. This latter effect is compounded when inactivated vaccines are administered, since the pullet has to be handled at these times. Such management practices that lead to reductions in feed intake further compromise bird health by limiting the uptake of essential vitamins.

Use of water vitamin supplements during such stressful situations ensures continuity of vitamin supply, since water intake is much less affected than is feed intake. At times when feed intake is reduced, birds are often willing to drink at near normal rates. This balance between feed and water intake is even more important when heat stress occurs. Layers will voluntarily reduce their feed intake by about 1gram for each 1°C increase in barn temperature. On the other hand water intake increases during such high temperatures and so the water supply is the obvious choice for administering vitamins during times of heat stress.

Pullet maturity

Both white and brown egg pullets are maturing as early as 16 weeks of age. These pullets have very small appetites which leads nutritionists to formulate diets based on daily feed intake. For example, the protein content of a diet designed for 19 week old layers will be much higher than in a diet used for the same birds at peak, when feed intake may be 15% higher. However, it is very unusual for nutritionists to add more of the vitamin premix to diets for newly-housed pullets that initially are eating just 80–85g of feed.

Layers require a constant supply of vitamins that are deposited in the growing yolk, and vitamins are especially critical for the synthesis of the albumen that occurs daily in a 2–3 hour period. Without an adequate supply of vitamins, especially the B complex, egg production is quickly compromised. Water supplements for layers in the first two weeks of production are therefore common practice, when even under ideal management, the birds low inherent feed intake compromises her supply of essential vitamins.

Breeders

Stress and feed intake

After the first week, breeder pullets will be fed limited quantities of feed. These very competitive feeding systems lead to more stressful situations where feed intake of individual pullets may be less than expected. With more variable intake of nutrients, problems of vitamin adequacy are going to accentuate other stressors such as vaccination, weighings and disease challenge.

Vaccination and immunity

Breeder pullets are vaccinated almost weekly up to the time of transfer to the adult facilities. A vaccine induces a mild version of the specific disease, and so the bird's immune system is in a constant state of flux, especially with multi-valent vaccines. A number of vaccines necessitate handling the bird. This activity poses a major physical and metabolic stress on both individual birds as well as the flock as a whole.

Many of the B vitamins are involved in metabolic reactions occurring as a result of vaccination stress and so optimum vitamin intake is essential for good vaccination response.

Vitamin A is also important in immunity because it is essential for integrity of epithelial tissue, which is the site by which many live vaccines enter the body. Vitamin supplements can help sustain vaccine response by providing a consistent and balanced supply of all vitamins essential for achieving optimum titers.

Hatchability

Problems with supply of vitamins to the breeder quickly translate into loss of hatchability and eventually loss of egg production. For some of the B vitamins a severe deficiency shows up within 5–7 days, in the form of embryo mortality. Egg production and certainly bird health are little affected in these early stages and so problems of inadequate vitamin supply are sometimes difficult to diagnose. Consequently the most significant economic losses occur due to minor fluctuations in vitamin supply that often go undiagnosed or are simply ascribed to age-related declines in hatchability. Routine use of vitamin supplements is often used for helping to sustain hatchability for the life of the breeder flock.

Broilers

Brooding

If chicks are chilled or overheated during early brooding, then enteritis often happens as evidenced by pasted vents. There can also be a temporary reduction in feed intake for 6–12 hours following feed change from crumbs to pellets. All of these management conditions that lead to reductions in feed intake further compromise bird health by limiting the uptake of essential vitamins.

Problems with digestion

Vitamins are digested and then absorbed in the first part of the small intestine. The processes of digestion and absorption require very exact conditions of pH and consistency of the undigested feed as it flows along the intestine. Disruptions to these conditions are most commonly caused by bacterial or viral infection or by feed ingredients that create a viscous digesta. Diseases such as coccidiosis and necrotic enteritis, even at sub-clinical levels, damage the gut lining, making the process of absorption less efficient. Feeding substantial quantities of wheat, wheat by-products or barley can increase the viscosity of the digesta and either disrupt digestion or prevent digested nutrients from moving to the absorptive gut wall.

There can also be competition between related nutrients for absorption. This does occurs with vitamins. Using an unbalanced vitamin supplement can lead to a deficiency of certain vitamins, because an excess of one vitamin can impair the absorption of another. Vitamin supplements can help overcome these potential problems by supplying a balanced mixture of highly-digestible vitamins that exactly mirrors the bird's requirement, with no individual vitamin in excess of immediate needs.

Using an unbalanced vitamin supplement can lead to a deficiency of certain vitamins, because an excess of one vitamin can impair the absorption of another.

Heat Stress

All birds have difficulty in keeping body temperature within closely defined limits. Fast-growing older broilers are especially susceptible to heat stress because of the extra heat generated from digestion of large feed intakes. A natural defence mechanism for the heat-stressed broiler is reduced feed intake, which leads to borderline uptake of essential vitamins.

Turkeys

Starve-out and rickets

The newly-hatched poult is very susceptible to minor problems with environmental control and feed and water quality. Less than satisfactory conditions can lead to increases in starve-out at 3–4 days and rickets in the following few days. With too hot or too cool brooding conditions the young poult has difficulty in achieving desired feed intake and growth rate in the first week, and this translates to reduced growth rate through to market weight.

These conditions will be aggravated by inadequate supply of vitamins in general and especially vitamin D_3 in terms of rickets. Vitamin water supplements are designed to provide a balanced mixture of vitamins in a readily absorbable form that will help poults to overcome these potential problems in the first week of life.

Mineral Supplements

Minerals are described as maco or micro, depending on the quantity added to a diet. Calcium, phosphorus and salt are macro-minerals, being added individually as separate ingredients. The micro-minerals, such as copper and manganese are added as a premix. Sometimes the micro-minerals are added as a separate premix, and sometimes combined with the vitamins.

Oyster shell is a much more expensive ingredient than limestone, but it offers the advantage of being clearly visible in the diet to the egg producer and so there is less chance of omission during feed manufacture.

Calcium

Calcium is usually added as limestone or oystershell. There has been considerable controversy in the past concerning the relative potency of limestone vs oyster shell as sources of calcium, especially for the laying hen. Particle size is perhaps more important than the source of calcium. Usually the larger the particle size, the longer the particle will be retained in the upper digestive tract. This means that the larger particles of calcium are released more slowly, and this may be important for the continuity of shell formation, especially in the dark period when birds are eating very little feed. Oyster shell is a much more expensive ingredient than limestone, but it offers the advantage of being clearly visible in the diet to the egg producer and so there is less chance of omission during feed manufacture. Birds also have some opportunity at diet self-selection if oyster shell is given, and this may be of importance in maintaining optimum calcium balance of egg-forming vs non egg-forming days.

Limestone should be in as large a particle size as can be readily manipulated by the bird's beak. For laying hens, this means a fairly coarse crumble consistency. Periodically, dolomitic limestone is offered to the feed industry. Dolomitic limestone contains at least 10% magnesium, and this complexes with calcium or competes with calcium for absorption sites. The consequence of feeding dolomitic limestone is induced calcium deficiency, usually manifested by poor skeletal growth or egg shell quality.

Dolomitic limestone should never be used in poultry diets.

Because high levels of sodium chloride can lead to increased water intake, a substitution of sodium bicarbonate for a portion of regular salt has been shown to be beneficial.

Phosphorus

Although wheat, corn and soybean meal contain large amounts of phosphorus, it is in an indigestible form. We have to add either phosphate minerals to the diet, or add a synthetic enzyme that can help the bird capture this natural plant phosphorus (See Section 4.6). Many inorganic phosphorus sources are used around the world. Most naturally occurring phosphate sources are unavailable to the bird unless they are heat-treated during processing.

The phosphorus in most phosphate sources, with the exception of soft phosphate, can be regarded as close to 100% available. Some rock phosphates contain various contaminants of concern for poultry. The most common of these is vanadium. At just 7–10 ppm (7 g/tonne) of the diet, vanadium will cause loss in internal egg quality and hatchability. At slightly higher levels (15–20 ppm), there is a change in the shell structure; the shell takes on a somewhat translucent appearance and appears more brittle.

Rock phosphates can also contain as much as 1.5% fluorine. Because fluorine can influence calcium metabolism, there are often regulations governing the maximum permissible levels in feed. Only de-fluorinated rock phosphates are recommended but remember that this product usually contains about 5% sodium.

Sodium and Salt

Most diets will contain some added salt, usually in the form of sodium chloride. Where iodine is not added as a separate ingredient, iodized salt must be used. In most countries the various salt forms are differentiated by colour, with common salt being a natural white colour and iodized salt being red. Cobalt-iodized salt is often used in diets for swine and ruminants, and can be used without any problems for poultry. This type of salt is usually coloured blue. Because high levels of sodium chloride can lead to increased water intake, a substitution of sodium bicarbonate for a portion of regular salt has been shown to be beneficial. Under these conditions, up to 30% of the supplemental salt can be substituted with sodium bicarbonate without loss in performance. Birds fed such diets often produce drier manure. For substitutions of sodium bicarbonate for sodium chloride above 30%, care must be taken to balance dietary chloride levels, since under commercial conditions it is often difficult to add economical sources of chloride other than with salt.

There is a trade-off when substituting sodium bicarbonate for sodium chloride under heat-stress conditions. Birds will drink less when bicarbonate is used, and this is the reason for substitution. However, we have to question this scenario, since higher levels of water intake are correlated with survival under extreme heat stress conditions. Calcium, phosphorus and salt ingredients are described in Table 4.

Micro-Minerals

The trace minerals, or micro-minerals added to diets are usually copper, iron, manganese, zinc, iodine and selenium.

Copper

Copper oxide, sulphate and carbonate are used by the feed industry. Copper oxide can be of very low biological availability, especially with poor quality samples that contain significant amounts of metallic copper. Good quality copper oxide can be considered as available as copper sulphate.

Iron

Ferrous salts should be used in feed manufacture. As with copper, the major contaminant can be the metal itself, which has a very low biological availability. Ferrous carbonate and ferrous sulphate are the preferred forms of iron. Ferrous salts are prone to chemical change during storage, such that 10–20% of ferric salts can be produced from original ferrous forms after 3–6 months storage at around 25°C.

Manganese

The major source of manganese used in the feed industry is manganese oxide. Sulphate and carbonate sources both have higher biological availability, yet they are usually uneconomical to use. Manganese oxide has a biological availability of 50–70%, yet this can be greatly influenced by its major contaminant, namely manganese dioxide. Manganese dioxide is only 50% as bioavailable as is the oxide, and so an appreciable content of dioxide can lead to a marked reduction in the effectiveness of manganese oxide. Oxides should not contain more than 10% dioxides. The range of availability quoted in research findings is usually a reflection of dioxide contamination.

Table 4 Calcium, phosphorus and sodium sources

Ingredient	% Ca	% P
Limestone	38.0	-
Oyster shell	38.0	-
Calcium carbonate	40.0	-
Bone meal	26.0	13.0
Monocalcium phosphate	17.0	25.0
Dicalcium phosphate	21.0	20.0
Tricalcium phosphate	23.0	19.0
Defluorinated rock phosphate	34.0	19.0
Curaco phosphate	35.0	16.0
Phosphoric acid (75%)	-	25.0
Ingredient	% Na	% Cl
Plain salt	39.0	60.0
Iodized salt	39.0	60.0 (I, 70 mg/kg)
Cobalt iodized salt	39.0	60.0 (I, 70 mg/kg; Co, 40 mg/kg)
Sodium bicarbonate	27.0	-

Zinc

Zinc oxide and zinc sulphate are the most common forms of zinc used in the feed industry. Zinc is often used as a catalyst in various industrial processes, and unfortunately catalysts, which are of low biological availability, sometimes find their way into the feed industry. Zinc sources can be contaminated with aluminum, lead and cadmium. If good quality sources are considered, then zinc oxide and zinc sulphate appear to be of comparable biological availability.

Selenium

Selenium is most often added to feeds as sodium selenite or sodium selenate. The most common naturally occurring form of selenium is selenomethionine, and this seems to have a much lower potency than either of the salt forms. There seems to be a greater availability of selenium within low protein diets, although this may be related to the fact that when birds are growing at a slower rate their absolute selenium requirement is reduced. Selenium availability, from whatever source, is improved when diets contain antioxidants.

Ultimately, the choice of using inorganic versus organic minerals is one of economics. Results may vary depending upon the levels and spectrum of trace minerals used and the bioavailability to be expected from inorganic sources that are available.

Selenite is more readily reduced to elemental selenium, and for this reason selenate is some times preferred. Selenium metal is less available and can form insoluble complexes with other minerals. Whichever form of selenium is used, the final diet inclusions are extremely low in relation to the other minerals, and so some degree of premixing is essential prior to incorporation in diets or premixes.

Iodine

If iodine is added to a mineral premix rather than supplied with salt, potassium iodide and calcium iodate are the preferred sources. Potassium iodide is very unstable and deteriorates rapidly with moderate exposure to heat, light and/or moisture. Calcium iodate is the most common source of supplemental iodine.

Organic Minerals

Organic minerals are mixtures of inorganic mineral elements bonded to some type of carrier such as an amino acid or polysaccharide. They are usually much more expensive than inorganic minerals, and so one expects improved bird performance through either enhanced absorption or better utilization.

Inorganic minerals are likely to contain trace quantities of heavy metals such as arsenic, lead and cadmium. Such levels of heavy metals are not problematic to poultry, although the EEC has recently imposed limits of these metals in mineral premixes and complete feeds. While it is challenging to consistently achieve minimum levels using convention mineral salts, most organic minerals are very pure and usually contain no heavy metals.

Ultimately, the choice of using inorganic versus organic minerals is one of economics. Results may vary depending upon the levels and spectrum of trace minerals used and the bioavailability to be expected from inorganic sources that are available.

Feed Additives

A number of additives are often used in poultry diets and most of these do not contribute any nutrients for the bird. Most additives are used to improve physical diet characteristics, feed acceptability or bird health. The following discussion is not intended to emphasize the effectiveness of or need for the various products but rather to highlight various implications of their use in terms of diet formulation, ingredient compatibility and/or general feeding management.

When wheat or wheat by-products are used at less than 10% of the diet, a binder will often be necessary if high pellet durability is desired, which is often the case for broilers and turkeys.

Pellet Binders

When pellet quality is of concern, a pellet durability index is often ascribed to ingredients and this is considered during formulation. This index may range from 55–60 for corn soy diets that are notoriously difficult to pellet, to 90–95 for wheat-based diets. With corn-based diets, it is often necessary to use synthetic pellet binders in order to achieve desirable pellet quality. In most instances, the need for a good pellet is necessary to placate the purchaser of the feed, because the bird is often tolerant of a range of quality in terms of growth rate and feed efficiency. The turkey poult is perhaps the most sensitive to pellet or crumble quality: growth rate can be markedly influenced by both pellet size and the proportion of fines.

When wheat or wheat by-products are used at less than 10% of the diet, a binder will often be necessary if high pellet durability is desired, which is often the case for broilers and turkeys. The two major types of binders have lignosulfonate or colloidal clays as the base product, with inclusion levels of around 5–12 kg/tonne. The colloidal-clay products may also aid in reducing apparent moisture content of the manure and more recently, some forms of clay have been shown to have activity in binding some mycotoxins. The lignosulfonate pellet binders often contain 20–30% sugars, and so contribute to diet energy level.

Anticoccidials

Anticoccidials are used in diets for broilers and turkeys and young breeding stock that are reared on litter floors. Over the past 20 years, the so-called ionophore anticoccidials have predominated and they have proved most efficacious in controlling clinical signs of coccidiosis. From a nutritional viewpoint, some care must be taken in selection of these products as they can influence metabolism of the bird under certain situations.

Monensin has been a very successful anticoccidial, and works well with both broiler chickens and turkeys. Monensin, like most ionophores, Nicarbazin seems to accentuate the undesirable effects of heat stress, and, if inadvertently added to layer or breeder diets at normal anticoccidial levels, can cause loss in reproductive performance.

has an affinity to bind certain minerals such as sodium and potassium. Lasalocid also binds metals, although its major affinity is for potassium and, secondly, sodium. Ionophores have been shown to alter mineral availability, although this should not be of concern under commercial conditions where most minerals are present in excess of requirements

Ionophores, and monensin in particular, have an adverse effect when used in conjunction with very low protein (methionine) diets for young birds (20% less than normal). When low protein diets or feed restriction are employed for birds less than 21 days of age, alternatives to ionophores should be considered to alleviate potential growth depression, loss of uniformity and poor feathering. However, with normal diet protein levels, the ionophores do not have a measurable effect on amino acid needs. Ionophores and monensin in particular cause some growth depression in young birds, although this seems to be completely overcome with compensatory growth during the withdrawal or finisher period. For monensin, a 5–7 day withdrawal is optimum for compensatory gain, assuming that no major coccidiosis challenge will occur during this time. With minimal challenge, a non-medicated withdrawal diet is recommended, while in situations of high challenge, an alternative anticoccidial may be necessary.

There has also been some controversy on the relationship between wet litter and certain ionophore products. Lasalocid, in particular, has been associated with wet litter, and as such, recommendations are often given for reducing diet sodium levels when this anticoccidial is used. Under such conditions adjustment of chloride levels is often ignored, and, as a consequence, performance is sub-optimal. The relationship between ionophores and water intake has not been fully resolved other than the fact that birds fed monensin do seem to produce drier manure.

Non-ionophore anticoccidials are not used exclusively in chicken broiler production, although their use is often recommended in shuttle programs. Nicarbazin is an anticoccidial that works well in such shuttle programs, although again there are some potential problems with this product. Nicarbazin seems to accentuate the undesirable effects of heat stress, and, if inadvertently added to layer or breeder diets at normal anticoccidial levels, can cause loss in reproductive performance. Nicarbazin fed to brown egg birds turns their eggshells white within 48 hours although this is completely reversible when the product is withdrawn from the feed. Even low levels of nicarbazin can cause some loss in shell colour, and mottling of egg yolks, and loss in fertility and hatchability of breeders.

Amprolium is used in diets for growing breeder pullets because, unlike the ionophores, it allows some build-up of immunity. Amprolium induces a thiamin deficiency in the developing oocysts, and as such, has been queried with respect to thiamin status of the bird. In most instances thiamin deficiency will not occur in birds.

Coccidial vaccines are now used commonly in breeders, and their use will likely increase for broilers. There has been some discussion about diet manipulation so as to improve the immune response. Oocysts start to cycle when birds are 10 days of age, and if the litter is exceptionally dry this important cycling is less effective. Under such extreme conditions, it may be advisable to temporarily increase diet or water sodium levels, so as to stimulate water intake.

Antibiotics, Growth Promoters

There has been a gradual reduction in the use of antibiotics, although growth promoting agents are still used extensively for meat birds. The mode of action of growth promoting agents is comparable to that of antibiotics in terms of beneficial modification of gut microflora. In this context, the type of dietary ingredients used may influence the efficacy of these products because microbial activity is influenced by digesta composition. It is unlikely that growth promoters result in increased digestibility of feed; rather improvements in feed efficiency are a consequence of increased growth rate and hence reduced days to market.

Over the past few years, there has been criticism about the use of antibiotics in poultry feeds, especially with respect to the potential for build-up of microorganisms resistant to a specific antibiotic, and subsequent transfer of this resistance to known pathogens. In this context, the use of antibiotics such as penicillin, that are also used in human medicine, come under very close scrutiny.

The mode of action of growth promoting agents is comparable to that of antibiotics in terms of beneficial modification of gut microflora.

It is very difficult to grow broilers without the use of growth promoters, since clostridial organisms often proliferate and clinical necrotic enteritis develops. While some countries have a ban on sub-therapeutic growth promoters in the feed, their use is escalating as water additives. Without the use of such ‘antibiotics’, there will undoubtedly be greater risk of bacterial overgrowth in the bird’s digestive tract and especially when poorly digested ingredients are used since these provide substrates for microbial fermentation in the lower gut. Such enhanced microbial growth can have various consequences for the bird. If the microbes are pathogens, disease can occur. With proliferation of non-pathogens there can still be effective loss of nutrients to the bird and undoubtedly such conditions contribute to feed passage where feed particles can be seen in the excreta.

There will undoubtedly be future interest in developing nutritional strategies aimed at reducing our reliance on sub-therapeutic antimicrobials. In general, such strategies revolve around limiting the nutrient supply to the intestinal microbes, altering the gut environment so as to hinder microbial growth and/or priming or improving the bird's immune response (Table 5).

If diets are made more digestible, then theoretically, there should be fewer substrates available for microbial growth. The greatest success in this area will likely occur from developments in feed processing and greater application of exogenous feed enzymes. There seems great potential for modifying gut pH, either with use of feed or water source acids, or simply by stimulating gizzard activity. Many organic acids are bactericidal, and while some are corrosive, there are few limitations in adding them to diets in terms of stability of most other nutrients. While such acids may not have a dramatic effect on pH of the small intestine, products such as lactic acid are bactericidal over quite a range of pH.

Laying hens and especially broiler chickens today have very rudimentary gizzards. With increased gizzard activity, there will be greater acid production in the stomach and this is obviously bactericidal. Stimulating gizzard growth and actively may therefore become more important, and contribute to health management of the birds. There are often reports of higher digestibility of broiler.

Table 5: Nutritional strategies to reduce reliance on sub-therapeutic growth promoters

	Areas of study	Examples
1. Limit microbial growth by limiting their nutrient supply	Use more digestible ingredients	Corn vs small grains
	Feed processing	Pelleting, expansion etc.
	Use of feed enzymes	NSP, lipase?
	4. Reduce diet nitrogen	Increased use synthetic AA's
2. Limit microbial growth by manipulating digesta pH	1. Feed/water acids	Phosphoric, propionic, lactic acids
	2. Stimulate gizzard activity	Feed whole grain or large feed particles.
3. Improve immunity to infection	1. Vaccines	Coccidiosis
	Prime the immune system	Fatty acids, Vitamin E
4. Interfering with sites of bacterial attachment	1. sugars	Mannanoligosaccharides (MOS)

There are often reports of higher digestibility of broiler feeds when particle size of feed is reduced. However, in most of these trials, the young broilers likely have a rudimentary gizzard. For birds that have previously been fed larger size particles and/or more fibre, such that gizzard activity is increased, there is greater digestibility of feed with a larger particle size. Gizzard function is generally a factor of fibre content of the feed together with consideration of feed particle size.

Another potential substitute for antibiotics is mananoligosaccharides (MOS) (Table 5). Gram-negative bacteria have mannose specific fimbriae that are used for attachment to the gut wall. Mannan derivates from the cell wall of yeast offer the bacterial fimbriae an alternative binding site, and consequently are excreted along with the undigested mananoligosaccarhride. Adding 1–3 kg of MOS per tonne of feed depending on bird age will likely be part of future strategies for growing birds on antibiotic-free diets.

The other issue involving use of antibiotics and growth promoters in poultry feeds is the potential for tissue or egg accumulation of these compounds. Adherence to regulated withdrawal periods eliminates these problems, as does scheduling of mixing non-medicated and medicated feeds in the mill. Most countries are now establishing GMP and HACCP programs at feed mills so as to eliminate any potential for antibiotic residues in poultry products.

Antifungal Agents

In many regions of the world, molds and associated mycotoxins are major problems, affecting both growth and reproductive performance. Mycotoxins produced by both aerobic field molds and anaerobic storage molds can accumulate, often undetected, in a range of ingredients. A number of antifungal agents are available, most of which are based on organic acids. Mold growth may be controlled by altering the pH of the feed. However, any mycotoxin already present in feed will not be destroyed by these antifungal agents. Apart from their cost, these organic acids can accelerate the corrosion of metal feeders.

In recent years, there has been some interest in use of aluminosiliacates (zeolites) as an adsorbent of toxins. Unfortunately, relatively high levels of aluminosilicates must be used and these provide no other nutrients and may act as adverse binding agents for some essential minerals. However, where aflatoxin contamination is common, adding up to 15 kg aluminosilicates per tonne of feed may be necessary in order to minimize the effect of this mycotoxin.

In addition to, or as an alternative to using such antifungal agents, there is a potential for minimizing mold growth through formulation, diet preparation and feeding management. The feed surface area is directly related to fungal activity since the greater the surface area of feed exposed to the atmosphere, the greater the possibility of fungal spore colonization. This fact is the most likely cause for the increase in mold growth seen with feed as it travels from the mill to the feed trough because particle size is invariably reduced. Up to a 50% increase in fines can occur with high-fat pelleted broiler diets between the time of pelleting and consumption by the bird. At the same time, there is a 100% increase in the potential (and most often the occurrence) of fungal activity. In areas of potential mycotoxin contamination, there is an advantage to maintaining as large a pellet or crumble size as possible. The heat generated during pelleting has been shown to sterilize feed, to some extent, because fresh pellets have low fungal counts. However, pelleting will not destroy mycotoxins already formed prior to pelleting, and warm moist pellets are an ideal medium for fungal growth. Research has shown increased fungal activity in feed taken from trough as opposed to tube feeders with the former having more feed exposed to the atmosphere.

With toxins such as aflatoxin, there is a benefit to increasing the protein content of the diet, and, in particular, sulphur amino acids. It is possible that sulphates may also be beneficial in helping to spare sulphur amino acids that are catabolized during aflatoxicosis. Due to the specific enzyme system involved with aflatoxicosis, selenium at up to 0.4 ppm may be beneficial in overcoming major adverse effects of this mycotoxin. There have also been reports of niacin increasing the catabolism of aflatoxin B1, and thus decreasing overall toxicity.

Diet modification and feed management can be manipulated to minimize chances of mycotoxicosis. However, such measures will not likely be 100% effective, and fungal growth can be reduced if moisture content of grains and feeds is kept below 14–15%.

Probiotics and Prebiotics

Probiotics, unlike antibiotics, imply the use of live microorganisms rather than specific products of their metabolism. Since they are not specific molecules they are difficult to quantitate and even more difficult to describe in terms of modes of action. Probiotics can be classified into two major types – viable microbial cultures and microbial fermentation products. Most research has centred on *Lactobacilli* species, *Bacillus subtilis* and some *Streptococcus* species. Similar to the situation with antibiotics, the mode of action is still unclear although the following have been suggested:

- beneficial change in gut flora with reduction in population of *E. coli*;
- lactate production with subsequent change in intestinal pH;

- production of antibiotic-like substances;
- reduction of toxin release (suppression of *E. coli*).

With these varied potential routes of activity, it is perhaps not too surprising that research results are inconsistent. In most instances, the feeding of live cultures modifies the gut microflora of birds usually with increases in number of *Lactobacilli* at the expense of coliforms. A healthy animal has a preponderance of lactic acid producing bacteria, and so it is only under situations of stress, when coliforms often increase in numbers, that probiotics will be of measurable benefit. In this context there is interest in the use of live cultures administered (orally) to day-old poultry as a means of preventing harmful bacteria such as salmonella from colonizing the gut.

The term competitive exclusion is often used synonymously with probiotics. It is assumed that the probiotic will have a competitive advantage over any inherent pathogen and either replace it or prevent its colonization. Bacterial antagonism may arise due to synthesis of inhibitors by the probiotic organism. Lactic acid from *Lactobacilli* and other species is an example of such a product. Probiotic organisms may also stimulate mucosal immunity. While undefined mixtures of bacteria, usually derived from cecal contents of healthy adult birds, seem to be effective probiotics, regulatory agencies are often concerned about dosing animals with unknown organisms. Defined synthetic mixtures of bacteria seem less efficacious at this time, possibly because we have only scant knowledge of the normal (beneficial) microbial population within a healthy bird. However, this approach to developing a probiotic probably has the best long-term chance of success. With potential instability in most feeds for many *Lactobacillus* species, there has been recent interest in probiotics based on *Bacillus subtilis* species, because they possess a viable spore that has greater stability than do most lactic acid producing cultures.

Regardless of somewhat inconclusive results, probiotic use is increasing, and the animal industry looks to such products as the substitutes for conventional antibiotics. These products seem ideal candidates for genetic manipulation. By using genetic engineering, some researchers suggest that bacteria can be reformed to carry more desirable gene characteristics, including the production of digestive enzymes and antimicrobial substances.

Regardless of somewhat inconclusive results, probiotic use is increasing, and the animal industry looks to such products as the substitutes for conventional antibiotics.

Prebiotics are aimed at supplying probiotics with an advantageous source of nutrients, implying that their needs are different from those of the host and/or different from those of potential pathogens. Certain oligosaccharides, which resist endogenous enzyme degradation, seem to promote a more favourable microflora in the lower small intestine and

Enzymes are now being manufactured specifically for feed use, and can be broadly categorized as carbohydrases and proteinases and those for digesting plant phosphorus. Increasing the digestibility of various carbohydrate fractions of cereals and plant proteins has received most attention, although there is growing interest in the potential for improving digestibility of both plant and animal proteins.

also the large intestine. However, certain pathogenic bacteria, such as *Clostridium perfringens* are also able to ferment some of the oligosaccharides. There is some preliminary work with pigs suggesting synergism for certain combinations of prebiotics and probiotics, which is expected if both are efficacious.

Yeasts

Yeast, or single-celled fungi have been used in animal feed and the human food industry for many years. Brewer's yeast was a common feed ingredient in diets for monogastric animals prior to the identification of all the B-vitamins. Today, some nutritionists still incorporate these inactivated microbes as a source of so-called unidentified growth factor. More recently there has been an interest in the use of live yeast cultures. These cultures most often contain the yeast themselves and the medium upon which they have been grown. Yeast cultures are usually derived from *Saccharomyces* species, in particular, *Saccharomyces cerevisiae*. As with probiotics, their mode of action in enhancing animal performance is not fully understood.

Yeasts may beneficially alter the inherent gut microflora, possibly through controlling pH. The presence of living yeast cells may also act as a reservoir for free oxygen, which could enhance growth of other anaerobes. At the present time, there does not seem to be any move to manipulate yeast for specific purposes related to animal nutrition. To some extent, this relates to scant knowledge on mode of action, and so should more facts be uncovered in this area so-called designer yeast may be considered.

Enzymes

Enzymes have been added to poultry diets every since workers at Washington State University showed improvement in digestibility of barley and rye-based diets when various enzymes were used. More recently, corn and wheat diets have predominated; these were assumed to be highly digestible and so there was little interest in feed enzyme application. Over the past few years, this area of nutrition has gained interest and activity due to the economics of small grain use and also because of a better understanding of mode of action and availability of various enzymes. Enzymes are now being manufactured specifically for feed use, and can be broadly categorized as carbohydrases and proteinases and those for digesting plant phosphorus. Increasing the digestibility of various carbohydrate fractions of cereals and plant proteins has received most attention, although there is growing interest in the potential for improving digestibility of both plant and animal proteins. Currently, enzymes are used most commonly to aid digestion of diets containing wheat, barley and rye where improvements are seen in dry matter digestibility and also in consistency of the excreta. There is also current interest in enzymes designed specifically to improve soybean meal digestibility.

The term non-starch polysaccharides (NSP) is now frequently used to describe what in the past has been referred to as fibre. Birds have a very limited ability to digest fibre because they lack the enzymes necessary to cleave these large and complex molecules. In animals such as the pig, and in ruminants, it is the resident microbial populations that synthesize cellulase type enzymes that allow for varying degrees of fibre digestion. If we can improve digestion of the complex carbohydrates, we not only increase potential energy utilization, but also remove any negative impact that these products may have on gut lumen activity and excreta consistency.

The NSP content of cereals and other by-product feeds is usually inversely proportional to their conventional energy level. These NSP components are most often associated with the hull and underlying aleurone layers. In order for normal endogenous enzymes to contact the starch endosperm, these outer layers must be disrupted or chemically degraded. Although many compounds fit into the category of NSPs, there are three main types of importance in poultry nutrition. These are the β-glucans in barley, the arabinoxylans in wheat and the raffinose group of oligosaccharides in soybeans.

Most cell wall NSPs exist either alone or as structural material often complexed with protein and indigestible lignin. Solubility of NSPs usually relates to the degree of binding to lignin and other insoluble carbohydrates. In water, most NSPs produce a very viscous solution, which has a predictably negative effect on digesta flow in the gut. Any increase in digesta viscosity causes reduced digestion and absorption. The increased gut digesta viscosity also influences the gut microflora and there is an indication that their overgrowth may add to the overall deleterious effects. To the poultry producer, the most notable effect of NSPs will be wetter, more sticky and viscous excreta.

Table 6 shows levels of NSPs commonly found in cereals and soybean meal. Oligosaccharides as found in soybean meal are perhaps the most complex structures within the NSPs and have proven difficult to digest with exogenous enzymes.

Addition of feed enzymes could therefore improve NSP availability, and, just as important, reduce the negative impact that these undigested residues have on digesta viscosity and manure consistency. Normal

Addition of feed enzymes could therefore improve NSP availability, and, just as important, reduce the negative impact that these undigested residues have on digesta viscosity and manure consistency.

Table 6: Non-starch polysaccharides in selected ingredients (%)

Ingredient	Cellulose	Arabinoxylan	Pectin	β-glucans
Corn	2.5	5.0	0.1	-
Wheat	2.5	6.0	0.1	1.0
Barley	4.8	7.0	0.2	4.0–5.0
Soybean meal	5.0[1]	0.5	12.0	–
1 depending on hull fraction returned				

digestion requires unimpeded movement of enzyme, substrate and digestion products throughout the digesta and especially close to the absorptive gut wall. As the viscosity of the digesta increases, the rate of diffusion decreases, which causes reduced digestibility of all substrates. The undigested viscous digesta subsequently translates to very sticky excreta which causes problems of litter management. Reduction in digesta viscosity is therefore highly correlated with efficacy of enzymes that can digest substrates such as β-glucans. In oats and barley the bulk of the NSPs are β-glucans, whereas in wheat and rye arabinoxylans predominate. Enzymes tailored for barley therefore contain β-glucanase enzymes, while those designed to improve wheat digestibility should contain xylanase and arabinoxylanase enzymes.

The most widely used feed enzyme is phytase. Phytase cleaves the phytic acid in soybean meal and cereals to release phosphorus and calcium. Phytic acid, a complex structure that binds phosphorus tightly, is the main storage source of phosphorus in plant material. Few animals produce the phytase enzyme necessary to digest the molecule and so phytic acid is largely undigested. Interest in the phytase enzyme arose because phosphorus has become an expensive nutrient, and undigested phytic acid adds greatly to manure loading of phosphorus. Phytate also binds other trace minerals and may conjugate with proteins and carbohydrates. Digestion of the molecule, therefore, can potentially release trace minerals, amino acids and energy, as well as calcium and phosphorus.

There are variable results reported for efficacy of phytase in commercial diets. Diet calcium level is perhaps the major factor in such variance, since high levels of calcium seem to reduce the effectiveness of phytase enzyme. However, if this is true, one wonders why phytase enzymes seem so efficacious in layer diets that contain from 4–4.5% calcium.

Each 500 units of phytase activity are equivalent to about 1 g of phosphorus as provided by sources such as di-calcium phosphate. Using 500 FTU of phytase/kg feed therefore provides the equivalent of 0.1% phosphorus in the diet.

Pigments

The yellow to orange color in avian fatty tissue is caused by various carotenoid pigments. These pigments control the colour of the egg yolk, the shanks and beaks of layers, and the skin colour that may be important in meat birds. The xanthophylls are the most important carotenoids in poultry nutrition; natural ingredients rich in these compounds are alfalfa meal, corn gluten meal and marigold petal (Table 7).

Table 7 Xanthophyll content of selected ingredients (mg/kg)

Ingredient	Xanthophyll
Corn	20
Wheat	4
Milo	1
Alfalfa meal	175
Corn gluten meal	275
Marigold petal	7,000

Corn contains much more xanthophylls than do other cereals, although high levels of pigmentation can only be achieved from natural ingredients by including other products such as alfalfa and corn gluten meal.

The various xanthophylls differ in their effect on skin and yolk pigmentation. β-carotene has little pigmenting value, although pigments such as zeaxanthin, as found in corn, is more easily deposited, while there is a very high incorporation rate of synthetic products such as β–apo-8-carotenoic ethyl ester. The zeaxanthin in corn tends to impart the darker orange-red colors, whereas the luteins, as found in alfalfa, cause a more yellow colour. Pigments are destroyed by oxidation, and so addition of antioxidants to feed, and general feed management applied to fat protection also apply to preservation of pigments.

Coccidiosis, malabsorption and certain mycotoxins will all reduce pigment absorption. Pigmentation in the young meat bird is directly proportional to pigments fed throughout growth. For the laying hen, however, yolk colour is a consequence of pigments consumed in the layer feed and the transfer of pigments accumulated in the skin and shanks when the bird was immature. This transfer of pigments to the ovary occurs regardless of diet pigments, and is responsible for the bleaching effect of the shanks and beak of yellow-skinned birds over time.

Because many of the naturally carotenoid-rich ingredients are low in energy, it is difficult to achieve high levels of pigmentation of meat birds without using various synthetic sources. Canthaxanthin, astaxanthin and β-apo-8-carotenoic acid (where allowable in poultry diets) can be used to impart the spectrum from yellow to orange/red colouration in either skin or egg yolk. As described more fully in

Chapter 4, there is now interest in enriching eggs with lutein, since this carotenoid is known to be important in maintenance of eye health in humans. Future designer eggs may well contain concentrated levels of lutein.

Flavouring agents

The chicken is not usually considered to have the ability to select feed based on flavour, or taste/smell. The chicken has only about 24 taste buds in comparison to 9,000 in humans and 25,000 in cattle. Relatively few studies have been conducted with flavouring agents for poultry, and for this reason, care must be taken in extrapolating data from other species. For example, sucrose octaacetate solution is reported to be readily accepted by birds, but universally rejected by humans. There seems little scope for use of flavouring agents with broiler chickens and turkeys that already seem to be eating at near physical capacity. However, there may be some potential with breeders for identification of agents that are distasteful to birds, as an aid in limiting their feed intake.

Flavour agents may be beneficial in masking any unpalatable ingredients and for maintaining a constant feed flavour during formulation changes. Flavours may also be useful tools in masking any undesirable changes in drinking water during medication. Use of a single flavour agent in both feed and medicated water may prevent some of the refusals seen with medicated water, especially for turkey poults.

Worming compounds

Most floor grown birds are exposed to infection from various species of worms. In many instances such challenge can be prevented or minimized with the use of anthelmintic agents. Products based on piperazine and hygromycin have been used most commonly over the last 15–20 years. Piperazine used in diets for laying birds has been shown to result in discoloration of the yolk. One report indicated about 4% incidence of discoloured yolks which appeared as irregular areas of olive to brownish discolouration when piperazine was administered at 28-day intervals.

Such yolk discolouration is most pronounced in summer months especially after prolonged storage at regular egg cooler temperatures. The mottling of yolks seen with another commercial product has been compared to the mottling seen with calcium-deficient birds, suggesting a similar mode of action. However, we are unaware of any published reports relating worming compounds to calcium deficiency and problems with shell quality.

Odour control

Various extracts of the yucca plant are claimed to reduce ammonia levels in poultry houses. A soluble component of the yucca plant seems able to bind ammonia, preventing its release from manure, which is especially important in confinement housing systems. Most poultry will react adversely to 50 ppm ammonia; this is in contrast to the level of 20–30 ppm which is the usual detection range for humans. Various commercial products have been shown to reduce environmental ammonia levels by 20–30%, and this has been associated with improved growth rate and reduced mortality.

Review Questions

1. Is water quality a problem on your farm? If so, which minerals are over the limits suggested in Table 3 in this chapter?

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2. Which nutrients affect levels of immunity?

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3. Can one safely feed higher levels of minerals and vitamins than a bird requires?

4. What causes rickets in humans?

5. Which mineral can, if present in adequate amounts, help overcome the effects of a mycotoxin?

8 Anthelmintics and Parasiticides for Poultry

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Control of Internal Parasites

Intestinal worms and coccidia are commonly diagnosed during necropsy of pullets, cockerels and occasionally broilers and turkeys. A preventative deworming program is suggested in rearing breeders to reduce the incidence and severity of intestinal worms. Severe intestinal worm infestations can cause diarrhea, poor absorption of nutrients, and enteritis. Clinical signs commonly seen with intestinal worm infestations include rough feathering, retarded growth, pasty vents and pale birds. Worms can be carriers of infectious diseases, including Blackhead, which is caused by *Histomonas meleagridis,* in turkeys.

The only approved anthelmintic for deworming poultry in Canada is for administration in water or feed (Piperazine 34 and Piperazine 52, Vétoquinol; Piperazine Dihydrochloride, Dominion; Co-op® Wormer 52%, IPCO; Super Pip-Zine 34, Dominion) to eliminate roundworms (*Ascaridia galli*). Piperazine is commonly used in both preventative and treatment programs. Due to its widespread use, poultry producers and veterinarians suspect roundworms are building some resistance against this drug, possibly resulting in more intestinal worm outbreaks.

Currently, there are no approved drugs in Canada for treatment of *Capillaria* spp. (hairworms), *Heterakis gallinarum* (cecal worms), *Syngamus* (gape worm) or tapeworms in poultry. As a result, poultry veterinarians may need to prescribe the extralabel use of dewormers such as albendazole (Valbazen®, Pfizer); fenbendazole (Safe-Guard®, Intervet) and ivermectin (Ivomec®, Merial). Veterinarians should contact the Canadian gFARAD (www.cgfarad.usask.ca) regarding extra-label use and withdrawal periods if these products are prescribed.

Coccidia are the most important parasites of poultry, both in terms of distribution, frequency, and economic losses. On-farm control of coccidiosis is a fine balancing act between ideal exposure to stimulate immunity and infection at a level that causes production losses or overt clinical disease.

Preventative drug use is more important than therapeutic drug use because most of the damage occurs before clinical signs are apparent in affected birds.

After natural infection, birds develop species-specific immunity to coccidia; the degree of immunity depends on the extent of infection and the number of re-infections the bird experiences. If an anticoccidial medication is too effective it can prevent natural immunity from developing, leaving the birds more susceptible to clinical disease if medications are discontinued. Yet, if not effective enough, losses from decreased weight gain and feed efficiency are extremely costly to the poultry producer.

Subclinical coccidiosis increases the susceptibility of birds to other disease agents, including *Clostridium*, *E. coli*, *Salmonella*, Marek's disease virus, infectious bursal disease virus, infectious bronchitis virus, and mycotoxins. Therefore, current control strategies involve reducing challenge from infectious oocysts, encouraging natural immunity in the birds, and preventing outbreaks of clinical and subclinical disease.

Medications are labeled either for therapy of clinical disease (therapeutic medications) or for prevention of clinical disease (coccidiostats). Preventative drug use is more important than therapeutic drug use because most of the damage occurs before clinical signs are apparent in affected birds. When clinical disease is present, water medications are preferred over feed medications for therapeutic treatment. Antimicrobials and supplementation with vitamins A and K may be included in the feed ration to improve recovery rate and prevent secondary infections.

Continuous use of anticoccidial drugs promotes the emergence of drug-resistant strains. Poultry veterinarians may recommend that producers use one anti-coccidial continuously through succeeding flocks, rotate anticoccidials used on a farm every 4-6 months, or treat a group of birds sequentially with different drugs (a shuttle program). Changing drug classes may be beneficial when resistance is detected on a farm. "Shuttle programs" are common practice in many countries, and offer some benefit in reducing emergence of drug resistance.

To limit the problems associated with drug resistance and continuous drug treatments, and to help ensure uniform and target weight birds, live vaccines are available that can be administered by spray in the hatchery or by feed or water application the first few days in the brooder house.

All treatment and vaccination strategies must be supported with effective biosecurity. The use of disinfectants with efficacy against coccidia oocysts reduces challenge pressure, which is important in reducing sub-clinical infection and clinical disease outbreaks while still allowing immunity to develop in the birds.

Therapy of Clinical Coccidiosis

Only sulfonamide antimicrobials and amprolium are useful for treatment of clinical coccidiosis in poultry.

Amprolium (Amprol® 9.6% Solution, Amprol® 25% Feed Mix, Merial) is an analogue of thiamine (Vitamin B_{12}) approved for the control of coccidiosis in poultry. The solution formulation is labeled for the treatment of clinical caecal coccidiosis in growing chickens and laying birds. The feed mix is labeled for chickens and turkeys (but not laying birds in production) for the prevention of coccidiosis. Coccidia are 50 times more sensitive to the affects of thiamine deficiency than poultry and mammals, so amprolium has a wide safety margin. Amprolium is more effective as a preventative than as a treatment for clinical coccidiosis. When the amprolium products are used according to label recommendations, no meat withdrawal time is needed.

Sulfonamide antimicrobials are approved for the treatment and prevention of coccidiosis in chickens and turkeys. These are the most effective treatments for outbreaks of clinical coccidiosis. Sulfamethazine (Sulfa "25", PVL; Sulfa 25% Solution, Bimeda-MTC; Sodium Sulfamethazine Solution 12.5% and 25%, Dominion) and sulfaquinoxaline are approved for use in poultry. Sulfaquinoxaline is used, either alone (Sulfaquinoxaline 19.2% Liquid Concentrate, Dominion) or in combination with pyrimethamine (Sulfaquinoxaline-S, Medprodex; Quinnoxine-S, Vetoquinol).

Para-aminobenzoic acid (PABA) is a precursor of folic acid, which must be acquired by bacteria and coccidia from their environment in order to synthesize nucleic acids. The cells of mammals and poultry utilize dietary folate for synthesis of folic acid and do not require PABA. Sulfonamides are PABA analogues, so when they are taken up instead of PABA, coccidia are unable to complete normal nucleic acid synthesis. Pyrimethamine inhibits an enzyme in the next step of the folic acid pathway for nucleic acid synthesis, so the combination of pyrimethamine with a sulfonamide is extremely synergistic.

Producers need to be careful to follow label directions for use and ensure that sulphonamide drug withdrawal times are followed to avoid violative residues in poultry products. A hemorrhagic syndrome has been reported in poultry and dogs treated with sulfonamides. It is most often reported with the use of sulfaquinoxaline in chickens for coccidiosis and in dogs given the products labelled for poultry.

Producers need to be careful to follow label directions for use and ensure that sulphonamide drug withdrawal times are followed to avoid violative residues in poultry products.

Sulfaquinoxaline is a vitamin K antagonist that causes an effect similar to that of warfarin (the anticoagulant found in rat poison). Sulfaquinoxaline may have additional adverse effects on coagulation; this may explain why supplementation of feed with vitamin K does not always prevent the syndrome in chickens. Rapid discontinuation of medication and initiation of therapy with vitamin K may reverse the effects.

Prevention of Coccidiosis

Coccidiostatic drugs are administered in poultry feed to prevent disease and the production losses associated with subclinical infection.

Ionophore antibiotics are *Streptomyces* fermentation products used in agriculture primarily for feed efficiency and anticoccidial activity. They alter the function of the cell membrane and cause the coccidia to rupture. Although ionophore antibiotics are used for growth promotion in cattle and pigs, they do not promote growth in chickens and may reduced rate of growth if administered to chickens not exposed to coccidiosis.

The prophylactic use of all antimicrobials as growth promotants in food animals has fallen under greater scrutiny due to fears of the spread of antibiotic resistance. Because of the complexity and high degree of specificity of ionophore resistance, it appears that ionophores do not contribute to the development of antimicrobial resistance to important human drugs and they should not be eliminated from use in animal feeds. However, some ionophores are now completely ineffective against avian coccidia.

The relative toxicities of the ionophores from lowest to highest are salinomycin < lasalocid < or = narasin < or = monensin (but lasalocid < monensin) < maduramicin. Ionophore toxicity causes cellular electrolyte imbalances, elevating extracellular potassium and intracellular calcium, resulting in severe cellular damage and death.

The dose necessary to cause toxicity is variable among species, with horses being the most sensitive and turkeys being more sensitive than chickens. Skeletal and cardiac muscle cells are generally the most severely affected; however, the specific tissues affected and resulting clinical signs vary from species to species. Skeletal muscle is primarily affected in dogs, ostriches, sheep and turkeys. Cardiac muscles are affected in cattle, and both myocardium and skeletal muscles are damaged in horses.

Age-related differences in ionophore sensitivity occur in poultry, with adult birds more sensitive to the toxic effects of ionophores than young birds. Ionophore toxicity occurs from dose errors in mixing with feed, accidental ingestion of treated feed by sensitive species, ingestion by cattle and sheep of poultry litter from maduramycin-treated flocks, concurrent administration with a medication that potentiates toxicosis, or accidental feed mill contamination of presumably untreated feed.

Ionophore toxicity occurs from dose errors in mixing with feed, accidental ingestion of treated feed by sensitive species, ingestion by cattle and sheep of poultry litter from maduramycin-treated flocks, concurrent administration with a medication that potentiates toxicosis, or accidental feed mill contamination of presumably untreated feed.

Heat stress and water deprivation exacerbate toxicity in chickens when lasalocid is administered at one to two times the recommended dose.

Ionophore antibiotics may adversely affect the hatchability of eggs. Lasalocid, maduramicin, monensin, and salinomycin are not labeled for use in replacement or laying chickens. Maduramicin, lasalocid and monensin are not labeled for use in replacement or breeding turkeys. When used according to label directions there are no meat withdrawal times for most of these products. With extra-label use (for laying birds, for example) prescribing veterinarians should consult the Canadian gFARAD for extralabel withdrawal information.

Monensin (Coban® Premix, Elanco; Monensin Premix, Bio Agri Mix) is a fermentation product of *Streptomyces cinnamonensis*. It is active against coccidia and *Toxoplasma*. Do not feed concurrently with tiamulin or severe growth depression may occur.

Lasalocid (Avatec® Medicated Premix; Alpharma) is a similar ionophore to monensin. It is extremely toxic to horses.

Salinomycin (Bio-Cox® 120 G, Alpharma; Coxistac® 6% Premix and 12% Premix, Phibro; Sacox® 120; Huvepharma AD; Salinomycin 60 Premix, Bio Agri Mix) is toxic to turkeys and causes excessive mortality at the label dose for chickens. Like monensin, it should not be fed concurrently with tiamulin.

Maduramicin (Cygro® 1% Premix, Alpharma) is approved for broilers and turkeys and has a 5 day meat withdrawal time when used according to label directions. Reduced rate of growth and no improvement in feed efficiency occurs if feed concentrations of 6 parts per million are administered to chickens not suffering from coccidiosis.

Narasin is available alone (Monteban® 70, Elanco) or in combination with **nicarbazin** (Maxiban®, Elanco). Narasin is approved for use in broilers and has a four-day meat withdrawal time when used according to label directions. It is toxic to turkeys, dogs and horses.

Nicarbazin (Nicarb®, Merial) was the first product to have truly broad-spectrum activity that is still in common use. Nicarbazin is an equimolecular complex of two synthetic chemicals, DNC (4,4-dinitrocarbanilide) and HDP (2-hydroxy-4,6-dimethylpyridine). Nicarbazin is toxic for layers, and a 4-day withdrawal period is required in for the combination product with narasin. Medicated birds are at increased risk of heat stress in hot weather.

Clopidol (Coyden®; Hyvepharma AD) is a coccidiostat approved for use in broilers and replacements for caged layers up to 16 weeks of age. When used as directed, there is no meat withdrawal time necessary.

Decoquinate (Deccox® 6 Premix, Alpharma) is a quinolone coccidiostat that arrests the coccidia in an early stage of development. It is approved for use in broilers with no meat withdrawal time when used according to label directions.

Diclazuril (Clinicox® 0.5% Premix, Schering-Plough) is a benzeneacetonitrile derivative anticoccidial used in broiler chickens and turkeys. Diclazuril is often effective against ionophore-resistant coccidia and strains resistant to various other drugs such as amprolium, clopidol, robenidine, and zoalene. When used as directed, there is no meat withdrawal time necessary.

Robenidine (Robenz®, Alpharma) is labeled for use in broiler and turkeys. It is a guanidine compound that allows initial intracellular development of coccidia but prevents formation of mature schizonts, thereby preventing reproduction. Drug resistance may develop during use. A six-day withdrawal period is needed to eliminate unpleasant flavor caused by residues in poultry meat.

Zoalene (Zoamix®, Huvepharma AD) is a nitrobenzamide coccidiostat approved for use in broilers, replacement chickens and turkeys. When used as directed, there is no meat withdrawal time necessary.

The major groups of insecticides include botanicals, pyrethrins, synthetic pyrethroids, organophosphates, and carbamates.

Control of External Parasites

There are many insecticides available to help control external poultry parasites. Follow all manufacturers' recommendations when using all insecticides. Insecticides are not drugs and their control falls under the Pest Control Products Act. Therefore, it is illegal to use these products in an extra-label manner, and poultry veterinarians cannot authorize extra-label use even by prescription. The major groups of insecticides include botanicals, pyrethrins, synthetic pyrethroids, organophosphates, and carbamates.

Rotenone (Co-op® Louse Powder, IPCO; Dri-Kil™ Louse Powder, Engage) is an extract of the derris root. It inhibits the target insect's respiratory systems. Rotenone is more toxic to birds and mammals than the pyrethrins and pyrethroids, but is still safe for general use.

Pyrethrins and Permethrin (Disvap®, Vétoquinol; Ectiban® 25 Fly Killer, Engage): The pyrethrins are a collection of six natural insecticidal esters derived from *Chrysanthemum* plants, which appeals those who want a "natural" product. They have excellent knockdown activity and very low avian and mammalian toxicity. But they are easily decomposed by UV light, so have poor residual activity. Their activity can be prolonged by microencapsulation or by addition of stabilizers.

Pyrethrins are almost always combined with piperonyl butoxide, a synergist that helps prevent pyrethrin breakdown. Permethrin is a synthetic analog of pyrethrin that has been altered to a more stable molecule with longer residual activity, thus making it ideal for treating facilities and equipment. At reduced concentrations it can be applied directly to the birds.

Malathion (Malathion 50, Vétoquinol) is an organophosphate approved for topical use on poultry and for premise spraying. It is one of the safest organophosphate compounds. The organophosphates bind to and inhibit the enzyme acetylcholinesterase, causing paralysis and death of the insects.

Carbaryl (Dusting Powder, Dominion; Sevin®, Vétoquinol) is a carbamate insecticide. The carbamates also inhibit acetylcholinesterase, but differently than the organophosphates. Carbamates compete for enzyme active sites utilizing a process known as carbamylation, a reaction which blocks the action of the enzyme without changing it structurally. Carbaryl is also a very safe insecticide.

Review Questions

1. What is the most important parasite in poultry in terms of both economic loss and prevalence? Why is it so difficult to control?

2. Why should a particular drug never be fed on a continual basis?

3. Only two types of medications can be used to treat coccidiosis. What are they?

4. What are ionophores?

5. What does the term “extra label” mean?

6. Why won't your veterinarian prescribe an insecticide for extra label use?

9 Pest Control and Management

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What is a pest? It is a general term for organisms (rodents, insects, etc.) which may cause illness or damage or consume food crops and other materials important to humans an organism that is considered a nuisance to man. In this chapter we will cover basic pest control and management using various means, including pesticide types, uses, storage and safety.

In today's world of food health safety and economic pressures, one cannot just throw anything at a problem: a systematic educated approach is necessary for success. We have to understand the pest's breeding, feeding habits and development cycles, because simply killing the pests, instead of solving the pest problem, leads to routine and repeat use of pesticides and the pests need to be killed over and over. It is often more economical to control the breeding and development cycle or use the habits to target the organism, than to actually kill the pest. This chapter will describe some of the life cycles of some common pests, and methods to control them.

Pesticides (liquids, solids and gases) are categorized as fungicides, herbicides, insecticides, and rodenticides. This chapter will deal with insecticides and rodenticide. All of these products need to be absorbed or consumed by the organism to cause damage or death. Because the products kill by absorption, and some organisms need multiple doses of certain products to become toxic, the survivors become the breeders and pass on the resistance to their progeny. The progeny then become more resistant to that product and the killing effect is diminished. To help combat this problem a regular change in pesticide active ingredients as indicated by the label, is imperative.

Handle these products with care and use protective equipment as described on the label.

Insects

There are many different types of insects that are pests to the poultry industry. Regardless of the type or form, learning the lifecycle and habits of the organism will increase our chances of control. Insecticides come in many forms.

Solutions

- active ingredient dissolved in liquid: water or organic solvent (oily)

Emulsions

- oily solutions dissolved in water and emulsifier

Wettable Powders

- mixed with water which make suspensions that need agitation

Powders

- ready to use

Granules

- make active ingredient distribution easier

Logo	Text	Oral LD_{50}* (mg/kg)
Octagon	Danger Poison	0 –500
Diamond	Warning Poison	500–1000
Triangle	Caution Poison	1000–2500

LD_{50}* (mg/kg)	Classification	Approximative Dose
0–50	Extremely toxic	< 1 teaspoon
50–500	Very toxic	1 ounce
500–2500	Moderately toxic	10 ounces
> 2500	Slightly toxic	20 ounces

*LD_{50} is the median lethal dose, the dose required to kill half the members of a tested population.

Safety is extremely important. Take note of Warning Symbols and amounts needed for toxic results. Remember that these products work from the inside and can be readily absorbed into the body; with prolonged or repeated exposure they can accumulate to toxic levels in your system. We also need to also be aware of the environment these levels can build up in. It could cause harm to other species. Follow the instructions on the label and use all the recommended protective equipment as indicated. Safe work involves everyone; no one is exempt.

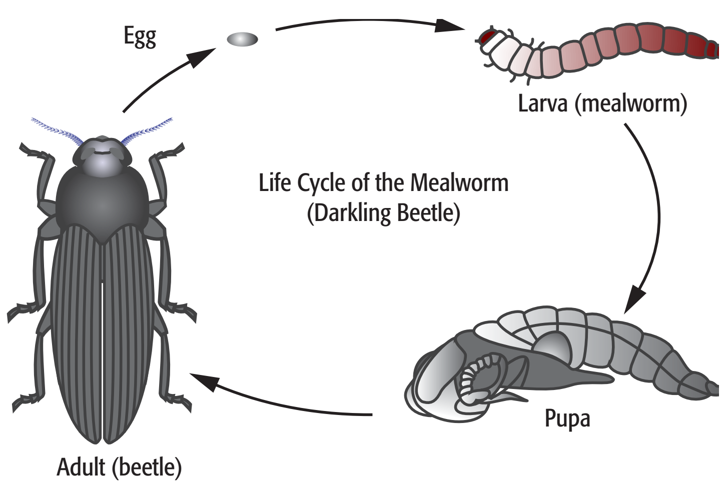
The following are some common insect pests and strategies to controlling them.

Darkling Beetle

These beetles are a large problem in the poultry industry. They can carry diseases which will cause death to birds. They are considered a nuisance to the human population. The darkling has a simple life cycle, from egg to larva (sometimes called a meal worm) to adult. This could take anywhere from 42–97 days to complete depending on the temperature. A single beetle can live up to one yeare and can lay upwards to 800 eggs at a time. They feed on poultry feed and grain that is molding. They live in the chaff on the floors, and in the walls of the buildings. They cannot transport food, and thus must come from the walls to feed. They do not need water to survive; they are able to get enough moisture from the food they consume.

Control

The pupa does not eat; the larva or meal worm consumes enough to last though the transformation to adulthood. Since they are growing and eating in the same area as the production birds, there are no

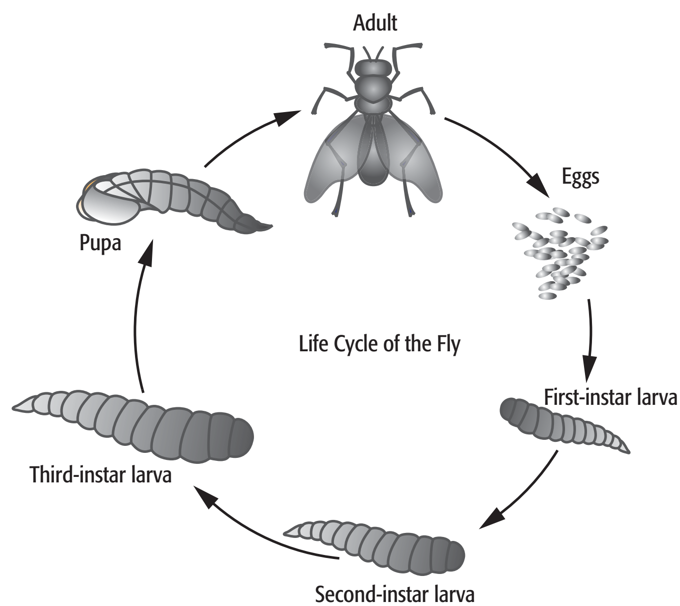


insecticides safe enough to use for control during production. This leads us to a small window between batches. They need heat to survive and move to the walls when the barn floor is cooler. Current products are contact poisons for underneath the chaff so that the beetle walks through the poison which attaches and ultimately absorbs into the body to toxic levels. To increase our chances for the beetle to be in contact with the product we should make a path between the wall and the chaff after the animals leave and before we cool the barn.

We can spray the product in that area, and up the walls where they will climb, then cool the barn, allowing the beetles to naturally move to the walls and contact the product on their way. Then clean the barn, spray again, lay the chaff and re-warm the barn for the next flock. This will result in the beetles coming down from the walls to feed and those that did not die from the initial contact, being exposed again. Remember: always follow the instructions on the label.

Flies

House flies always seem to be around no matter where we are. These are flying insects and can move long distances. Flies can also carry diseases, and are considered pests. They can lay up to 1,000 eggs in a lifetime and can go from egg to adult in as little as five days, depending on temperature. There are several methods for controlling flies.



Space Sprays

These products are used for a flash kill, and are effective in controlling adult flying organisms. These products will dissipate in the air and have a short target time. Be aware that if used in the presence of production animals or humans continuous use can result in toxic levels being absorbed by non-target animals, and cause damage to them. These products are only effective against adult flies that happen to be in target range. There is also a possibility of built-up resistance to a specific product with continuous use.

Wall Spray

Wall sprays normally have longer active periods. These products have to be applied out of the birds' reach, to avoid ingesting or absorbing the product. The most economical process is to observe sitting habits before applying and apply on those areas if possible. Again, these are made for contact to the adult population. Dust and other attractants will be adsorbed and make the product less potent and available. Resistance with continuous overuse is possible.

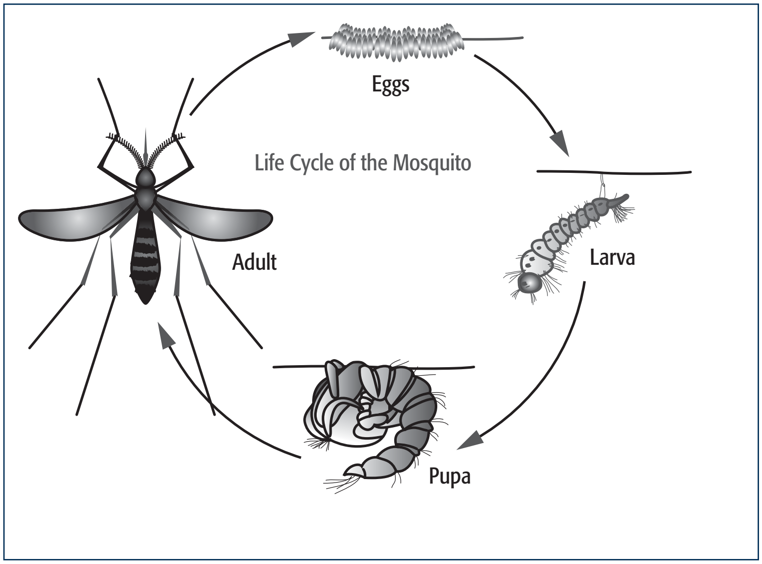
Granular Bait

These products contain attractants to draw the fly to them. They must be kept out of the non-target animal's way. Moisture can be a problem considering that sugar is normally an attractant medium. This focuses on the adult population and can build resistance with continuous use.

Alternative Measures

These are normally sticky tape, wires or glue traps. The fly lands on the strip and cannot get off. These are non-chemical means and are good for the environment. To get efficient placement, watch the patterns and apply them in high pest traffic areas. These products are for the adult flying population and are very good for population estimation.

All of these methods are good for control in different situations. However they all still lead to the possibility of a new generation being hatched and re-infesting the control area. The final area for control is the breeding area. Flies are born in organic matter and live their first stages in it. If there is a way to remove this organic matter or make the development area less favourable, the livability of the new generation would be greatly reduced. This would result in fewer adults to kill and thus less product to use.



Mosquitoes

Many products come in the same form as the fly products, and the results are similar. The difference is in the life cycle.

A mosquito develops in stagnant water, even as little as 1 cm deep. Therefore, if we want to control the breeding area, movement of water or removal of stagnant water will decrease hatching and thus decrease the adult population.

Learning the habits or life cycles of insects can result in less use of insecticides and result in a healthier environment, and lower the costs.

Rodenticide

Left untouched in ideal conditions a single pair of mice can reproduce over 500 progeny in one year; 500 mice can consume upward to 500 kg of feed.

Rodents can cause disease transfer and also can cause extensive damage. The two main organisms are mice and rats. The breeding cycles of the two are similar, but the number of development days differ. However, the habits are different and one has to tailor practices to increase success. Left untouched in ideal conditions a single pair of mice can reproduce over 500 progeny in one year; 500 mice can consume upward to 500 kg of feed. The main source of killing the rodent is through rodenticides. These are consumed and kill from toxic level build ups. Rodents have the ability to communicate and warn others of danger and because of this most bait has a delay kill on them. This delay will make them think the bait is okay and not warn others of it. This will allow others to consume it also.

Mice

Mice like to hide and not be seen. They normally only seen at quiet times. If one is seen in a busy time, it is normally scurrying from hiding spot to hiding spot. Mice also do not need water to live; they can get enough to live from the feed it consumes. Mice continuously urinate when walking, thus leaving a scent trail to be followed by others in the future. All of these factors are important in station placements for better effectiveness.

Before considering station placement and rodenticide uses, discourage breeding areas and make it more difficult for animals to enter a building. Mice need an area to burrow in and hide; thus, cleaning up debris in and around the barn would be beneficial.

To discourage barn entry, a two-foot barrier (at least) of gravel that is kept clean will help; mice have a fear of being caught by birds and try to avoid open areas. Next, any holes bigger than the size of a pinky finger should be sealed. Remember to look up as well as down, as mice are very good climbers. To seal a hole, the best practice is to spray it with 10% bleach solution to break the previous mouse scent trail then stuff the hole with coarse steel wool and seal with non-permeable material. The bleach will discourage new mice from finding past trails and holes; the steel wool is a substance that mice can not chew through.

Bait stations are excellent tools in controlling mice. The stations are a great place to hide and while they are there they can chew on the bait. These stations are made for to hold block baits. Mice are proficient hoarders, and they tend to hide a large portion of their food for rainy days. This could be a problem, because non-target animals could consume the bait. This is why blocks are important to use in the stations: blocks force them to eat right at the site, because in the stations the blocks are secured.

There are other forms of the bait such as pellets and mash. These are good for areas that are protected and non-active (attics, for example). The mice will feel more comfortable to sit and eat and not take the food away. Here is another area in which we can be more efficient. Mice move near the edge of the walls, and like to hide. Thus, stations, whether for live traps or bait stations, would have a better chance in their path.

Rats are somewhat different from mice. Rats need a source of water in order to survive; therefore, you will never find them further than a couple hundred feet from water.

Rats

Rats are somewhat different from mice. Rats need a source of water in order to survive; therefore, you will never find them further than a couple hundred feet from water. They have a social hierarchy and only the top Alphas and some of the Betas do the breeding. The lower

Wear personal protective equipment when removing dead rodents. They still can carry diseases after they die, diseases which are transferable to humans.

hierarchy Omegas are usually kicked out of the burrows and sent to find and test food. Rats are larger and can only fit through holes at least as big as your thumb. They also have similar fears of overhead prey and therefore do not like being in the open.

Non-rodenticide procedures are the same as for mice. Place gravel barriers around the barn, seal holes, and clean up debris, thus making it uncomfortable for them to move and breed.

Blocks secured in stations are important, because these animals are bigger and could carry a block. The stations are good for the animals that are running around, mostly Omega rats. A more efficient way to control the population is to find the burrows and put bait down the holes; this ensures that it gets close to the Alpha rats. When the Alpha rats consume the bait and die, breeding is halted for a while until new Alphas are established. The Beta and Omega rats will fight to the death to become Alphas. To add to the breeding delay, once action ceases at the burrow, break the hole down or fill it in. They will have to make another before continuing. The more you increase the delay, the fewer rats there are to get rid of.

Rodenticides are poison and can leave residues on your hands when handling. Make sure you use protective equipment when handling the bait. Also, rodents do not like the smell or taste of the oils from your hands and the bait will not be as attractive to them. A final warning: wear personal protective equipment when removing dead rodents. They still can carry diseases after they die, diseases which are transferable to humans. Remove the dead rodents because they are another source of food for other.

Pests can come in many forms, and controlling them is an important part of health and biosecurity measures in the barn. With all the advancements in poisons, control is easier. However, it is important to note that the lifecycle and habits of the organisms are just as important. This information helps us be more efficient with the poison we use and also helps us use less poison. We need to work smarter, safer and be more environmentally sound to compete in the market place.

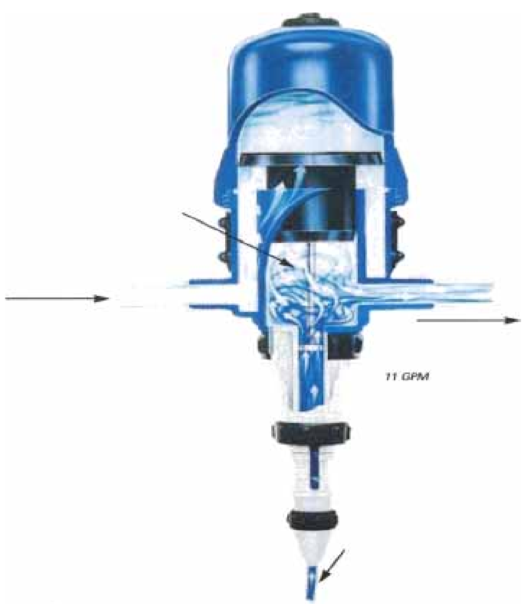
10 Medicators – Use and Calibration

David Van Walleghem

There may be a time when even through your best efforts in biosecurity, you still need to medicate. One of the most efficient ways to medicate is through the water. In the face of a disease, birds may have suppressed appetites, but they always drink. This chapter deals with how to water medicate properly and economically.

There are two main types of medicators, one which is mechanical and one which has electrical moving parts. The electrical moving part medicator is similar to what you see in a hospital where a tube is inserted into a mechanism that squeezes out the product. You do not normally see these in a barn situation due to the moving parts and the need for constant replacement of the injector hoses. The more common one is the water-powered mechanical medicator (see diagram 1).

Diagram 1



The beauty of working with a ratio is that it does not matter what system you work in: the principle is the same.

In this medicator the water fills a chamber which is attached to a pump. As the chamber rises with the increased water, it pulls the piston in the pump which pulls into it a portion of medication from a stock solution. Once the chamber fills to its maximum amount a valve is triggered, the water in the chamber is released and the chamber falls. The valve is reset and the process continues. This is a pulse type system where measured amounts of stock are released every time the chamber empties, giving large concentrated stock into the lines. However, because the water takes time to reach the birds, the medication has time to dissipate into the line making the water the right concentration for drinking.

Medicators are proportional systems as described above and the unit to measure the proportional amounts is called a ratio. Most medicators work on a 1:128 ratio: this means that 1 part comes from the stock and 127 parts come from the water source, which, when combined, equals 128. The reason that this became popular is because there are 128 oz in a gallon and when the medicators were developed the Imperial system was the most popular measurement system. This means 1 oz to 128 oz, or 1 gallon of final volume.

Another common ratio is 1:256 which in the Imperial system is ½ oz per gallon. The beauty of working with a ratio is that it does not matter what system you work in: the principle is the same. For example, in the Metric system, 1:128 would mean 1 millilitres:128 millilitres, since normally we work in full litres and 1000 millilitres (ml) = 1 litre, the conversion would be approximately 8ml:1 litre or in the case of 1:256 is approximately 4ml:1 litre. The only thing you have to remember is that you have to use the same unit of measurement on both sides of the ratio. One advantage of using the metric system is that you can go between a solid to a liquid easily because 1 ml is equal to 1 gram. This works well because we measure the drinking water as a liquid, but most of the medications we use are powders. Most over-the-shelf products and veterinarian-recommended medications have the stock solution concentration worked out for the producers for a particular stage of production.

Example: 2 grams of active ingredients in a litre of water for 5 days.

Think of a big tank theory – use a chart and determine how much water your birds will drink in the five days.

1. For example, 1000 broilers in week 2.
   They will drink 67 ml/bird/day.
2. Therefore 67 x 1000 = 67000 ml or 67 liters/day.
3. We need enough for 5 days so… 67 x 5 = 335 litres.
4. We need 2 grams/litre of drinking water (final water):
   335 x 2 grams = 670 grams or 0.67 kg in total.
5. Now apply the ratio of the medicator – say 1:128 or 1 litre of stock to 127 litres of extra water to make up 128 litres of drinking water.

Total water consumed is 335 litres 335/128 = 2.6 litres of total stock needed.

Remember: the final stock volume needs to be 2.6 litres. Therefore:

- A solid will dissolve, thus one needs 670 grams of medication and 2.6 litres of water.
- A liquid will use part of the stock volume; therefore we would need 670 ml of medication and 1.93 litres of water, which will together make 2.6 litres of stock.

These calculations are only as accurate as the information we have and give to the veterinarian or whoever is figuring out the stock. We need to make sure the numbers are accurate by checking if the medicators are working correctly. The medicators should be checked at least a couple of times per year. If we don't check and we indicated that the medicator was working at 1:128 and if it was really working at 1:100, we would be overdosing the birds and could kill them or result in a longer withdrawal: or if it were 1:200 we are under-dosing the birds and the medication may not have the same effect and again can change the withdrawal.

To test the medicators put a known stock volume (1 litre is a good measurement) and fill a tank from the outgoing water until the stock (litre) is gone. Measure the final volume in the same units as the stock (litres). This final number is the ratio because you started with 1 unit in your stock and ended up with the final volume.

Some medicators can be adjusted to what is wanted; otherwise you need to inform whomever is mixing the stock to adjust accordingly. It would be a good practice to perform this test before a new batch in case there is need to use it in that batch.

The next important number is the consumption. If there is no chart available you can determine it yourself. Presumably, you checked your ratio at the beginning of the batch and recorded it. All that is left to do is to make a stock of water that is big enough to last a 24 hour period. Measure the stock before starting the test, and again at the end of the 24 hours. The missing amount, times the ratio, will give you the total amount of water consumption in a day. This is the most accurate way to determine proper consumption for the production birds in your poultry house, and to give the most accurate dosing of any medication.

Your flock may drink a different amount than the chart. This could be because of climate, growth rate, genetics, or many other factors. This gives validity to dry runs (running the medicator while the batch is on with just plain water as the stock). This gives us an accurate consumption of the flock at the time in the conditions present. These dry runs also are useful just before a standard medication (pulse medication) is planned in the flock to make sure the medicator is working properly. If it is not, it gives you time to fix it before the planned pulse medication needs to be administered.

An example:

1. Start with 1 x 20 litre pail (5 gallons).
2. After a 24 hour period 15 litres are left. Therefore 20 – 15 = 5 litres.
3. The ratio is working at a 1:256 ratio with 10,000 birds. 5 x 256 = 1280 litres total consumption/10,000 birds = 0.128 liters or 128 ml per bird.

Cleaning the medicator is important. Medications don't all get along; some react with others and may cause precipitation of product which will gum up the line and affect the ratio, but, more seriously, might alter the medication and make it useless. Also, some medications left sitting in the apparatus could damage seals or injector tubes, which will result in them needing replacing. It is a good practice to run some clean water stock through the medicator right after a medication run. This will help clean out any residues that might be lingering and have it ready for the next run.

The public is watching food producers very closely so when you are using any medications you must be accurate. Accuracy is important for withdrawals and ultimately food safety. This helps sell the final product.

A bonus in being accurate is economics, because the pharmaceutical companies have done numerous tests to prove effectiveness of their products and the best rate and time to utilize them. This information can help you, your veterinarian, and/or whoever helps develop a plan for a flock to develop the best path to use for your advantage. The simple tests in this chapter will help you benefit from the advantages in your plan to increase the health and growth in your flock.

Review Questions

1. You do a dry run to insure your medicator is working properly. You fill up a 20 liter (5 gallon) pail with the out put from the medicator. In that time you use 156 ml of stock. What is your medicator ratio set at?

2. You need to find out how much product you need to medicate your birds for 5 days. You know your medicator is running at 1:128 ratio. You do a dry run and find they use 12 liters in a 24 hour period. The package says to use 2 grams per liter of drinking water for the 5 days. How much product do you need? What concentration is the stock?

A1 Food Producer Calculations Made Easy

David Van Walleghem
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This chapter deals with calculations necessary in daily operations.

Reading Labels

Trying to read a label today can be very confusing. We deal in two main types of measuring systems – Imperial and Metric. Which one does the label use? Let's start with some basic math.

1 US gal = 128 oz
1 L = 1000 ml
1 US gal = 3.79 L (or ≈ 4 L)
1% = 0.01 = $^{1}/_{100}$ = 1 part in 100***
1 part ⇒ 1 g, 1 kg, 1 ml, 1 L, 1 oz, 1 gal,...
1 ml H_2O = 1 g H_2O (= 1 cm^3 H_2O)
1 % = 1 g/100 ml (= 10 g/L)
1 oz/US gal ≡ $^{1}/_{128}$ (≈ 8 ml/L)
$^{1}/_{2}$ oz/gal ≡ $^{1}/_{256}$ (≈ 4 ml/L)

Using Distributing Systems

There are two main types of distributing systems: the Medicator (Dosatron) and the Venturi pump. Both of these systems work on ratios. A ratio means the amount of product drawn from the stock solution by the apparatus compared to the amount of water drawn from the main source. For example, a 1:128 means 1 ounce is drawn from the stock and 127 ounces from the main water system to make up 128 ounces of drinking water.

The Medicator (Dosatron) works with no electrical parts, just water pressure. The water enters a chamber, and the chamber lifts. The chamber is attached to a pump which draws some of the stock solution into it. Once the chamber is filled, a valve triggers the camber and the entire product released into the line. This system has a high ratio and is great for water medications, which will have time to dissipate in the lines, but it is not as good for extremely fast movement demands as washing.

In the Venturi pump system the high pressure water is forced into a funnel-type apparatus, then immediately in an inverted funnel. This action causes a suction effect, and if there is a hole at the exchange place, the product will be sucked up and mixed in the turbulent area. Orifices of various sizes are used: the smaller the orifice, the less product uptake. This procedure normally has a low ratio and is great for the washing and cleaning process.

Cleaning with Detergents

Why bother using detergent? Some people say, “I have high pressure and extremely hot water. And I disinfect anyway.” That method does not work very well and actually costs more money.

When using detergents properly the washing time is cut by 30–50%, a huge bacterial load is washed away and the surface is more prepared for the disinfectant to perform efficiently. Bacteria and viruses are able to make themselves a protective coat called biofilm. This biofilm is very sticky and holds very well to surfaces, even in high pressure washes. This film is also very hard to penetrate by the disinfectant. Detergents, however, unstick the biofilm, allowing the washing procedure to wash it away. One can reduce the bacteria/virus load 85–90% with this alone.

There are two main types of biofilms, one that is slimy and greasy, for which you need an alkaline detergent (Biosolve, Chlor-a-Foam) to remove, and one that is a mineral (scale) for which one needs an acidic detergent (Biofoam, Acid-a-Foam).

Warm water definitely helps the workability of the detergents. However, water which is too hot (above 60°C) bakes the protein onto the surface and makes it extremely hard to take off.

Now that we understand the process we can prepare the surface by physically removing excessive organic material. Next, apply the detergent on the surface in an amount that is similar to that which you would use if you were painting a surface. How much paint (detergent) do you need? First measure all the surfaces you want to wash.

length x width = surface area

Remember that you have four walls, a ceiling, a floor, and equipment. Below is a calculation for a simple room of 100 x 50 x 10 feet tall.

Floor	100 x 50 =	5,000	
Ceiling	100 x 50 =	5,000	
Walls side	100 x 10 = 1,000 x 2 =	2,000	
Walls end	50 x 10 = 500 x 2 =	1,000	
Total		**13,000**	**sq ft**
Equipment	10% more surfaces		
	13,000 x 10% (or 0.1) =	1,300	sq ft extra
Total	**13,000 + 1,300 =**	**14,300**	**sq ft total**

Next, determine how much product you need. A rule of thumb is 250–300 ml/ square metre to soak a room (paint the walls).

10 sq ft =	1 sq m
14300/10 =	1430 sq m
250 ml/1 sq m to soak a room	
250 x 1430 =	357,500 ml or 357.5 litres (paint to do the whole room)

Now determine how much pure product is needed according to the label.

Product label says 1:100 or 1 part in 100 or 1%	
We need 358 litres total and 1% has to be product so, 1% x 358 litres =	3.58 litres of product (the rest is water)

If you put the entire 358 litres with the 3.58 litres in it in a large tank you can just draw from that and you can paint and apply the detergent to the entire room. However, most people do not have a 400 litre tank, or need a lot more than that and thus use a distributing system.

One of the most efficient methods of distribution is through a Venturi pump type system. These systems come in many forms from foam guns to back packs to inline injectors, all of which will work well. The only thing you need to know is what the ratio is for your specific apparatus – in other words, how much is drawn from the stock in comparison to the final outcome. The easiest way to measure is to take 1 litre in the stock and see how much water is produced out of the gun when the litre is used up. Once we know the ratio, we can determine the stock concentration as below.

Example A Venturi pump works at a 15:1 ratio (for every 15 litres of final solution, 1 litre comes from stock and 14 come from the water supply If the final is 358 litres 358 /15= 24 litres of stock needed; in that stock we need 3.58 litres of pure product. Remember the final stock volume msut be 24 litres. Thus, it will include 3.58 litres of pure product and 20.4 litres of water. A solid will dissolve; therefore, one could use 3.58 kg and 24 litres of water.

Review

1. Measure and add surface areas
2. Determine the amount of water needed to wet all surfaces
3. Find the working dilution rate of the degreaser
4. Find the amount of product needed
5. If using a distribution system, divide by the ratio

Let the detergent sit for a minimum of ten minutes to do its work. Detergents work best when they are rinsed off (power washed) before they dry on. However, if they do dry on before rinsing off, simply rehydrate them with a mist of water. If you mist them, you are diluting the detergent and making them less effective.

One last point on detergents: cheaper is not always cheaper. Cheaper detergents require more product in more challenging areas (such as a farm production facility), while a more expensive one will have a set working concentration no matter how great the challenge. More expensive detergents are cheaper to use per square metre than cheaper products.

Once the surface dries, it is ready for the disinfectant. The choice and amount are both equally important. Bacteria/viruses come in different forms, enveloped and non-enveloped. The difference is the outer layer; the enveloped has a fat layer. This makes it soft and easier to penetrate. The less fat and more protein, the harder it is to penetrate, and thus the organism is harder to kill.

Some of the products are a lot more expensive than the others. However, they kill more effectively and, therefore, you get what you pay for. The extra cost for the higher end disinfectants is minimal compared to the increase is production, or the decrease in medications, not to mention the decrease in labor to detect, calcuulate and administer the medications. To keep costs down let's be as accurate at painting on the disinfectant as we were with the soap.

Let's use a different room with multiple floors for this calculation.

Floor	200 x 100 =	20,000	
Ceiling	200 x 100 =	20,000	
Walls side	200 x 10 = 2,000 x 2 =	4000	
Walls end	100 x 10 = 1,000 x 2 =	2,000	
Total		**46,000**	**sq ft**
Equipment	15% more surfaces		
	46,000 x 15% (or 0.15) =	6,900	sq ft extra
	6,900 + 46,000 =	52,900	total
How many houses? 3			
	52,900 x 3 =	158,700	sq ft
	10 sq ft = 1 sq m		
	158,700 /10 =	15,700	sqm
	250 ml/1 m^2 to soak a room		
	250 x 15,700 =	3,967,500	ml
	or	3967.5	litres
Product label says	1:250 or 1 part in 250 or 0.4%		
	We need 3,968 litres total and 0.4% has to be product 0.4% x 3,968 litres =	15.87	litres of product

Now let's use a different Venturi ratio. A Venturi pump works at a 12:1 ratio (for every 12 litres final solution, 1 litre comes from stock and 11 from the water supply).

If the final amount is 3,968 litres 3,968/12 = 330.6 litres of stock needed, and in that stock we need 15.87 litres of pure product. Remember the final stock volume needs to be 330.6 litres therefore liquid 15.87 litres of pure product and 314.72 litres of water Use 15.87 kg of stock and 330.6 litres of water.

Rules

- Do not apply on very wet surfaces (possible further dilution of product)
- Apply evenly and softly (like painting)
- Wet all surfaces to just almost (normally 250ml/10 sq ft)
- Let all products sit for a minimum of 10 minutes after application before proceeding to the next step. (Let it do its work.)
- Do not use water temperatures in excess of 140°F.

There may be a time when, in spite of your best efforts in cleaning, you still need to medicate. Most off-the-shelf products and medications recommended by veterinarians, the stock solution concentration will be calculated for you, but I thought it would be good to go through an example of how this is done.

Example: 2 grams of active product in a litre of water for 5 days.
Think of a big tank theory – use a chart and figure out how much total volume of water your birds will drink in the 5 days.

Assume that have 1,000 broilers in week 2. They will drink 67 ml/bird/day.
Therefore, 67 x 1000 = 67000ml or 67 litres/day and we need enough for 5 days so
67 x 5 = 335 litres
We need 2 grams/litre of drinking water (final water)
335 x 2 grams = 670 grams or 0.67 kg in total.

Now apply the ratio of your medicator – say 1:128 or 1 litre of stock to 127 litres of extra water to make up 128 litres of drinking water.

Total water consumed is 335 litres
335/128 = 2.6 litres of total stock needed
Remember the final stock volume needs to be 2.6 litres.
Use 670 grams of solid and 2.6 litres of water.

Be certain that your medicators are working correctly. They should be checked a couple of times a year. If they are a 1:100 instead of 1:128, you are overdosing the birds and could kill them, or thus could result in a longer withdraw: or if it is 1:200 you are under-dosing them and the medication may not have the same effect. All one needs to do is to put a known stock volume (1 litre is a good measurement) and fill a tank from the outgoing water until the litre is gone. Measure the final volume and you have the ratio. Some medicators can be adjusted to what is wanted; for others you should inform your veterinarian of the difference so they can adjust the stock accordingly. It would be a good practice to perform this test before a new batch in case there is need to use it in that batch. Also if you ever need to determine how much the birds are drinking you have the ratio and can see the disappearance of the stock over a period of time and. Do the math to figure out how much is consumed.

Food producers we are, and now mathematicians! We need to understand and apply products to their most effective and safest state to get the most out of our dollar.

A2 Common Conversions

After determining the correct volume of water to be treated, use this formula to calculate the correct amount of material to use:

Amount of material needed =
volume x conversion factor x ppm desired x (100/% active ingredient)

Volume = volume of water to be treated. Can be any volumetric units of measurement – cubic feet, litres, gallons, acre-feet.

Conversion factor =
the weight of material that must be added to one unit volume of water to give one part per million (ppm). See below for conversion factors.

ppm desired = the treatment rate desired in parts per million (ppm)

% active ingredient =
the percent ingredient of the material to be used. Most materials used in treating fish diseases or aquatic weeds are 100% active or are considered to be 100% active for treatment purposes.

Weight of chemical that must be added to one unit volume of water to give one part per million (ppm)

2.72 pounds per acre-foot	= 1 ppm
1,233 grams per acre-foot	= 1 ppm
1.233 kilograms per acre-foot	= 1 ppm
0.0283 grams per cubic foot	= 1 ppm
0.0000624 pounds per cubic foot	= 1 ppm
0.0038 grams per US gallon	= 1 ppm
0.058419 grains per US gallon	= 1 ppm
0.07016 grains per Imperial gallon	= 1 ppm
1 milligram per litre	= 1 ppm
1 microlitre (μL) per litre	= 1 ppm
0.001 gram per litre	= 1 ppm
8.345 pounds per million gallons of water	= 1 ppm

NOTE: The metric prefix ' milli ' does NOT mean a millionth, it stands for a thousandth. A prefix table can be acceessed from http://www.simetric.co.uk/siprefix.htm

Some associated conversion factors*

1 acre-foot	= 43,560 cubic feet
1 acre-foot	= 325,850 gallons
1 acre-foot of water	= 2,718,144 pounds
1 cubic foot of water	= 62.4 pounds
1 cubic foot of water	= 6.24 Imperial gallons
1 US gallon of water	= 8.34 pounds
1 Imperial gallon of water	= 10 pounds
1 US gallon of water	= 3,785 grams or 3.785 kg
1 litre of water	= 1,000 grams = 1 kg (approx)
1 litre of water	= 1,000 cubic centimetres (cc)
1 cubic metre	= 1,000 litre
1 cubic metre	= 1 metric tonne of water (appx.)
1 US fluid ounce	= 29.57 grams
1 US fluid ounce	= 1.043 ounces (av)

*See www.onlineconversion.com

Definition of PPM

This is a way of expressing very dilute concentrations of substances. Just as per cent means out of a hundred, so parts per million or ppm means out of a million. Usually describes the concentration of something in water or soil. One ppm is equivalent to 1 milligram of something per liter of water (mg/l) or 1 milligram of something per kilogram soil (mg/kg).

Ppm (parts per million) to % (parts per hundred)

Example

1 ppm = 1/1,000,000 = 0.000001 = 0.0001%

10 ppm = 10/1,000,000 = 0.00001 = 0.001%

100 ppm = 100/1,000,000 = 0.0001 = 0.01%

200 ppn = 200/1,000,000 = 0.0002 = 0.02%

5000 ppm = 5000/1,000,000 = 0.005 = 0.5%

10,000 ppm = 10000/1,000,000 = 0.01 = 1.0%

20,000 ppm = 20000/1,000,000 = 0.02 = 2.0%

The metric system is the most convenient way to express this since metric units go by steps of ten, hundred and thousand. For example, a milligram is a thousandth of a gram and a gram is a thousandth of a kilogram. Thus, a milligram is a thousandth of a thousandth, or a millionth of a kilogram. A milligram is one part per million of a kilogram thus, one part per million (ppm) by mass is the same as one milligram per The kilogram. Just as part per million is abbreviated as ppm, a milligram per kilogram has its own symbolic form – mg/kg, which unlike ppm is unambiguous.

- By mass:
  - one milligram in a kilogram is 1 ppm by mass.
  - one milligram in a metric tonne is 1 ppb by mass.
- By volume:
  - one millilitre (or cubic centimetre) in a cubic metre (or kilolitre) is 1 ppm by volume. For most gases (those behaving much like an ideal gas) this is numerically equivalent to µmol/mol on the basis of molecules (not atoms). See Avogadro's law.
- By mass/volume ratio for dilute aqueous solutions (ppm *w*/*v* or ppm *m*/*v*):
  - 1 litre (L) of water has mass of approximately 1 kg, so 1 milligram per litre (mg/L) or 1 microgram per millilitre (µg/ml) is, loosely speaking, 1 ppm, and 1 microgram per litre (µg/L) is 1 ppb, for small concentrations in a water solution.

– ppm (or ppmm) is also sometimes used to describe small concentrations in water, in which case 1 ppm is equivalent to 1 mg/l because a liter of water weighs approximately a 1000 g. This use of ppm tends to be phased out in favour of mg/l.

Parts Per Million – Some Interesting Comparisons

- One part per million is one second in 12 days of your life.
- One part per billion is one second in 32 years of your life.
- One part per million is one penny out of $10,000.
- One part per billion is one penny out of $10,000,000.
- One part per million is one pinch of salt on 20 pounds of potato chips.
- One part per billion is one pinch of salt on 10 tons of potato chips.
- One part per million is one inch out of a journey of 16 miles.
- One part per billion is one inch out of a journey of 16,000 miles.
- One part per trillion is a six inch leap on a journey to the sun.
- One part per billion is one square foot in 36 square miles.
- One part per trillion is a postage stamp on an area the size of Texas.
- One part per million is approximately one bogey in 3,500 golf matches.
- One part per billion is approximately one bogey in 3,500,000 golf matches.
- One part per million is approximately one bad apple in 2,000 barrels.
- One part per billion is approximately one bad apple in 2,000,000 barrels.
- One part per million is approximately one lob in 1,200 tennis matches.
- One part per trillion is approximately one error among all the words of all the front page stories in all the issues of more than 2,000 daily newspapers in the United States if their publication had started with the invention of moveable type for the printing press.

A3 Biographies of our Authors

Randy Carriere, Intervet Canada

Randy Carriere was born and raised in Winnipeg Manitoba. He received a Bachelor of Agricultural Sciences (Animal Science) from the University of Manitoba in 1997. He has worked in the agricultural industry since 1989, holding positions with Feed Rite(Ridley), Landmark Feeds(Maple Leaf), Elite Swine Inc.(Maple Leaf) and Intervet Canada.

He has worked primarily in feed sales for poultry and vaccine sales.

Randy has served as technical sales representative with Intervet Canada for the poultry industry in Western Canada for the past five years. He shares his knowledge and experience with producers through seminars and tradeshows, as well as by providing educational materials and participating in the Poultry Serviceperson Industry Workshop planning committee since 2004.

Dr. Patricia Dowling

Dr. Patricia Dowling is a Professor of Veterinary Clinical Pharmacology at the Western College of Veterinary Medicine at the University of Saskatchewan in Saskatoon, Saskatchewan. She is a graduate of Texas A&M University (BSc in Animal Science and DVM) and of Auburn University (MS in Large Animal Medicine and Surgery). She is also a Diplomate in The American College of Veterinary Internal Medicine and The American College of Veterinary Clinical Pharmacology.

Dr. Dowling received the University of Saskatchewan's Student Union's Teaching Excellence Award in 2005 and the Norden Distinguished Teacher Award in 1995.

She is one of the editors of Antimicrobial Therapy in Beterinary Medicine, published by Iowa State University Press and Handbook of Veterinary Drugs (Lippincott, Williams and Wilkins). She was a contributing editor for the Cattle Medicine Course published by Alberta Agriculture in 2005.

Dr. Dowling has extensive experience working with animal health and food safety including research dealing with oxytocin residues, the use of antimicrobials in food animals, and BST.

Dr. Tom Inglis

Dr. Tom Inglis works for Poultry Health Services Ltd. providing diagnostic and flock health consulting for Alberta poultry producers. He works out of the Airdrie Agricultre Centre building and contributes data generated from diagnostic and field investigations to the passive disease surveillance database for the Agrifood Systems Branch.

Tom was born in Saskatoon and raised in Vermilion and Edmonton where he attended the U of A, completing a BSc. in Agriculture. Tom's career working in the poultry industry started with the Alberta Poultry Research Centre and poultry program at the U of A where he worked with Dr. Frank Robinson and Dr. Doug Korver. He is a graduate of the Western Canadian Veterinary College in Saskatoon.

He trained under Dr. Jim Hanson and Dr. Detlef Onderka in addition to working at the Aviagen diagnostic lab in Newton, Scotland. Tom also completed an externship at the University of Georgia's Poultry Diagnostic and Research Center.

His primary areas of interest are preventative medicine, diagnostics and production management.

Tom is an avid fly fisherman and also enjoys hunting, hiking, camping, skiing, playing guitar and cooking.

Dr. Steve Leeson

Dr. Steve Leeson is the Chair of the Department of Animal and Poultry Science at the University of Guelph. He is a prolific researcher, with 325 papers in refereed journals, 500 papers for scientific and industry meetings and six books on various aspects of poultry nutrition and management.

Dr. Leeson received a Diploma in Poultry Technology at Harper Adams College in England, a Master of Philosophy at the University of Nottingham, and a Doctor of Philosophy at the University of Nottingham. His area of research at the University of Nottingham was poultry nutrition.

He has received numerous awards during his career, including the American Feed Manufacturers Nutrition Research Award, the Ontario Agricultural College Distinguished Research Award, the Canadian Society of Animal Science Industry Extension Award and the Canadian Society of Animal Science Lifetime Achievement Fellowship.

Dr. Leeson's research interests include feeding programs for laying hens and broilers and nutrient enhancement of eggs and meat.

David Van Walleghem

David Van Walleghem obtained his BSA, specializing in Animal Science, at the University of Manitoba. He has extensive experience in livestock mangement, including managing an 80 cow dairy herd for Van Crown Dairy Inc. and managing a 10,000 animal finisher operation for Triland Inc..

David has also worked in the Health Division of Elite Swine Inc. (Maple Leaf Agra Division) where he also co-ordinated the Genetics program.

He is currently with Sheridan, Heuser, Provis where he is involved in biosecurity, production animal health testing, and production animal trials.

He also owns and runs Bio-Vantage Agri-Consultants where he consults on biosecurity issues. Vétoquinol is one of the companies for which he consults.

Dr. Craig Wilkinson

Dr. Craig Wilkinson is the Director of Animal Care in the Faculty of Agricultural, Life and Environmental Sciences at the University of Alberta. This Faculty encompasses research using a wide variety of species, including agricultural species, traditional laboratory animals, and wildlife. Craig is responsible for ensuring that high standards of animal care and use are practised in compliance within the guidelines of the Canadian Council on Animal Care and provides consultative services to researchers with respect to technical procedures and animal health issues. He also teaches undergraduate courses in Animal Behaviour and Welfare, and Animal Health to animal science and pre-vet students, regularly lectures in other courses, and develops and provides training for users of poultry, swine and cattle in research.

Craig earned a B.Sc.(Honors) in Zoology at the University of Alberta (1986) and a DVM from the Western College of Veterinary Medicine in Saskatoon (1990). In 1990 and 1991, Craig worked in mixed animal veterinary practice and then became a founding partner in a companion animal practice in Edmonton, where he spent five years. In 1996 he left full-time private practice and took on the role of Operations Manager and Veterinarian at the Edmonton Humane Society Animal Shelter. He joined the University of Alberta in his current position in the summer of 2001. Craig also continues to practice companion animal medicine part-time at several clinics in the Edmonton area. He has served as a board member of the Alberta Farm Animal Care Association since 2003, and is currently Chair of the Animal Welfare Committee for the Alberta Veterinary Medical Association.

Dr. Wilkinson was named Alberta SPCA Veterinarian of the Year in 1998, and received the Alberta Veterinary Medical Association Communication Award the same year. He received the Louis D. Hyndman Sr. Award in 2004 for contributions to improving the welfare of animals used in research at the University of Alberta.

A4 References

Links

Alberta Veterinary Medical Association – www.avma.ab.ca
Canadian Veterinary Medical Association –
www.canadianveterinarians.net
Saskatchewan Veterinary Medical Association – www.svma.sk.ca
British Columbia Veterinary Association – www.bcvma.org
Western College of Veterinary Medicine – www.usask.ca/wcvm
Health Canada – www.hc-sc.gc.ca
University of Alberta – www.ualberta.ca
University of Saskatchewan – www.usask.ca
University of British Columbia – www.ubc.ca
Agriculture Canada – www.agr.ca
Canadian Food Inspection Agency – www.inspection.gc.ca
Compendium of Medicating Ingredient Brochures –
www.inspection.gc.ca/english/anima/feebet/mib/cmibe.shtml
Alberta Agriculture Food and Rural Deveopment – www.agric.gov.ab.ca

Boards and Associations

Alberta Egg Producers
#101, 90 Freeport Boulevard NE, Calgary, Alberta T3J 5J9
Toll Free: 1-877-302-2344
Bus: 403-250-1197
Fax: 403-291-9216
www.eggs.ab.ca

Alberta Turkey Producers
4828 – 89 St., Edmonton, Alberta T6E 5K1
Bus: 780-465-5755
Fax: 780-465-5528
www.albertaturkey.com

Alberta Chicken Producers

#111, 4208 – 97 St., Edmonton, Alberta T6E 5Z9
Bus: 780-488-2125
Fax: 780-488-3570
www.chicken.ab.ca

Alberta Hatching Egg Producers

#203, 9605 – 41 St., Edmonton, Alberta, T6E 5X7
Bus: 780-434-8414
Fax: 780-434-9552
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Canadian Egg Marketing Agency

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www.canadaegg.ca

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Alberta Livestock Industry Development Fund

Suite 100, Greystone IV, 4207 – 98 St., Edmonton, Alberta T6E 5R7
Bus: 780-442-3300
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www.alidf.ca

Chicken Farmers of Canada

350 Sparks Street, Suite 1007, Ottawa, Ontario K1R 7S8
Bus: 613-241-2800
Fax: 613-240-5999
www.chicken.ca