RESPIRATORY DISEASES OF POULTRY: DIAGNOSIS AND CONTROL APPROACHES

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Respiratory diseases of poultry are associated with severe economic losses, due to high mortality, high medication cost, drop in egg production in layer and breeder flocks and in many cases low fertility and hatchability. In breeder flocks attention must be paid to prevent infections with vertically transmitted agents such as Mycoplasmas. Early recognition and monitoring programmes are essential in managing the infections and minimizing the economic impacts.

Several pathogens are incriminated as possible cause either alone (mono-causal) or in synergy with different other micro-organisms (multi-causal) or accompanied by non-infectious factors such as climatic conditions and management related problems (Table 1).

Table 1: Some possible cause of respiratory disease in poultry

<table>
<thead>
<tr>
<th>Non infectious Management</th>
<th>Infectious Viral agents</th>
<th>Infectious Bacterial agents</th>
<th>Infectious Mycotic agents</th>
<th>Infectious Parasites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Litter quality</td>
<td>IB, ILT, ND, Influenza A, aMPV,</td>
<td>PMV3, Pox</td>
<td>Chlamydia, Haemophilus, Bordetella</td>
<td>Syngamus, Cryptosporidium</td>
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<td>Stocking density</td>
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<tr>
<td>Ventilation rate</td>
<td></td>
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<tr>
<td>Temperature</td>
<td>ORT, P. multocida, Mycoplasma, E. coli</td>
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<td></td>
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<tr>
<td>High ammonia level</td>
<td>Chlamydia, Haemophilus, Bordetella</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>High dust concentration</td>
<td>Streptococci, Staphylococci</td>
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<tr>
<td>Feed</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High dust content</td>
<td>Aspergillus fumigatus</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Vitamin A deficiency</td>
<td></td>
<td></td>
<td></td>
<td>Syngamus, Cryptosporidium</td>
</tr>
</tbody>
</table>

These infectious agents can be introduced and spread in poultry farms by different routes. It occurs either by the vertical and/or horizontal route. At early days of age the main disease problems are related to vertically transmitted infections such as Mycoplasma, salmonella, E. coli or improper hatchery management. Those and other infectious agents can also be transmitted horizontally (laterally) by direct contact between infected and non-infected susceptible birds, and through indirect contact with contaminated feed, water, equipment, environment and dust through ingestion or inhalation. The severity of clinical signs, duration of the disease and mortality are extremely variable and are influenced by type, virulence and the pathogenicity of the infectious agent, immune status and age of the birds as well as by many environmental factors such as poor management, inadequate ventilation, high stocking.
density, poor litter conditions, poor hygiene, high ammonia level, concurrent diseases and the type of secondary infections.

The diagnosis of the disease complexes usually is not a straightforward business. Basically the diagnosis consists of case history as well as management and environmental investigation on spot. In addition, clinical investigations and post-mortem examination are an important step toward disease diagnosis. However, clinical signs and necropsies are mostly not the final step of the diagnosis. The final diagnosis can be reached by laboratory diagnosis. Presumptive diagnosis of infections therefore must be confirmed by isolation and identification of the causative agent. Further possibilities are the detection DNA or RNA using PCR. Serological examinations for detection of antibodies can be carried out.

Worldwide the emerging and re-emerging respiratory diseases and or infections of poultry are Infectious Bronchitis (IB), Infectious Laryngotracheitis (ILT), Avian Metapneumovirus (aMPV), *Ornithobacterium rhinotracheale* (ORT) and Fowl cholera (FC) infections. In addition, Avian Influenza (AI), Newcastle disease (ND) and Mycoplasma infections appear to cause problem in some countries.

Disease prevention and control focuses primarily on dedicated planning and sound management practices, which prevent the introduction and spread of infectious diseases. This includes managing the environment by supplying adequate ventilation and heat to maintain bird comfort, to keep the litter in good condition, insure supplying fresh feed and water of diseases with good quality, and limiting exposure to infectious agents through biosecurity, cleaning and disinfection. Eradication policy and killing of animals by legislations for disease control purposes are commonly applied in cases of suspicion or confirmed outbreaks with a considerable public health and/or economic impact such as in case of ND and HPAI and sometimes by industry in case of vertically transmitted infections such as mycoplasma and Salmonella in breeder flocks. In all case knowledge about micro-organism, sensitivity to physical and chemical agents, mode of transmission and method of isolation and/or detection are essential. Vaccination is regarded as one of the most beneficial biopharmaceutical interventions, due to its ability to induce protection against infectious diseases through activation of the immune system. However several considerations should be taken in account before using vaccines such as: governmental regulations, epidemiological situation in the area and/or on the farm, goal of vaccination, availability of the vaccine and cost benefit analysis. Progressive vaccine production technologies such as recombinant, subunit, reverse genetic and nucleic acid vaccines can significantly reduce the cost of vaccines, ensure better efficacy and allow easy and rapid intervention to face the steady mutation of the microorganisms. Furthermore, the development of efficient vaccines against bacterial infections will lead to a reduction of the use of antibiotics and subsequently of the development of resistant bacteria.

Antimicrobials are important and essential tools to control bacterial infectious diseases, if the above mentioned measures did not prevent the infection in aim to insure health of the flock and to enhance the welfare and to reduce the economic losses. In such cases, therapy should be considered as the last effective weapon, but treatment without accurate diagnosis, critical selection of the product, accurate dosage, adequate duration and monitoring treatment is
unacceptable. In addition, if necessary as in case of treatment failure, corrective action should be taken.

**Conclusion**

As respiratory diseases in poultry are mostly associated with severe economic losses early recognition and monitoring programmes are essential in managing the infections. Generally, therapy or vaccination alone is of little value, unless they are accompanied with improvements in all aspects of management and biosecurity. Biosecurity is the cheapest, most effective means of disease control available and no disease prevention program will work without it.
MEASURES FOR THE REDUCTION OF DISEASE AND MORTALITY DUE TO ESCHERICHIA (E.) COLI INFECTIONS IN CHICKENS AND IMPACT OF A LIVE MODIFIED E. COLI VACCINE

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\(E.\) coli health problems cause significant economic losses to the poultry industry. \(E.\) coli infections in chickens are responsible for a large number of different diseases at various ages. In older birds infections with \(E.\) coli manifest often as septicemia and cellulitis. Preventive measures include a thorough hatching egg hygiene, limitations of disease introduction into the house, appropriate keeping conditions, an optimal housing climate, and a good vaccination scheme against other pathogens (Barnes and Gross, 1997; Vandekerchove, 2004).

Within a comprehensive approach encompassing all dimensions that contribute to effective disease control the vaccination with a modified live \(E.\) coli vaccine has been assessed. The impact of the vaccine on mortality and different colibacillosis lesions has been investigated under laboratory conditions. Figure 1 shows mortality rates of one group of SPF White Leghorn chickens that were vaccinated at one day of age by coarse spray and challenged intratracheally at an age of either 8 or 12 weeks. In figure 2 the reduction of mortality and different lesions of colibacillosis are shown after a first vaccination at first day of life followed by a second vaccination at 14 weeks of age. These birds were challenged in week 20 of life.

Figure 1: Reduction of mortality in % after a vaccination at day 1 and challenge at 8 or 12 weeks of age.
In a third trial broilers were vaccinated at first day of age by coarse spray application and challenged at 2 weeks of life. One week later birds were examined for cellulitis and internal lesions (figure 3).

In all three trials non vaccinated control groups were challenged at the same time points and it could be shown that vaccination contributed statistically significant to the reduction of mortality, internal lesions as well as to cellulitis lesions.

In order to evaluate the field efficacy of the live E. coli vaccine two large scale field studies were conducted comparing the health (mortality, condemnation rate) and technical performance (FCR: feed conversion ratio, ADWG: average daily weight gain, slaughter weight) in vaccinated and non vaccinated broilers. Study 1 included 16 flocks vaccinated and non vaccinated broilers. Study 2 6 vaccinated and 15 non vaccinated flocks. Table 1 shows the differences between mean scores from vaccinated and non vaccinated flocks. In both trials it could be demonstrated that Poulvac E.coli was effective in reducing the consequences of colibacillosis when used in day-old broiler chickens.
Table 1: Improvement of health and performance in broilers vaccinated with Poulvac E. coli in comparison to non vaccinated chickens

<table>
<thead>
<tr>
<th>Study</th>
<th>Mortality (%)</th>
<th>Condemnations (%)</th>
<th>Feed Conversion Ratio (FCR)</th>
<th>Average Daily Weight Gain (ADWG) (g)</th>
<th>Slaughter Weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study 1</td>
<td>-1.1</td>
<td>-1.0</td>
<td>-0.04</td>
<td>+1.3</td>
<td>+16.83</td>
</tr>
<tr>
<td>Study 2</td>
<td>-0.4</td>
<td>-0.34</td>
<td>-0.04</td>
<td>+2.55</td>
<td>+60.0</td>
</tr>
</tbody>
</table>

In diseased animals therapeutic measures mainly consist in the administration of antibiotics and may be subjected to several restrictions like the availability and inefficacy of drugs or withdrawal times as well as even legal limitations. In all these trials birds vaccinated with Poulvac E. coli showed statistically significant lower amounts of mortality and lesions like pericarditis, perihepatitis, airsacculitis and cellulitis in comparison to non vaccinated control birds. In addition an overall improvement in performance became obvious. Thus it could be demonstrated that vaccination is an efficacious measure that prophylactically contributes to the control of colibacillosis and its consequences in chickens.


Summary

Thirty years of research in ducks diseases revealed that more than 80% of death and other economical losses are caused by bacterial infections diseases.

Riemerella (R.) anatipestifer, the causale agent of infectious serositis is most important, followed by conjunctivitis, aerogen infections and damages of legs/webs complicated by bacterial infections. Septicaemic infections caused by E.coli, Sc. gallolyticus subspp. gallolyticus, other Steptococcus spp. and Enterococcus cecorum are of special importance.

Enzootic outbreaks of Riemerella anatipestifer - infections cause economical losses of 2,5 Million Euro at production of 2,9 Million ducks within one year though it should be noted that more than 50% of economical losses are individual, especially reduction of quality, condemnation of slaughtered animals, increased feed consumption and others. Modern duck production is not effective without successful control of R. anatipestifer-infections. That is why special research program was carried out for diagnostic and combating of R. anatipestifer-infections.

Most important achievements are following:

- Cultivation rate of R. anatipestifer was increased more than 3 times by development of a selective blood agar with addition of Gentamycin and Neomycin, as growth of R. anatipestifer is inhibited by more than 20 very common bacterial species of environmental microflora.

- Agglutination antibodies are decisive for immunity against R. anatipestifer. For that reason, serotyping of R. anatipestifer by agglutination is a necessity.

- Typing of 8809 R. anatipestifer strains from Germany, England, Netherlands, Hungary, Czech Republic, France, Poland, Thailand and Taiwan revealed, apart from 20 known in international literature described serotypes, 9 additional new serotypes and one new bacteria spp. related to Riemerella, whose taxonomic position is not finally defined. Each country and region has other serotypes.

- Resistance of ducklings against R. anatipestifer - infections mainly depends from natural antibodies. Until age of 16 days they are used under normal conditions and ducklings are most susceptible. After that age resistance develops. To 50th day of life DL50 increases 10 times every 10 days. Because of that reason natural outbreaks of R. anatipestifer-infections have a peak of losses between 15th and 25th day.
- Repeated vaccinations of parent ducks with polyvalent *R. anatipestifer*-vaccine (3-5 serotypes) reduce infectious polyserositis of commercial ducks decisively due to increased transmission of maternal antibodies. Regularly vaccination of parent ducks with *R. anatipestifer* vaccine reduces infectious polyserositis to more than 90% of commercial ducks.

2011 and 2012 study for bacterial infections in ducks was made by using MALDI-TOF (Matrix Associated-Laser-Desorption-Ionisation-Time-of-Flight) differentiation system.

The bacterial flora of 3665 ducks from 347 farms/companies was investigated. Together 12577 strains were differentiated, out of these 11735 bacterial strains (93,3%), 597 fungal strains (4,75%) and 245 strains from yeast (1,75%). Total 304 microbiological species/genera were identified. 303 strains (2,41%) could not be identified by MALDI-TOF.

Bacterial infections were detected in 3393 ducks (92,58%).

The detection rate of 25 most important pathogens of ducks declined in following sequence in Germany:

- *E. coli* - 1677 (45,76%)
- *Aspergillus fumigatus* - 485 (13,23%)
- *Enterococcus cecorum* - 378 (10,31%)
- *Pseudomonas aeruginosa* - 355 (9,69%)
- *Globicatella sulfidificiens* - 189 (5,16%)
- *Riemerella Th58* - 180 (4,31%)
- *Staph. delphiniu*intermedium/pseudointermedium - 151 (4,13%)
- *Cl. perfringens* - 150 (4,09%)
- *Klebsiella pneumoniae* - 90 (2,46%)
- *Sc. plurimalium* - 77 (2,10%)
- *Acinetobacter baumannii* - 74 (2,02%)
- *Sc. dysgalactiae* - 52 (1,41%)
- *Staph. aureus* - 38 (1,03%)
- *Aeromonas veronii* - 53 (1,45%)
- *Rothia nasimurium* - 51 (1,39%)
- *Enterobacter cloacaee* - 42 (1,15%)
- *Helcococcus kunzii* - 34 (0,93%)
- *Citrobacter koseri* - 28 (0,76%)
- *Sc. gallolyticus* subspp. gallolyticus - 28 (0,76%)
- *Arthrobacter cuminisii/protoph.* – 27 (0,76%)
- Pathogen *Salmonella enterica* spp. (*S. typhimurium*/*S. enteritis*) - 22 (0,60%)
- *Trueperella pyogenes* - 14 (0,38%)
- *Bisguard Taxon* 14/26 - 12 (0,35%)
- *Elizabethkingia meningoseptica* - 4 (0,11%)

*Enterococcus cecorum* was diagnosed as very important primary pathogen causative agent of following diseases:
- Sudden death syndrome (8-15 day old ducklings)
- Yolk sac inflammation
- Ovary degeneration Ascites
- Pneumonia, aerosacculitis, sinusits of sinus nasalis
The following figure illustrates the occurrence of infections caused by Enterococcus cecorum and *Sc. galloyticus* subsp. galloyticus (sudden death syndrome) and their successful reduction by vaccination of parent ducks.

Together our results revealed a strong interaction as well between hygienic keeping conditions of ducks and spectrum and frequency of bacterial infections as well as of bacterial infectious state of parent ducks and their offsprings.

Figure 1: Occurence of *Sc. galloyticus* subsp. *galloyticus*-infection in ducks and of *Enterococcus cecorum*-infection in ducks, geese, chicken, and turkey 2009-2012
MAIN PROBLEMS OF INFECTIOUS DISEASES IN PEKIN DUCKS IN GERMANY

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Duck production in Germany

In 2012 22.8 mio ducklings hatched in Germany (Statistisches Bundesamt, 2013). Most of them were raised in intensive fattening units with an average of about 14000 birds per flock.

Housing and management conditions for commercial pekin duck production are based on standards agreed upon by the ministry and the poultry association in four federal states (Nds. ML, 2003): In conventional production systems pekin ducks are kept indoors in open or massive poultry houses with littered floor. Up to 25% of slatted floor is accepted to ensure drainage under the drinkers. Fresh, clean straw is added daily in order to keep the floor as dry as possible. Drinking water is provided by nipple systems; additional open troughs to fulfil the biological need for grooming and cleaning of nostrils and eyes are used in some farms but have not yet established as standard.

Pekin ducks are reared in two phases: About 15 ducklings/m² are kept for about 16 days in a duckling house before moving to the fattening unit with up to 20 kg/m². Within 40 to 45 days the ducks reach 3kg of live weight with an FCR of 2.0 to 2.2 and 3.5% mortality.

Occurrence of infectious diseases

Ducks are fairly disease resistant when good husbandry and management techniques are practiced.

The most common infectious agent found in pekin ducks of our contract farmers is *E. coli*, whereas infections with *Riemerella anatipestifer* (R.a.) have the most significant economic impact due to high losses and carcass condemnation. Riemerellosis is often associated with septicaemic *E. coli*-infections. Severe losses are caused by the serotypes 1, 6 and 7 with first clinical signs appearing from day 18 onwards.

Increased mortality between day 10 and 20 may be related to infection with *Enterococcus cecorum*. In the absence of secondary infections clinical symptoms will cease once the ducks get older.

Providing the ducks daily with fresh litter implicates a constant risk of introducing pieces of mouldy material into the duck house, which may be responsible for fungal infections or negative effects of mycotoxins on productivity.
Although some of the most devastating diseases in ducks have a viral origin (e.g. duck virus enteritis, duck viral hepatitis), viral infections are currently of little importance in commercial pekin duck production in Germany.

**Securing a good health status**

Once a pathogen has entered a duck farm, both age groups kept in the duckling and the fattening units are likely to be infected. In the worst case, the eggs for the next flock have already been placed in the setter and the ducklings to hatch can’t be placed elsewhere. In that case three consequent flocks are at risk, before depopulation of the whole farm facilitates comprehensive hygienic measures.

With regard to these conditions entailed in the rearing practices, disease prevention and early detection are of utmost importance to secure a good health status and productivity on duck farms. Health and hygiene programs should be designed individually for each duck farm and include

- Biosecurity provisions
- Standard operating procedures (e.g. for cleaning and disinfection, preparation of the duck house for the new flock, flock inspection)
- Disease control, monitoring programmes (e.g. for Salmonella, avian influenza)
- Pest control

Vaccination of parent stock is an integral part of our health program. The vaccination scheme considers the health status of the parent stock as well as the disease status on our contract farms and is adjusted regularly. Since the assortment of commercial vaccines licensed for ducks is very limited, mainly flock-specific (autogenous) vaccines are used for parent stock and on farms with high risk of infection.

Antibiotic treatment of bacterial diseases in fattening ducks is restricted by long withdrawal periods. In Germany only one antibiotic is licensed for ducks with a withdrawal period for meat of 14 days (Ursocyclin®-Pulver 20%, Serumwerk Bernburg AG). Considering a fattening period of 42 days, any other antibiotic may only be applied before 14 days of age in order to meet legal requirements.

Provision of open water, as recommended by the Standing Committee of the European Convention for the Protection of Animals Kept for Farming Purposes (Europarat, 1999), results in a higher bacterial contamination of the drinking water (Bergmann et al., 2011). Although no negative impact on the ducks’ health has been found in studies up to now, the possible impact of open water on transmission of infectious diseases within a flock and between different flocks in a duck house needs to be taken into consideration for health and hygiene programs.

**Literature**


http://www.ml.niedersachsen.de/portal/live.php?navigation_id=32022&article_id=110595&_psmand=7

INTESTINAL DISORDERS

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Beside numerous aspects of flock management and husbandry infectious agents play a significant role in gut health and the overall performance of a poultry flock. Agents involved in gut health vary from parasites towards viruses which might have an influence on gut physiology and function. Resolving the consequences and pathogenesis of an infection of the gut reflects a certain challenge, keeping in mind that the field situation varies in comparison to experimental conditions. Furthermore, the type of birds is important with regard to the prevalence of certain pathogens and the options for control.

Inflammation of the gut tissue by parasites has usually a strong impact on gut health as parasites resist within the gut, which makes them vulnerable for effective treatments. Considering nematodes older birds can easily be re-infected and several treatments may be needed to limit the worm burden. *Eimeria* spp. are of relevance in all type of birds with special relevance for chickens and turkeys. Vaccines were developed in the last decades in order to establish a practical alternative for the common approach of anticoccidial drugs administered in the feed. At least organic production relies on such approaches. *Histomonas meleagridis*, a protozoan flagellate, was recently shown to induce severe lesions in the caeca of chickens lacking options for treatment. A severe drop in egg production is reported from the field which can also be reproduced experimentally, without any further clinical signs or lesions. This indicates that gut physiology is comprised in certain ways.

The running stunting syndrome also known as infectious running and stunting syndrome, pale bird syndrome or malabsorption syndrome is an important disease condition in broilers. This wide range of terminology indicates that several factors may contribute to this disease condition, rendering it towards a multifactorial disease. Viral infections are regarded as primary pathogens ranking bacterial infections second. In recent years reports were published on Astro-, Corona-, Parvo-, Rota-, Reo- and Adenoviruses are commonly detected in such clinical cases. However, experimental studies are still very limited which would be helpful to elucidate the functional mechanism and to develop vaccines. This is already achieved for necrotic enteritis caused by *Clostridium perfringens*. In recent years infections of the gizzard due to fowl adenovirus serotype 1 has gained certain importance and the clinical outcome is identical with the running stunting syndrome. In layers and breeders *Brachyspira* spp. has gained some attention recently but clinical and experimental data are still very limited.

The presentation will highlight some of the above mentioned disease conditions and the consequences of a certain microorganism on gut health. Applications of Ussing chambers are helpful to investigate the intestinal transport of nutrients and the impact on barrier function of
the gut. This can also be determined for microorganism like *Campylobacter jejuni* in the absence of clinical signs.
Diagnosing poultry diseases starts at the farm with the clinical observation of individual birds and the flock. Sectioning of birds is carried out afterwards in order to identify lesions and collect samples to be processed in the laboratory. This whole process is nowadays very often underestimated with the tendency to rely more and more on the following laboratory investigation. This is even more pronounced with the implementation of new technologies, like PCR, next generation sequencing or mass spectrometry (MALDI-TOF MS). Such technologies rely on certain equipment in addition to specified knowledge. This increases the complexity of diagnostic procedures, especially in cases a new disease condition appears and/or a certain disease has changed its pathogenesis.

With no doubt, reliable diagnostic methods are crucial in order to support the clinical supervision of poultry flocks. The demand for diagnostic laboratories is steadily increasing with regard to several parameters, such as price, time and reliability. For the laboratory itself all parameters should be considered equally, whereas for the veterinarian and the farmer the price and time period to obtain the result are sometimes prioritized as they are much easier to be quantified and reliability is taken for guaranteed. In order to achieve all this and to fulfil the overall demand laboratories should have some quality assurance (QA) system in place, like accreditation or certification. Such systems are set up in order to:

- implement a clear approach to follow up each individual method as investigations are based on standard operating procedures
- certify that all people involved in the process handle the samples in the same way
- establish systems which enforce laboratories to participate in ring tests bearing the chance for them to compare results with other labs by processing the same samples

Despite existing QA systems the lack of standardization between laboratories is obvious, especially in the area of new methods and technologies. Even though PCR was already invented nearly three decades ago it is still a good example for this. In addition, methods based on certain technical equipment are mostly concentrated at certain places with less exchange of data and people, contradicting a comprehensive use of experience.

The presentation will focus on achievements of new technologies but will also address the concerns of QA and the need to link theory with practise or technology with a certain disease/flock.
The main ways to control any infectious disease are to prevent the introduction in an area supposed to be free from the infectious agent by regular biosecurity and monitoring and in case of the presence of the infection in one area measures should be taken to prevent the spread to other places. For that measures such as biosecurity, movement restriction, treatment, vaccination and in some cases eradication can be applied. Eradication policy and killing of animals for disease control purposes are commonly applied in cases of suspicion or confirmed outbreaks with a considerable public health and/or economic impact.

These infectious agents can be introduced and spread in poultry farms by different routes. It occurs either by the vertical and/or horizontal route. At early days of age several vertically transmitted infections such as salmonella, E. coli, leucosis, Mycoplasmas, avian encephalomyelitis and others can be introduced into the farm. Those and other infectious agents can also be transmitted horizontally (laterally) by direct contact between infected and non-infected susceptible birds, and through indirect contact with contaminated feed, water, equipment, environment and dust through ingestion or inhalation. Biosecurity is a set of management practices to prevent and/or to reduce the potential for the introduction, and spread of infectious agents onto and between farms. Since the flock performance is directly linked to good biosecurity measures, the biosecurity of farms has to be upgraded to a much higher level than that for disease control. However, a high level of biosecurity at all times and at all production levels is difficult and expensive to maintain.

Biosecurity and hygiene plans should be adopted for each farm. Farm owners, managers and workers should be involved in the design and implementation of the biosecurity plan. The aim is to create an environment where poultry are protected from carriers of infectious agents. Controlling the movement of people, animals, equipment, and vehicles in and out of the farm and within the farm area is essential.

Visitors are one of the major vectors and carriers of infectious agents. Visitors include supervisors, veterinarians, vaccination crews, catching crews, electricians, feed truck drivers, and other similar. Visitors can transmit diseases from one farm to another via dust on hands, hair, and clothing. Ask visitors to register by name including the date and time of their visit and make visitors wear boots and coveralls. Install properly managed spray stations for use on traffic entering and leaving the farm. Make sure that all go through the wash station before and after leaving the farm. Make sure that all visitors use footbaths when entering the farm and moving from one area of the farm to another. Vehicles onto the site have to be restricted. The wheels and underside of necessary vehicles entering the farm (feed trucks) should be sprayed with disinfectant. Do not allow the driver to leave the truck or wander around the farm. In general, other animal species must never be present on the farm. Employees should
not have, or work with, other domestic animal species at home. Since also household pets constitute a serious hazard, dogs and cats should not be present in the barns.

All-in, all-out principle should be adopted wherever possible. Multiple ages of birds on a farm constitute a serious disease risk, in particular if multiple age birds are closely associated.

Cleaning, disinfection and vector control must be integrated in a comprehensive disease control programme. They should include houses, equipment and surroundings. Areas around houses should be constructed of materials and surfaces that can be cleansed and disinfected.

The procedure should be tailored to meet the particular needs. The cleaning and disinfection programme should include time schedule, type of disinfectant and concentration, desired level as well as check and microbiological monitoring of the procedures. Barn disinfection is not complete, if disinfection of water lines and feed lines is not performed. The procedures should be established not only for cleaning and disinfecting the house and surfaces but also for cleaning and disinfection of the equipment which is itself used for cleaning.

When a poultry house is depopulated, all droppings and litter should be removed from the house prior to starting dry- and wet cleaning as well as disinfection. Rodents especially rats and mice, are particularly important sources for contamination of poultry houses. An intensive and sustained rodent control is essential and needs to be well planned and routinely performed. Monitoring and recording rodent activity and bait consumption is an important part of a rodent control program. Wild birds can be carriers of different microorganisms therefore their presence inside barns is not acceptable. Houses should be constructed in a manner that makes it difficult for wild birds to enter. They have to be kept in good repair to prevent entry and nesting. In addition, Darkling beetles are important carriers of several pathogens of poultry. Control of darkling beetles relies on applying insecticide as soon as the birds are moved out of the barn. After cleaning and disinfection leave the house empty for two to three weeks before a new flock is placed. Restocking of one day chicks from known source is important, if it is possible.

Litter for use should be of good quality. Storage of litter either straw or shavings must be done in barns with good rodent, wild bird, and animal control. Contamination of litter during storage can be a major source for infection. Precautions should be taken especially with straw, which can be contaminated in the field. Therefore at least a 3-month quarantine of straw is recommended instead of using fresh straw.

Since the success of any disease control programme depends on the farm and personal sanitation, it is essential to incorporate education programmes about micro-organisms, modes of transmission as well as awareness of the reasons behind such control programmes by people involved in poultry production.
POULTRY AND FOOD SAFETY: NEVER-ENDING STORY

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In spite of significant improvements in technology and hygienic practices in developed countries at all stages of poultry production, accompanied by advanced improvement in public sanitation, foodborne diseases remain a persistent threat to human and animal health. Food safety and quality are still big issues of major concern in developed countries. In developing countries, the need to produce sufficient food to meet the requirements of population increases, accompanied by bad economic situations often overshadow the need to ensure safe food products. Regardless of this fact, safe food is a fundamental requirement for all consumers, rich or poor.

Many reports during recent years have shown that Campylobacter spp. and Salmonella are the most common causes of human foodborne bacterial diseases linked to poultry. In some areas also verotoxin producing Escherichia coli 0157:H7 (VTEC), Listeria and Yersinia have surfaced as additional foodborne pathogens causing human illness. Several other toxicogenic bacterial pathogens, such as Staphylococcus aureus, Clostridium perfringens, Clostridium botulinum and Bacillus cereus can also enter the human food chain via contaminated poultry carcasses. In addition, the development of antibiotic resistance in bacteria, which are common in both animals and humans, such as Methicillin Resistant Staphylococcus aureus (MRSA) and Extended-spectrum beta-lactamase (ESBL) bacteria, are also an emerging public health hazard.

To control the food borne organisms, information is required to understand more fully, how microbial pathogens enter and move through the food chain, and the conditions, which promote or inhibit growth for each type of organism. In general the main strategy to control food borne infections in poultry should include: monitoring, cleaning the production chain from the top especially of vertically transmitted microorganism such as Salmonella by culling infected flocks, hatching egg sanitation and limiting introduction and spread of infections at the farm level through effective hygiene measures which should be applied in poultry houses and their environment. An intensive and sustained rodent control is essential and needs to be well planned and routinely performed and its effectiveness should be monitored. In addition, reducing bacterial colonization by using feed additives, competitive exclusion or use of vaccines are further possibilities. Live and inactivated vaccines are used to control Salmonella in poultry. Generally, vaccination alone is of little value, unless it is accompanied by improvements in all aspects of management and biosecurity. In addition, further attention must be paid to the development of efficient vaccines against campylobacter infections. In the long term, development of poultry lines that are genetically resistant to some pathogens should be progressed. Finally, since the success of any disease control program depends on the farm and personal sanitation, it is essential to incorporate education programs about microorganisms, modes of transmission as well as awareness of the reasons behind such
control programs by people involved in poultry production. In addition, effective education programs must be implemented to increase public awareness of the necessary measures to be taken for protection against foodborne contamination of food products.

Currently, in the EU several regulations are in force in aim to protect the consumers. The EU has adopted an integrated approach to food safety from the farm to the fork. The approach consists of both risk assessment and risk management measures involving all key actors.

The risk assessment as defined by WHO and the FAO means scientific evaluation of known or potential adverse health effects, which is an integral part of risk analysis, and which also includes risk management meaning evaluating, selecting and implementing different courses of action. These should be followed by risk communication, which meaning exchanging information among all interested parties. The four steps of risk assessment are a) hazard identification; b) exposure assessment; c) hazard characterisation and d) risk characterisation. The "General Food Law" was passed on 21 February 2002 (Regulation EC/178/2002) and after a transition period the law is in force since 1st January 2005. The food law aims at ensuring a high level of protection of human life and health taking into account the protection of animal health and welfare, plant health and the environment. It also aims to harmonise existing national requirements in order to ensure the free movement of food and feed in the EU. The food law recognises the EU's commitment to its international obligations. Further aim of this regulation is to ensure a coherent approach in the development of food legislation.

Based on the above mentioned regulation further regulations are in force e.g. one on the hygiene of foodstuffs EC 852/2004 and another on requirements for feed hygiene EC 183/2005. In addition, Regulation No 853/2004/EC laying down specific hygiene rules for food of animal origin is fully applied since January 2006. The provisions of this regulation apply to unprocessed and processed products of animal origin. Furthermore, regulation EC No 854/2004 laying down specific rules on the organisation of official controls on products of animal origin intended for human consumption is fully applied since January 2006.

In November 2003, the European Parliament Council Regulation 2160/2003/EC on the control of salmonella and other specified food-borne zoonotic agents was passed. This regulation covers the adoption of targets for the reduction of the prevalence of specified zoonoses in animal populations at the level of primary production and followed by several regulations: for breeding flocks (EC 1003/2005), for laying hens (EC 1168/2006), for broilers (EC 646/2007) and breeding as well as fattening turkey flocks (EC 584/2008). Food business operators must have samples taken and analysed for the zoonoses and zoonotic agents. In addition, the flocks should also be sampled by the competent authority in accordance to the regulation related to production direction.

Also the EU has decided to ban the use of growth-promoting antibiotics in feed of food producing animals completely by January 2006 based on the EC regulation No 1831/2003. In addition, according to Commission regulation (EC) No 1177/2006 antimicrobials shall not be used as a specific method to control salmonella in poultry. In some cases however the use of antimicrobial can be permitted.
Use of antimicrobial drugs in animal husbandry has been widespread since they were introduced to therapy of infectious diseases little more than a half a century ago. Intensive agricultural practices have put antimicrobials in the forefront of therapeutic agents used in treatment for food producing animals. Antimicrobial therapy of food producing animals differs in many ways from antimicrobial use in humans. While the therapy in humans is almost solely individual, it is in most cases unit (flock, heard) treatment in veterinary applications. Therefore, treatment of large units involves therapeutic antimicrobial use in the diseased animals and metaphylactic treatment of the rest of the unit, i.e. administration of antimicrobials to healthy individuals in intimate contact with the sick animals. Consequently the bacterial ecosystem differs significantly from the typical ecosystem in human antimicrobial therapy. This has consequences in resistance formation and resistance transfer. Most antimicrobial drugs are based on molecules that micro-organisms themselves produce in order to fight bacterial invasion. As the bacteria adjusted to overcome such challenges, resistance to antimicrobial drugs obviously existed way before antimicrobial drugs were introduced to the therapeutic arsenal. While the bacteria are well equipped to find ways to overcome antimicrobial effects, it is exceedingly difficult to avoid resistance formation even if antimicrobials are used in a focused and well controlled manner.

Veterinary use of antimicrobials has gained significant status in the discussion concerning resistance avoidance in human infections. The concern is not limited to typical food borne infections, such as Salmonella, Campylobacter and Escherichia coli, but also to the potential transfer of resistance genes to non-food related pathogens that were originally produced in animal antimicrobial therapy. While many of these questions have not been fully answered by science and there is a huge emotional public perception involved, the regulator has been poorly prepared to deal with these questions in veterinary drug licensing. Obviously sick animals must be treated and the regulator is responsible for the approval and the availability of effective treatments. On the other hand the regulator cannot approve use of compounds that may endanger human health and food safety. The regulatory process of veterinary drug approval typically consists of three different aspects: 1. Drug efficacy, 2. Target animal safety and 3. Food safety. In the case of antimicrobial drugs, these points are interrelated and resistance has a significant role in that.

Effective dose is one of the essential factors in the regulatory process. Various countries apply different criteria to describe efficacy. The US Food and Drug Administration (FDA) require efficacy trials in treatment of a specific disease. In many other countries the regulator will approve use based on in vitro efficacy assessment such as minimum inhibitory concentration
(MIC). In this approach the MIC represents the pharmacodynamic (PD) aspect of the therapy and must be associated with the pharmacokinetic (PK) aspect to establish an effective dose resulting from use of the PK/PD relationship as: AUC/MIC, Cmax/MIC and T/AUC. AUC (area under the concentration vs. time curve), Cmax (maximum drug concentration) and T (time above MIC). Unfortunately the target values for those ratios are disease dependent. The food safety parameters are determined in relation to the dose.

Residue depletion withdrawal time is determined based on good veterinary practice (compliance to dose). The target value, maximum residue level (MRL), is determined either by chemical criteria (toxicological end point) or by microbiological criteria (microbiological end point) whichever is lower. Generally the microbiological end point is the lower and the safe concentrations are actually determined to ensure that the antimicrobial concentration in food does not change the human intestinal flora. The pathogen is eradicated and there is no human exposure.

Unfortunately the issue is much more complicated. The causative organism looses susceptibility resulting in sub-therapeutic dose. Sub-therapeutic concentrations select for resistance. Similarly MIC can change over time requiring higher dose to maintain the required PK/PD ratio. The allocated withdrawal time will no longer be valid. Rigid dose regimen of antimicrobials may lead to therapeutic failures and increased resistance.

Recently there have been concerns relating to the use of certain antimicrobial classes in farm animals classified by the WHO as “critically important antimicrobials” for human therapy. WHO has prioritized fluoroquinolones, macrolides and 3rd and 4th generation cephalosporins as such. Would these antimicrobials become unavailable to the farm animal practitioner, the regulator need to consider what alternatives are available.

The regulator has taken actions to remove approved drugs from the market. The most prominent example is the fluoroquinolone withdrawal from poultry use in the US to prevent fluoroquinolone resistance in Campylobacter. However, human Campylobacter infections are seldom treated with antimicrobials and, macrolides are considered the first line antibiotics. Fluoroquinolones are in wide use in human community medicine undermining resistance concerns. This discourages the pharmaceutical industry to develop new veterinary antimicrobials when the basis for regulatory ruling is unclear.

Banning of modern antimicrobials from farm animal use will result in increased use older inefficient antimicrobials and probably also in increase resistance formation. If the resistance transfer hypothesis holds, approval of modern antibiotics for farm animal use may increase resistance formation in pathogens of human concern. Either way the regulator will face public health concerns.

The evidence in support or against the resistance transfer hypothesis becomes crucial for future regulatory actions. If it occurs, in what way and which pathogens (or commensals) are involved? From the animal welfare point, farm animals must be treated properly. Lack of effective antimicrobials will seriously compromise food production. The food producing industry cannot risk public health. Without sufficient research the regulator is likely to apply
the “precautionary principle”. That may carry huge economic consequences that not only hurts the industry but may also affect food prices in a significant way causing also social consequences.