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Poultry coccidiosis: prevention and control approaches

Geflügelkokzidiose: Prophylaxe- und Kontrollmaßnahmen

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Introduction

Coccidiosis is the major parasitic disease of poultry with substantial economic losses due to malabsorption, bad feed conversion rate, reduced weight gain and increased mortality. In addition, the use of anticoccidial drugs and/or vaccines for treatment and prevention, contributes a major production cost.

Aetiology

Coccidia are protozoa which have the ability to multiply rapidly inside cells lining the intestine or caeca. The species of coccidia that are infective to poultry belong to the *Eimeria* genus. Many of these species can infect poultry and there is no cross-immunity between them. Most infestations under field conditions are mixed but one species will be dominant. *Eimeria* have a self-limiting life cycle and are characterized by a high tissue and host specificity.

The *Eimeria* cycle includes two distinct phases; (a) the internal phase (schizogony + gamogony) in which the parasite multiplies in different parts of the intestinal tract and the oocysts are excreted in the faeces (The part of the intestinal tract and the total duration of the internal phase of the cycle is dependant on species), (b) the external phase (sporogony) during which the oocyst must undergo a final process called sporulation before they are again infective. Sporulation requires warmth (25–30°C), moisture and oxygen (Levine, 1982).

Seven species of *Eimeria* are known to infect **chickens** and they show a wide variation in their pathogenicity (Tab. 1). In addition, two further species have been described, namely *E. hagani* and *E. mivati*, but further studies on the importance of these species are needed (Conway and McKenzie, 2007).

In **turkeys** seven species of *Eimeria* have been reported (Tab. 2), however *E. innocua* and *E subrotunda* are considered non-pathogenic (Trees, 1990; McDougald, 2003).

Geese are parasitized by two species; *Eimeria truncata* (unusually this is found in the kidney) and *Eimeria anseris.* A large number of specific coccidia have been also reported in **ducks**, but the validity of some of them is still not clear. The most pathogenic coccidial infection of ducks is *Tyzzeria perniciosa*, which causes haemorrhagic enteritis in ducklings less than 7 weeks of age (Trees, 1990; McDougald, 2003).

Transmission

The oocysts are extraordinary resistant to environmental stress and disinfectants, remaining viable in the litter for many months. Temperatures above 56°C and below 0°C are lethal but it seems to be impossible to decontaminate a previously contaminated poultry house or environment. Sporulated oocysts can be spread mechanically by wild birds, insects or rodents and via contaminated boots, clothing, equipment or dust. Direct oral transmission is the natural route of infection (McDougald, 2003).

Clinical signs and lesions

Several *Eimeria* species are able to cause clinical signs in infected and unprotected birds; however subclinical infections are frequently seen. These are often underestimated but mostly result in impaired feed conversion and reduced weight gain.

Coccidiosis generally occurs more frequently during the warmer months of the year (Smith, 1995). Young birds are more susceptible and more readily display signs of disease, whereas older chickens are relatively resistant as a result of prior infection.

The severity of an infection depends on; the age of birds, *Eimeria* species, number of sporulated oocysts ingested, immune status of the flock and environmental management.

Infected birds tend to huddle together, have ruffled feathers and show signs of depression. The birds consume less feed and water, and droppings are watery to whitish or bloody. This results in dehydration and poor weight gain as well as mortalities.

The lesions of coccidiosis depend on the degree of inflammation and damage to the intestinal tract. They include thickness of the intestinal wall, mucoid to blood-tinged exudates, petechial haemorrhages, necrosis, haemorrhagic enteritis and mucous profuse bleeding in the caeca.

The tissue damage in the intestinal tract may allow secondary colonization by various bacteria, such as *Clostridium perfringens* (Helmbolt and Bryant, 1971), or *Salmonella Typhimurium* (Arakawa et al., 1981; Baba et al., 1982). Infestation with *E. tenella* also increases the severity of *Histomonas meleagridis* infection in chickens (McDougald and Hu, 2001).

Diagnosis

Coccidiosis is often extremely difficult to diagnose and can only be done in the laboratory (Conway and McKenzie,

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Tab. 1. Some characteristics of important *Eimeria* spp. infecting chickens
Einige Merkmale der wichtigsten Eimeria spp. bei Hühnern

Host	Eimeria	Location	Pathogenicity*
Chickens	*E. acervulina*	Duodenum, Jejunum	++
	E. brunetti	Ileum, Rectum	+++
	E. maxima	Duodenum, Jejunum, Ileum	++
	E. mitis	Duodenum, Jejunum	+
	E. necatrix	Jejunum, Caeca	+++
	E. praecox	Duodenum, Jejunum	+
	E. tenella	Caeca	+++

* – non-pathogenic; + low pathogenic; ++ moderately pathogenic; +++ highly pathogenic

Tab. 2. Some characteristics of important *Eimeria* spp. infecting turkeys
Einige Merkmale der wichtigsten Eimeria spp. bei Puten

Host	Eimeria	Location	Pathogenicity
Turkeys	*E. adenoeides*	Caecum	+++
	E. dispersa	Duodenum, Jejunum	+
	E. gallopavonis	Rectum	++
	E. innocua	Duodenum, Jejunum	–
	E. meleagridis	Caecum	+
	E. meleagrimitis	Duodenum, Jejunum	+++
	E. subrotunda	Duodenum, Jejunum	–

* – non-pathogenic; + low pathogenic; ++ moderately pathogenic; +++ highly pathogenic

2007), by counting coccidia per gram of faeces and/or examining the intestinal tract to determine the lesion scores, as described by JOHNSON and REID (1970). The estimation of the lesion scores is difficult in turkeys (IRION, 1999). Since it is common for healthy birds to possess some coccidia, consideration of flock history and lesion scores must be carefully evaluated before making a diagnosis or treatment recommendations.

Intestinal coccidiosis may be confused with necrotic enteritis, haemorrhagic enteritis, or other enteric diseases. Caecal coccidiosis may be confused with histomoniasis and salmonellosis due to their similar lesions (HAFEZ, 1997).

Prevention and Control: Yesterday, Today and Tomorrow

In the past it has been realized that eradication of coccidia is not realistic and hygienic measures alone are not able to prevent infections. However, if an outbreak of coccidiosis occurs, treatment via the drinking water should start as soon as possible. The most commonly used drugs are sulphonamides, amprolium and toltrazuril. Today the prevention and control of coccidiosis is based on chemotherapy, using anticoccidial drugs and/or vaccines along with hygienic measures and improved farm management.

Anticoccidial drugs

According to SHIRLEY and CHAPMAN (2005) the most significant study that had the greatest impact on control of coccidiosis was that of DELAPLANE et al., (1947) which showed that the administration of low concentrations of sulphaquinoxaline in the feed effectively controlled the disease.

The rapid development of the broiler industry in the 1950 s required the urgent availability of anticoccidial drugs. This soon led to intensive activities by several companies to produce a range of chemical products that were effective in the control coccidiosis. However, these products also prevented treated birds from building up any natural immunity and they were not effective enough to kill all exposed coccidia. The result was that the surviving coccidia quickly became resistant to the products and severe outbreaks of the disease occurred. According to CHAPMAN (1994a) nicarbazin was introduced in 1955 to the USA and was extensively used in broiler production. In the 1970 s several other highly efficacious synthetic drugs were introduced but due to the rapid development of drug resistance, they were withdrawn shortly afterwards. The development of resistance was documented for these anticoccidial chemical drugs (JEFFERS, 1974a,b; MCDOUGALD et al., 1986). It is likely that resistance has developed to more recent anticoccidial drugs but this has not been investigated and may have gone unrecorded (CHAPMAN, 2005).

A major enhancement in coccidiosis control occurred in the 1970's with the introduction of monensin as the first ionophore coccidiostat. Introduction of ionophores changed the ability to control coccidiosis – an impact that remains to this day (SHIRLEY and CHAPMAN, 2005). The effectiveness of ionophore coccidiostats lies in the fact that whilst they kill the majority of the invading parasites, they permit a small leakage of coccidia enabling a degree of host immunity to develop. Resistance to ionophores develops very slowly and there is more of a tendency to increased levels of tolerance. CHAPMAN and HACKER (1994) as well as MATHIS (1999) observed a marginal to poor effect of different ionophores to several *Eimeria sp.*

Tab. 3. Some anticoccidial drugs used for prevention in chickens and turkeys in the EU
Zusatzstoffe zur Verhütung der Kokzidiose bei Hühnern und Puten in der EU

Generic name	Brand Name Manufacture	Category of animals	Max. Age (weeks)	Conc. (ppm) Min.	Conc. (ppm) Max.	Withdrawal time (Days)
Diclazuril	Clinacox Janssen	Broiler Pullets Turkey	– 16 12	1 1 1	1 1 1	5
Decoquinate	Deccox Alpharma	Broiler	–	30	50	3
Halofuginone	Stenorol Huvepharma	Broiler Pullets Turkey	– 16 12	2 2 2	3 3 3	5
Lasalocid sodium	Avatec Alpharma	Broiler Pullets Turkey	– 16 12	75 75 90	125 125 125	5
Maduramicin ammonium	Cygro Alpharma	Broiler Turkey	– 16	5 5	5 5	5
Monensin sodium	Elancoban Elanco	Broiler Pullets Turkey	– 16 16	100 100 60	125 125 100	3
Monensin sodium	Coxidin Huvepharma	Broiler Turkey	– 16	100 90	125 100	3
Narasin	Monteban Elanco	Broiler	–	70	70	1
Narasin/ Nicarbazin	Maxiban Elanco	Broiler	–	80	100	5
Robenidine HCl	Cycostat Alpharma	Broiler Turkey	–	30	36	5
Salinomycin sodium	Sacox Huvepharma	Broiler Pullets	– 12	60 50	70 50	1
Salinomycin sodium	Salinomax Alpharma	Broiler	–	50	70	1
Semduramicin	Aviax Forum	Broiler	–	20	25	5

Since the 1970's, coccidiostats have been regulated under the Feed Additives Directive 524/70/EEC (EEC, 1970; 2004), which has now been replaced by Regulation No 1831/2003/EC (EC, 2003; 2007). As such, they have not been subject to veterinary prescription status, since they are required routinely in the feed of commercial broilers and turkeys.

Currently several types of anticcocidial drugs are available including synthetic compounds (chemicals), quinalone and certain ionophore antibiotics (Tab. 3). In recent years, however, few new drugs have been introduced. All types of drug used for coccidiosis control are unique; in their mode of action, the way in which parasites are killed or arrested, and the effects of the drug on the growth and performance of the bird. Very few drugs are equally efficacious against all *Eimeria* species (McDougald, 2003).

The efficiency of anticoccidial agents can be reduced by drug resistance and management programmes are designed to prevent this developing, which results in better gut health and feed utilization by birds. Using a drug rotation, with constant monitoring of the oocysts in the faeces and in the litter, or shuttle programme (ionophore/chemical) seems to be of great value. Rotation involves changing the product used every 4–6 months. The alternative to a rotation programme is a continuous program where the same products are used until a problem develops or until a new product is introduced on the market. Rotations are only possible if drugs with different mode of action follow each other. On the other hand, a shuttle programme uses two or more products during the grow-out period of a flock. The principle is to use the drug most suited to each phase of the grow-out, so that one drug is used for the starter period, whilst another is used during the grower and finisher phase. The drug withdrawal period is a very important consideration for treatments used in finisher feeds (Paeffgen et al., 1988; Smith, 1995). A 'switch' system can also be used where the anti-coccidial agent is changed at each restocking within an operation.

A coccidiosis 'break' is often an indication of an immunosuppression problem. Concurrent infection with immunosuppressive diseases such as Marek's disease may interfere with development of immunity to coccidiosis (Biggs et al., 1969) and infectious bursal disease (IBD) may exacerbate coccidiosis, placing a heavier burden on anticoccidial drugs (McDougald et al., 1979).

Vaccination

The poultry industry is facing problems of drug resistance, a lack of new anticoccidial products, the susceptibility of turkeys to ionophore toxicity and consumer pressure to decrease the use of antibiotics in animal feed. It is therefore being forced to seek alternative strategies to control Coccidiosis, which has made the use of vaccines more attractive.

Although it has been known for many years that the host exposure to low numbers of coccidia oocysts allows the development of a protective immunity, live coccidiosis vaccines weren't used in poultry until the 1960's. There is now a tremendous amount of knowledge about the immune response of chickens to coccidia infections (LILLEHOJ, 2005) and the development and use of vaccines is increasing (WILLIAMS, 2002; SHIRLEY and CHAPMAN, 2005; SHIRLEY, 2000).

Several different live vaccines have been commercially developed and they are mostly composed of either virulent or attenuated parasitic strains. Non-attenuated vaccines have been used for many years in the USA. Coccivac® vaccine (Schering Plough Animal Health) was developed in the early 1950 s. The "B" and "D" types are different mixtures of *Eimeria* species; the "T" type is for turkeys and was introduced in 1970's (WILLIAMS, 2002; SHIRLEY and CHAPMAN, 2005). In addition, Immucox® and Immuncox – T® were developed in Canada (Vetech Laboratories) and have also been used for many years (JULIAN et al., 1999).

Towards the end of the 1980's new live attenuated vaccines came onto the market including; Paracox® (Schering-Plough Veterinary Ltd, UK) and Livacox® (Biopharm, Czech Republic). They have been characterized, for their short life cycle, as "precocious" (JEFFERS, 1975) and with their reduced pathogenicity were introduced commercially in the EU (SHIRLEY, 2000).

Recently three further live non-attenuated vaccines have developed; Nobilis® CoxATM (Intervet), ADVENT™ and Inovocox™. Nobilis® CoxATM consists of a mixture of wild-type *Eimeria* spp. that is relatively tolerant to ionophores (VERMEULEN et al., 2001). Advent™ (Viridus Animal Health, USA) is marketed as having more viable oocysts (truly sporulated oocysts that can cause immunity) than other vaccines and Inovocox™ (Embrex) was designed for administration in *ovo*. Other live vaccines have been reported to be under development and/or introduced in some countries (WILLIAMS, 2002; CONWAY and MCKENZIE, 2007).

Recently a sub-unit vaccine CoxAbic® (Abic-Israel) has been introduced, prepared from purified gametocyte antigen, isolated from *E. maxima* (WALLACH et al., 1995). Broiler breeder flocks vaccinated, twice intramuscularly, during the rearing period are able to pass maternal antibodies to their offspring and immunity to infection has been demonstrated with *E. acervulina*, *E. maxima*, *E. mitis* and *E. tenella* (FINGER and MICHAEL, 2005).

Commercial use of coccidia vaccines in the EU began in 1992 with the introduction of a vaccine for replacement breeders and laying pullets, followed in 2000 by a vaccine for commercial broilers. Now vaccines are used as the primary method for coccidiosis prevention in breeding flocks and to some extent in laying hens and broiler chickens. Currently, three vaccines are available, EU-wide (Paracox®-5 and Paracox®-8) and one other (Livacox®) is available in a limited number of countries (Czech Republic, Italy, Latvia and Slovak Republic). Vaccines have proved to be a valid addition to coccidiosis control in commercial broilers and it is estimated that approximately 12% of the commercial broilers produced in Europe rely on vaccines alone for coccidiosis control. Most of these are found in Southern Europe where season and climate favours a lower coccidiosis challenge (FEFAC, 2007).

The use of vaccines is able to replace drug-resistant field strains of *Eimeria* with "drug-sensitive" vaccine strains. This is observed in the restoration of sensitivity to ionophores such as monensin and salinomycin as well as to the chemical drug diclazuril (CHAPMAN, 1994b; CHAPMAN et al., 2002; MATHIS, 2003).

Long-term sustainability of coccidiosis control in poultry may therefore be facilitated by the adoption of rotation programs, involving the alternate use of a vaccine and drugs in successive flocks. Programs involving the rotation of vaccines with traditional chemotherapy are currently used by the poultry industry. The highly effective chemical anticoccidials need only be used for specific cycles, when conditions in the house produce a greater coccidiosis challenge. Chemical use, limited to a single cycle, will dramatically reduce oocyst levels in the facility. The following cycles can then use vaccination to repopulate the house with anticoccidial-sensitive oocysts, which are highly sensitive to both the chemical and ionophore programs. The vaccination cycles should be followed by the use of an ionophore, which should perform very efficiently in the vaccine-repopulated house (RADU, 2004).

Currently some trails are being carried out on the efficacy of alternative products such as herbal extracts under controlled challenges and many have not shown measurable coccidiosis prevention. CHRISTAKI et al. (2004) investigated the effect of dietary supplementation with Apacox (Apa-CT, s.r.l. Italy), a commercial preparation of herbal extracts, on the performance of broiler chickens experimentally infected with *Eimeria tenella.* The obtained results indicated that Apacox exerted a coccidiostatic effect against *E. tenella*. This effect was, however, significantly lower than that exhibited by lasalocid. DUFFY et al. (2005) carried out investigations on the effects of dietary supplementation of Natustat™ a plant derived product (Alltech Inc., KY, USA) and salinomycin on performance, feed efficiency and intestinal lesion scores in broiler chickens, challenged with *Eimeria acervulina, Eimeria maxima and Eimeria tenella* challenge. In first trial birds were challenged via contaminated litter with known amount of Eimeria oocysts. In the 2nd trial trail the source of challenge was the litter from the 1st trial. The performance parameters were significantly improved by the addition of Natustat™ (1,925 Kg/tonne) and salinomycin (66 g/tonne) to the diets of challenged birds, compared to non-supplemented birds. They concluded that Natustat™, a propriety natural a alternative for protozoal control, is as effective as Salinomycin. On the other hand CLAVÉ HUBERT and VAN DER HORST, (2004) found no differences between groups treated with an herbal product and an infected negative control, on mortality, litter score, live weight gain or feed conversion index.

Conclusion

Infections with coccidia are often associated with severe economic losses. Currently the prevention and control of coccidiosis is based on good hygiene, chemotherapy (Coccidiostats) and immunization. Monitoring programmes are essential for the early recognition strains developing resistance. Generally, anticoccidial drugs or vaccination alone is of little value, unless they are accompanied by improvements in all aspects of management. More attention should be given to improved sanitation and hygiene at the farm level. Including, all parameters which can improve litter quality such as; appropriate installation and management of watering systems, providing adequate feeding space, maintaining recommended stocking density and supplying adequate ventilation.

Summary

Coccidiosis is the major parasitic disease of poultry with substantial economic losses. In the past it has been realized that eradication of coccidia is not realistic and hygienic

measures alone are not able to prevent infections. Today the prevention and control of coccidiosis is based on chemotherapy, using anticoccidial drugs and/or vaccines along with hygienic measures and improved farm management. The efficiency of anticoccidial agents can be reduced by drug resistance and management programmes are designed to prevent this developing. Several different live vaccines have been commercially developed. Long-term sustainability of coccidiosis control in poultry in the future may therefore be facilitated by the adoption of rotation programs, involving the alternate use of a vaccine and drugs in successive flocks. Currently some trails are being carried out on the efficacy of alternative products such as herbal extracts with various results. The present paper review the prevention and control approaches of poultry coccidiosis in past and future.

Key words

Coccidiosis, Chickens, Turkeys, Prophylaxis, Vaccination

Zusammenfassung

Geflügelkokzidiose Prophylaxe- und Kontrollmaßnahmen

Die Infektion mit Kokzidien ist die bedeutendste parasitäre Erkrankung beim Geflügel. Sie ist in der Regel mit wirtschaftlichen Verlusten verbunden. In der Vergangenheit wurde festgestellt, dass eine Ausmerzung der Kokzidiose nicht realistisch und die hygienischen Maßnahmen allein nicht ausreichend sind, um dieses Ziel zu erreichen. Heute stützt sich die Bekämpfung der Geflügelkokzidiose neben den hygienischen Maßnahmen sowie der Verbesserung des Managements vor allem auf Chemotherapie und/oder Immunprophylaxe.

Die Wirksamkeit von Kokzidiostatika kann durch Resistenzbildung herabgesetzt werden. Um das Aufkommen von Resistenzproblemen zu verringern, werden unterschiedliche Anwendungsprogramme entwickelt und eingesetzt. Darüber hinaus werden verschiedene Lebendimpfstoffe kommerziell hergestellt und zugelassen. In Zukunft wird eine langfristige nachhaltige Kokzidiosekontrolle beim Geflügel unterstützt durch Rotationsprogramme bzw. Wechselanwendung von Kokzidiostatika und Impfstoffen in Sukzessivherden.

Zurzeit werden pflanzliche Produkte erprobt, diese brachten unterschiedliche Ergebnisse. Die vorliegende Übersicht fasst die Prophylaxe- und Kontrollmaßnahmen der Geflügelkokzidiose in der Vergangenheit und von heute zusammen.

Stichworte

Kokzidiose, Hühner, Puten, Prophylaxe, Impfung

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