

Coccidiosis Summary

Introduction

1. This summary was prepared by a DISCONTTOOLS group of experts on avian coccidiosis, which is caused by parasitic protozoa of the genus *Eimeria*. The group reviewed the current state of knowledge on avian coccidiosis, considered existing tools for diagnosis and disease control, identified gaps in the availability and quality of these tools and summarised the research necessary to develop new or improved tools. Full details are available on the web site at <http://www.discontools.eu/>.

Disease profile

2. Seven well-characterised *Eimeria* species have long been known to infect chickens. Since the last DISCONTTOOLS evaluation, the isolation and characterisation of parasites representing three 'operational taxonomic units, (OTUs)' has shown these to be new species of *Eimeria* of the chicken: *E. lata* (OTU-X), *E. nagambie* (OTU-Y) and *E. zaria* (OTU-Z). All three are common across the southern hemisphere and have been detected in North America and southern Europe. Their contribution to coccidiosis in the field is not known.

3. A further seven species are reported to infect turkeys with many species described in other hosts. Molecular sequencing has clarified the taxonomy of species that infect turkeys but there are many gaps in knowledge of life cycles, pathogenicity, immunogenicity and disease pathologies in hosts other than the chicken.

4. Most, but not all, *Eimeria* species are strictly host-specific. They exhibit monoxenous life-cycles with no intermediate hosts. Disease severity is variable and depends on parasite and host factors.

5. Mixed infections are common in field samples but interactions between *Eimeria* species and how these affect disease outcomes are not known. Each *Eimeria* species infects epithelial cells in a restricted region of the gut (from duodenum to colon, including the caeca); the molecular basis for this site specificity is not well understood.

6. The primary means of controlling coccidiosis are prophylactic medication of the feed with anticoccidial ionophores and/or synthetic drugs or vaccination with live *Eimeria* oocysts.

7. There is high genetic diversity between strains/isolates of a species. A limited number of studies indicate high prevalence of intra-specific genetic diversity in parasite populations which allows for rapid emergence and selection of new genotypes. Parasite population structure and disease epidemiology differs according to geographic location and host density. Epizootiology research is hampered by not being able to readily distinguish strains within species.

8. *Eimeria* parasites are transmitted by the faecal-oral route and it is rare to find uninfected commercial flocks. Infective oocysts maintain viability from weeks to months. High humidity and mild temperatures favour viability, whereas high temperatures, low moisture and high concentrations of ammonia kill parasites. There are few safe and effective oocysticides so development of products to use when animals are present, which overcome interference by organic matter and which improve penetration of surfaces, would be beneficial.

9. Pathogenicity is due to destruction of gut epithelia, villous atrophy and in some cases (*E. tenella*, *E. necatrix*, *E. brunetti*), disruption of sub-epithelial tissues leading to severe haemorrhage and death. Species infecting the small intestine cause malabsorption, leakage of plasma proteins, increased mucus production and other phenomena that adversely affect welfare and performance. Three levels of disease are recognised: coccidiosis is a mild infection with no discernible adverse effects; subclinical coccidiosis causes slight, but economically important reduction in growth and feed utilisation; clinical coccidiosis is a serious, sometimes fatal, disease.

10. Severe coccidiosis may be mitigated by birds receiving prophylactic anticoccidials and/or having acquired immunity through vaccination or early life exposure to low numbers of parasites.

11. Gut damage by *Eimeria* and resulting protein leakage renders hosts susceptible to bacterial infection including *Clostridium perfringens*, which causes necrotic enteritis as well as carriage of zoonotic bacteria including *Campylobacter jejuni*. Effective control of coccidiosis reduces bacterial dysbiosis and has the potential to reduce carriage and spill-over of bacterial food borne zoonoses.

Risk

12. All poultry are at risk by contact with faeces: broilers kept indoors (intensive, on litter) or outside (free-range, on ground); laying-birds kept on slatted floors or in wire-floored cages. The threat of disease increases with greater density of hosts and with poor management/husbandry.

13. Arthropods, wild birds, rodents, humans and any other animals with access to poultry faeces may act as mechanical vectors of infective oocysts.

14. There are significant knowledge gaps about how *Eimeria* parasites interact with their hosts, their tropism for different parts of the gut, the impact of mixed infections, how they induce pathology and how the host mounts a protective and highly species-specific immunoprotective response.

Diagnostics

15. Current diagnostics are insufficient when considering the global stage. Classical methods are highly informative but not applicable to mass testing whilst molecular tools, which are available in specialised settings, can identify and quantify infection but do not evaluate intensity (ie pathology).

16. There are no rapid tests to identify drug resistance or differentiate between strains of a single species including circulating field and vaccine parasites.

17. Subclinical coccidiosis has impacts on bird welfare and efficiency of performance, but there are no methods to diagnose subclinical disease (in live birds) and differentiate from inapparent infection (coccidiasis).

18. Rapid methods to determine immunological cross-reactivity of *Eimeria* strains (especially newly emerging genotypes and antigenic variants) would be of value for research.

19. The lack of affordable diagnostics for mass use, as well as reliable modelling of the impact of poor coccidiosis control are both obstacles to accurately estimating the impact of coccidiosis

Vaccines

20. Live vaccines make important contributions to control of coccidiosis, especially in breeder and layer sectors where they are widely deployed.

21. In the USA, where retailer pressure is driving down use of anticoccidial drugs in meat birds, live non-attenuated vaccines are used in ~ 40% of broiler production despite the impact these vaccines can have on feed conversion and weight gain of short-lived birds due to subclinical coccidiosis (caused by re-cycling of fully virulent vaccine parasites).

22. In Europe where only live-attenuated vaccines produced in SPF chickens are licenced for use, the relative cost of vaccines remains high compared to anticoccidial drugs and vaccine use in broilers is more limited, albeit with significant variation between countries.

23. Producing novel vaccines using molecular technologies (eg recombinant subunit, nucleic acid or live-vector expression) remains desirable, especially if such vaccines could induce robust protection against several *Eimeria* species across a flock in less than three weeks without the need for live parasite re-cycling (boosting).

24. No anticoccidial vaccines for turkeys are currently licensed in Europe.

25. Whilst the three newly described species of *Eimeria* that infect chickens may be controlled by anticoccidial drugs, they are not controlled by current live vaccines.

Pharmaceuticals

26. There are a range of pharmaceutical tools available for control or treatment of coccidiosis, although significantly fewer than in previous times as some companies have not re-registered compounds due to costs. It is notable that there is little visible investment in new drug discovery, despite the recent availability of high-quality molecular sequence databases

27. Resistance to all currently used in-feed anticoccidial drugs is commonly detected in field isolates and little is known about mechanisms of action or resistance

28. It is broadly accepted in Europe that in-feed anticoccidials remain an essential tool to control coccidiosis in fast-growing broilers, and in turkeys. However, the debate continues and there is a strong desire in the veterinary community to ensure that anticoccidial use is monitored effectively.

29. A few coccidiostats are available to treat birds suffering from coccidiosis usually by including a soluble compound in the drinking water. The results can be equivocal and better therapeutic drugs to treat outbreaks of clinical disease are needed.

Conclusions

30. *Eimeria* species are serious global pathogens of domesticated poultry. Infections must be controlled to avoid clinical coccidiosis which causes high morbidity and mortality, and to avoid subclinical coccidiosis which impacts on animal welfare and productivity.

31. Since the last DISCONTTOOLS evaluation there have been major steps forward in describing in detail the genotypes, transcriptomes and proteomes of the most important parasite species; these datasets provide excellent materials for new approaches to diagnostics, drug discovery and vaccine development.

32. There has also been significant progress in understanding the importance of gut health and the interaction of coccidial parasites with intestinal microbiomes, and a much-increased recognition that subclinical coccidiosis has an impact on bird welfare and performance and is an important co-factor in dysbiosis and necrotic enteritis.

33. Whilst the number of publicly funded research groups working on coccidiosis globally has diminished over the past years, there has been significant uptake of research and development within the private sector with a strong focus on improved tools for diagnosis and control.

34. There remain many significant gaps in knowledge of the biological processes that occur during infection and understanding of the host-pathogen molecular interactions that underpin the outcomes of infection, disease and recovery.

35. Collaborations between academic researchers, poultry producers and veterinary pharma are needed both to support specific projects and to share knowledge/evidence on the effectiveness of interventions and the impact of coccidiosis.