E. coli – the underestimated broiler breeder pathogen

The threat of avian pathogenic Escherichia coli (APEC) is greater than ever today due to the demand for intensified poultry production, while antibiotic usage in farming is getting restricted.

Antibiotics are important for maintaining animal health, but their use has come under scrutiny in recent years due to the rise of antibiotic resistance globally.

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Colibacillosis is still considered one of the leading causes of economic losses in the poultry industry worldwide. It is a general term for several avian diseases caused by APEC, which manifests in a wide range of clinical conditions, such as airsacculitis, perihepatitis, pericarditis, peritonitis, salpingitis, polyserositis, omphalitis, cellulitis or 'infectious process' and swollen head syndrome in broilers and long-lived birds (see photographs).

While the majority of E. coli strains are considered opportunistic pathogens, disease outbreaks being precipitated by predisposing factors, such as concurrent virus infections or inappropriate husbandry practices, the possibility that some virulent types may act as a primary pathogen have also been widely supported.

Colibacillosis in broiler breeders and their offspring

Most studies on colibacillosis refer to broilers, however laying hens can also be severely affected. Therefore, broiler breeder companies should not underestimate this pathogen as the outbreaks characterised by salpingitis/peritonitis are also economically devastating due to decreased egg-production as well as increased mortality, culling and treatment costs.

In a 2013 Dutch study of only APEC-associated peritonitis in four layer and two broiler-breeder flocks, total losses including the cost of antibiotics were estimated to be €0.4 million for the layer sector and €3.3 million for the meat sector.

Colibacillosis in neonatal chicks can also be a consequence of poor chick quality and sanitation in the hatchery, leading to early chick mortality.

A growing body of evidence, both peer-reviewed research and practical farm trials suggest that APEC infections in broiler chicks with clinical colibacillosis appeared to correlate with the E. coli strain isolated from their breeders.

An APEC transmission from breeders to broiler chickens is possible. The penetration of APEC present on the outer surface of the shell membrane, into the egg during incubation is not always fatal for embryos, so they may hatch and become carriers of the pathogenic agent.

In a study by Giovanardi, the majority of APEC strains in chicks isolated from yolk sacs and field cases of omphalitis and yolk sac infections were already observed in one-day-old chicks from where the systemic infection spread. The fact that a genetic similarity between APEC clones inside a single production chain from breeders to broilers, indicates field cases of omphalitis or colibacillosis originated from an APEC embryo infection before hatching. The timing of infection has been described as reflecting the broiler chicken mortality pattern.

With a bacterial infection acquired after hatching, the mortality begins after more than 20 hours; with an embryo infection it begins at hatching. Even if present even in very small amounts in the yolk sac, APEC could selectively overgrow the non-virulent strains of E. coli and cause septicaemia later.

Higher prevalence of E. coli in broilers

A five year ProHealth Sustainable Intensive Pig and Poultry Production project concluded in the EU in November 2018 has developed an understanding of the multi-factorial dimension of animal pathologies linked to the intensification of production, and one of them is E. coli infection in broiler production and the role of broiler breeders.

The study involved four broiler parent flocks, which were followed during the whole production period (20-60 weeks) with post-mortems and bacteriological examinations of randomly selected dead birds. Newly hatched chickens from each flock were swabbed in the cloaca taking into account the parent age at 30, 40, 50 and 60 weeks, and bacterial flora was analysed.

The causes of first week mortality were determined pathologically and bacteriologically.

E. coli isolates were selected for Pulsed-Field-Gel-Electrophoresis and Multi-Locus-Sequence-Typing.

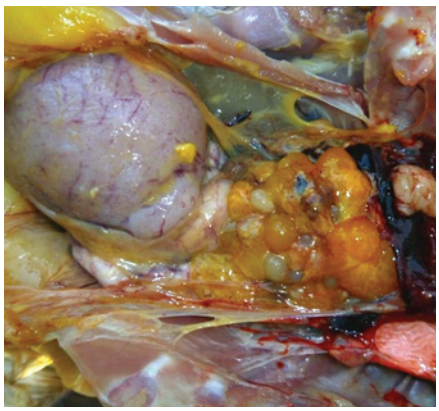
The results of 99 broiler breeder post-mortems found 29.2% were due to salpingitis/peritonitis followed by 8.3% of birds which were egg bound with involvement of E. coli infections.

More than 430 broiler offspring were sampled and E. coli infection was more prevalent in birds hatched from older breeders. Normal and floor eggs were also sampled in the hatchery, and there was a higher presence of E. coli in the latter.

This study by the University of Copenhagen concluded there was a

Continued on page 13

From left, omphalitis in a broiler chick; salpingitis in a meat-type laying hen; and peritonitis in a meat-type laying hen (Photos courtesy of Dr Tony Unandar, a private poultry farm consultant).



Continued from page 11
tendency towards a higher prevalence of E. coli associated first week mortality in broilers originating from older breeders as well as a higher prevalence of E. coli in breeders originating from floor eggs.

Certain strains were particularly prevalent, such as E. coli ST 131 and 95, which are virulent and can pass down the chain. Nearly half the investigated E. coli strains were transmitted between salpingitis/peritonitis affected breeders newly hatched at the hatchery and cases of first week mortality in broilers.

The recommendations following this ProHealth study into E. coli infections are: floor eggs from broiler breeders cannot be recommended for use as they pose an E. coli infection risk and increased horizontal transmission in the hatchery; general hygiene measures, use of medicines, vaccination, genetic selection and food supplements should be used to mitigate this production disease.

Maintaining good poultry house hygiene as well as careful environmental management are considered important steps in prevention. However, once an APEC infection is established, the standard treatment is administration of antibiotics. In almost all of these cases such routine antibiotic administration is done without carrying out any antimicrobial susceptibility testing to determine the most effective drug against the avian pathogenic E. coli isolated from the affected birds.

Calculation	Unit Price ($)	Total ($)	
6% mortality in a 450,000-hen flock = 27,000 hens	13/hen	351,000	Mortality costs **(A)**
[(156 eggs/hen X 27,000 hens)] /12 = 351,000 dozen eggs	2.27/dozen eggs	796,770	Production losses **(B)**
	A+B =	1,147,770	Total loss **(C)**
Conservatively assuming two doses of Poulvac E. coli reduces mortality by 0.5%			
0.5% saving in a 450,000-hen flock = 2,250 hens	13/hen	29,250	In mortality savings **(D)**
[(156 eggs/hen X 2,2500 hens)] /12 = 29,250 dozen eggs	2.27/dozen eggs	66,398	In increased revenues **(E)**
	D+E=	95,648	Total return **(F)**
Investment to vaccinate a 450,000-hen flock with two doses of Poulvac E. coli = $12,000 **(G)**			
	F:G =	8:1	ROI

Table 1. For a typical complex that manages 450,000 hens, 6% mortality equates to a financial consequence of about $1.15 million annually. Conservatively assuming two doses of Poulvac E. coli reduces mortality by 0.5%, it could result in a potential ROI of about 8:1.

Reduced use of antibiotics

While antibiotics play an important role in the control of APEC infections, their continuous use leads to the emergence of drug resistant strains of E. coli, including multi-drug-resistant strains. Thus, pathogenic E. coli drug resistance has become a focus of the international community.

The pressures surrounding indiscriminate use of antibiotics are well established, with the World Health Organization naming resistance to the antimicrobials a 'major global threat' to human health, leading to huge pressure on their use in poultry production.

A number of developed countries have taken antibiotics considered critical to human health, such as colistin, out of food animal production altogether following the evidence of major increase in colistin resistance due to a plasmid-mediated resistance gene — MCR-1 detected in E. coli isolated from poultry and swine.

This is coupled with a growing number of E. coli isolates that are resistant to multiple antibiotic products, further compounding the problem. Once an isolated problem, E. coli has become more prevalent in long-lived birds as poultry companies reduce or eliminate antibiotics in the hatchery and in feeds. As E. coli is transmitted vertically from breeders to their offspring, prophylactic measures should include the reduction of disease carrying APEC in the higher levels of the production pyramid.

Vaccine development

Vaccination can be considered an important preventative tool in this global effort to reduce reliance on antibiotics. Over the years, vaccination against E. coli, either by killed/autogenous or live E. coli vaccines to protect modern poultry flocks of all types has been practiced to prevent colibacillosis or chronic respiratory disease (CRD) outbreaks.

Autogenous E. coli vaccines fall into the category of killed vaccines. Often produced as an 'emergency' vaccine in response to a colibacillosis outbreak, they comprise inactivated whole cells of the organism isolated from the diseased birds. The common drawbacks from autogenous vaccines are labour intensive to handle individual birds for injection, and have been known to cause adverse injection site reactions.

As with the killed vaccine, autogenous E. coli vaccines tend to stimulate more of a systemic antibody response with a limited cell-mediated response. These types of inactivated vaccines therefore have a more limited ability to give an overall broad protective immune response and cross-serotype protection.

In recent years, there is only one licensed live attenuated vaccine for colibacillosis: Poulvac E. coli. The laboratory and field trials of Poulvac E. coli have proved its efficacy in offering birds protection from this economically important disease.

The onset of immunity is 14 days, and it can offer birds' protection for up to 45 weeks of age. Clinical trials found the O78 type afforded the most effective protection when compared with three other serotypes, O1, O2 and O18.

Typical administration is either as a spray or via drinking water, at day one for breeders, although this can be adapted if required.

The data obtained in the study suggests that the immune response produced by a spray Poulvac E. coli vaccine is mainly a cellular response, especially relevant to the site in contact with the pathogen. It is suggested that macrophages act first and then recruited lymphocytes act in the production of secreted IgA to protect the host.

As with any live vaccination, it is crucial not to limit its efficacy through poor handling. Taking care to store this product in line with the manufacturer's guidelines, and administer it with clean, non-chlorinated water (with a vaccine stabiliser added) will ensure the broadest protection across a flock.

Data from more than 300,000 broiler breeders, over 28 flocks, in the US were vaccinated prior to lay. Between 26 and 31 weeks flocks were compared with the same number of unvaccinated birds from the year before. Over that five-week period, cumulative mortality was 33% lower. In addition, just two out of the 28 vaccinated flocks required antibiotic treatment, compared with 13 of the 28 in the control group. All field trials to date have demonstrated between 1-2% improved hen liveability.

The financial gains afforded by lower mortality in broiler breeders are hard to overstate.

A 450,000-bird flock with 6% mortality in the US is missing out on $1.5m in revenue (27,000 hens at $13 each plus 350,000-dozen eggs at $2.27 each).

Reducing mortality by 0.5% in this scenario saves 2,250 hens and 29,250-dozen eggs, generating at a conservative estimate $95,400 set against a $12,000 vaccination cost to vaccinate a 450,000-hen flock with two doses of Poulvac E. coli, a return of investment (ROI) of 8 to 1 (see Table 1).

Conclusions

To conclude, avian pathogenic E. coli (APEC) remains one of, if not the most costly cause of disease in modern poultry production worldwide. Its threat should not be underestimated as study findings imply that broiler breeders asymptomatically infected with these salpingitis-causing strains might represent a major reservoir of infection for the broiler progeny and contribute significantly to first week mortality.

As the established treatment practice through antibiotic therapy is becoming restricted, other effective prophylactic measures such as general hygiene, disinfection procedures of hatching eggs, probiotics supplementation and vaccination to breeders need greater attention.

The vaccination with an attenuated live E. coli vaccine may offer a cost-effective outcome in broiler breeder flocks against homologous and heterologous strains challenge. ■

References are available from the author on request