

# Reducing pathogenic *E. coli* infection by vaccination

**The impact of *E. coli* infection on broiler flocks can be substantial. New vaccines, however, will help in preventing this erosive disease complex.**

By Dr Simon M. Shane, Durham, NC, USA

**A**vian pathogenic *E. coli* (APEC) represents the most economically significant disease complex affecting the world's broiler industry. APEC is responsible for a number of conditions, principally as bacterial opportunists that affect both parent level and commercial broiler flocks following immunosuppression and subsequent exposure to a respiratory viral infection. The most common conditions encountered include: Septicemia, peritonitis and salpingitis in broiler breeders; airsacculitis and septicemia complex in commercial broilers; Cellulitis or "infectious process" (IP) resulting in downgrades of broilers, and; Swollen Head Syndrome in broilers and occasionally breeders.

## Antibiotics common practice

Currently APEC infections are controlled indirectly by protecting against primary respiratory pathogens, including Newcastle Disease (ND), Infectious Bronchitis (IB), laryngotracheitis (LT), mycoplasmosis (MG & MS) and immunosuppressive viral infections, Infectious Bursal Disease (IBD), chicken anemia (CA) and Marek's disease (MD). In addition, measures are required to reduce environmental stress associated with temperature extremes, improper ventilation, mycotoxins, contaminated drinking water and suboptimal hygiene, which all contribute to the occurrence of APEC infection.

In many countries it has been common practice to administer antibiotics to suppress infection with APEC. Market pressures, trade restrictions and statutory restraints have reduced the availability of antibiotics. Imprudent and prolonged medication has resulted in widespread resistance to therapeutic agents. This has necessitated a re-evaluation of APEC infection and the introduction of vaccines specifically developed to stimulate an immune response against pathogenic *E. coli* as an adjunct to concurrent vaccination against primary respiratory and immuno-suppressive pathogens. Approaches to control that eliminates the routine or excessive

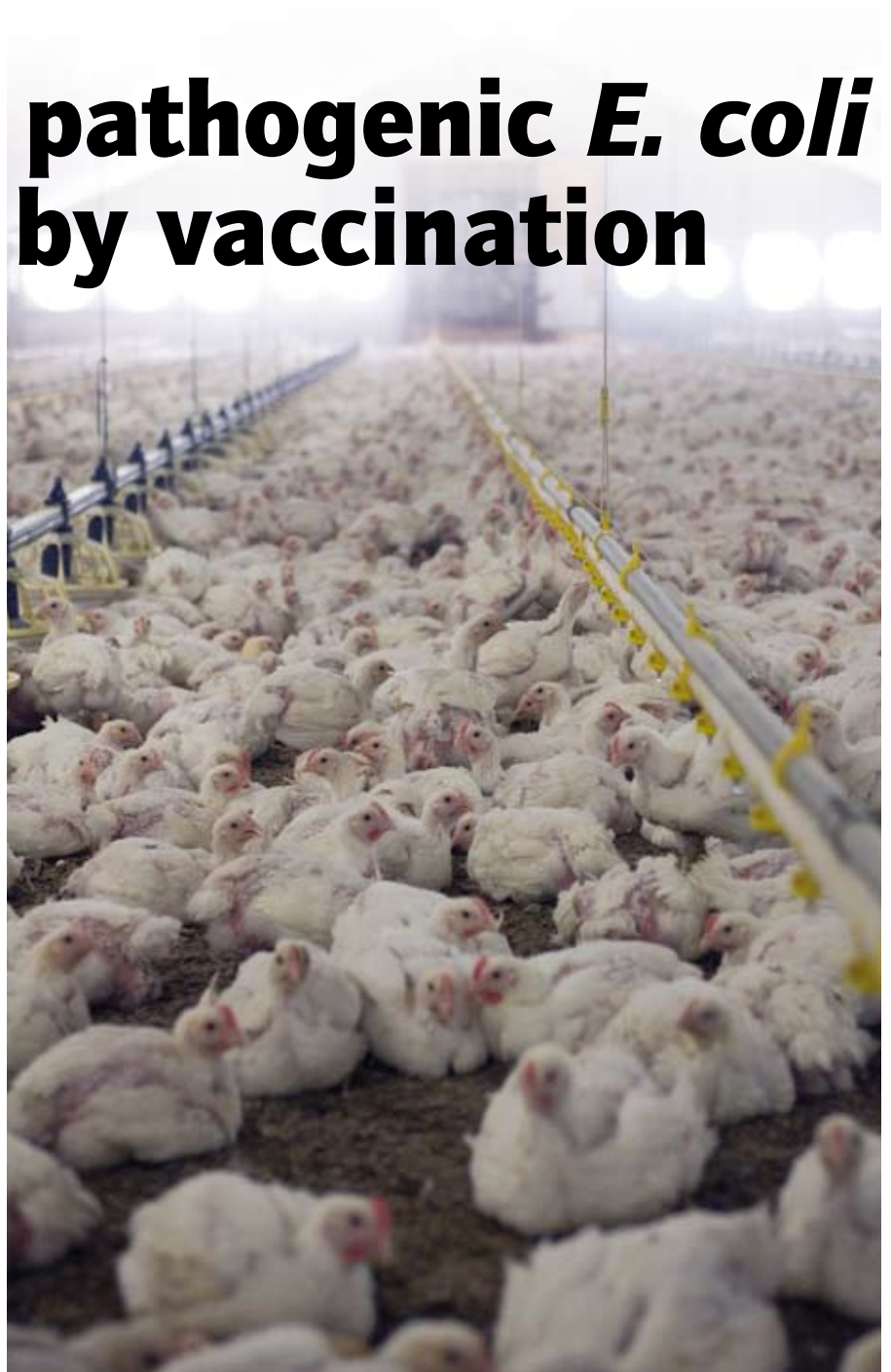
use of antibiotics will be met with favour from consumers and regulators.

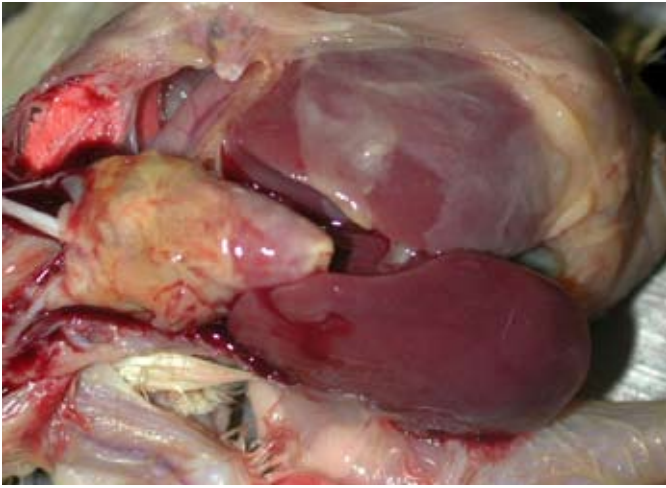
## Epidemiology and occurrence

Replacement broiler breeder pullets which are otherwise successfully immunised against a wide range of respiratory and systemic diseases frequently demonstrate elevated mortality during the period following onset of production through 45 weeks of age. Losses are associated with peritonitis and septicemia and with salpingitis in older flocks. Infection with APEC can occur by inhalation of contaminated house dust resulting in infection of the abdominal air sacs and extension to the serous surfaces of the body cavity, an ascending infection of the reproductive tract precipitating salpingitis

and peritonitis or through the consumption of contaminated water.

In broilers, infection from contaminated drinking water or inhalation of dust laden with APEC can result in septicemia and airsacculitis, respectively. These conditions are often preceded by exposure to immunosuppressive viruses and are triggered by respiratory viral infections. Flocks that are infected with *Mycoplasma spp.* by either the vertical or horizontal routes are especially predisposed to APEC airsacculitis. Swollen Head Syndrome, which occurs in many areas of the world, is a multifactorial condition involving the sequence of immunosuppression by IBD, MD or CA followed by exposure to a respiratory virus, which may include single or combined infection with IB, TRT or ND. Infection of the





**Pericarditis and perihepatitis in a broiler, due to *E. coli* infection, denoted by a grey pseudomembrane covering the pericardium of the heart and the serosa of the liver. If birds survive to harvest, they are condemned on inspection as being unwholesome.**



**Acute airsacculitis due to *E. coli* infection, characterised by a foamy exudates which progresses to caseous airsacculitis. Surviving birds are stunted. Processed birds are condemned.**

tissue surrounding the eyes and the subcutaneous areas of the head represents the terminal stage of the complex and is a direct result of infiltration of the subcutaneous fascia with APEC.

“Infectious Process” is an emerging condition characterised by subcutaneous cellulitis of the fascia overlying the breast and ventral body cavity and frequently extending to the inguinal region. This multifactorial condition is associated with immunosuppression, and field surveys have revealed a number of pathogens involved, including APEC.

### Treatment of APEC infections

Administration of approved antibiotics to breeder flocks demonstrating elevated mortality associated with septicemia and salpingitis is effective in reducing mortality only over the short-term. Frequently an increase in mortality occurs following cessation of therapy. Obviously the antibiotic selected must be shown to be effective against the strains of APEC that are isolated.

Septicemia and airsacculitis collectively represent an annual average condemnation rate of 0.2% of the approximately 170 million broilers processed each week in the US. The condemnation rate increases during winter and may exceed the standard value by 5-10 fold in specific broiler complexes with underlying problems of immunosuppression, respiratory infection and exposure to APEC. Applying the standard of 0.2% downgrading, the US broiler industry suffers losses of €38 million annually from the inspection categories of “septicemia/airsacculitis” and “infectious process”.

### New vaccines effective

Broiler breeder flocks affected with APEC salpingitis, peritonitis and airsacculitis are sometimes vaccinated with homologous-strain autogenous inactivated *E. coli* vaccines. These

products are expensive to produce, require individual administration by injection, impact pullet growth and maturity and have variable long-term effectiveness, given the variety of APEC strains in the field to which flocks may be exposed.

Advances in molecular biology have created new vaccine strains effective against APEC. Deletion of the *aroA* gene, which is necessary for metabolism of cyclic amino acids, results in loss of virulence. Modified gene-deleted vaccines stimulate both tissue (cellular) immunity and humoral (circulating antibody) immunity. The first commercial *E. coli* vaccine for chickens directed against APEC was licensed by the US Department of Agriculture in 2006. The product, Poulvac® *E. coli* manufactured by Fort Dodge Animal Health has been used extensively in the US egg industry to suppress APEC peritonitis and salpingitis in flocks producing table-eggs. Following successful laboratory and controlled field trials the vaccine has been extended to the broiler industry in the market represented by “problem farms and complexes” in which elevated breeder mortality and high plant downgrades impact profitability. Trials conducted in the Middle East, Latin America and North Africa showed benefits against APEC mortality in both breeder and broiler flocks. Poulvac *E. coli* is administered by the spray route to broilers as early as day-of-age in the hatchery and is compatible with anticoccidial and Newcastle/Bronchitis vaccines. Replacement breeder pullets can be immunised against APEC by administration of vaccine by coarse spray during the first week of age followed by a second dose at 12 weeks of age.

### Financial benefits

The potential impact of Poulvac *E. coli* on IP and broiler performance is demonstrated in a trial conducted at



**Peritonitis due to *E. coli* infection in a broiler breeder hen.**



**Alternative depiction of peritonitis and pericarditis.**

Auburn University (Table 1). Applying a subcutaneous challenge model to reproduce cellulitis, the vaccine showed 16% protection against suppression of body weight, reduced colibacillosis by 32%, mortality by 51% and the "IP" (cellulitis) score was reduced by 60%. In a structured field evaluation in a complex with a persistent problem of APEC downgrades the data from 2 million broilers vaccinated with Poulvac was compared with 2 million non-vaccinated broilers placed concurrently on farms with comparable housing and management. The vaccine afforded 40% protection against septicemia and 63% against airsacculitis (Table 2). The recorded rate of "IP" (cellulitis) was reduced by 58% and the proportion of downgraded portions was reduced by 25%. Vaccination resulted in a 40% reduction in downgrading, restoring the complex to values consistent with the region and slightly higher than the average US standard. Vaccination resulted in sales of additional product valued at €11,000 per week, offsetting the €7,000 cost of vaccination. The actual saving to the producer was far in excess of the incremental revenue arising from the sale of product, which otherwise would have been downgraded. Efficiency in the plant was enhanced as line speeds were restored to normal level and additional labour associated with overtime and re-work was reduced by over 50% for all birds processed.

**Reviewing potential impact**

Experience has shown that APEC infection can degrade live bird parameters including weight gain, feed conversion and livability. Table 3 projects losses attributed to APEC infection in a US complex producing 1 million broilers per week. Infection was assumed to result in a 2% decline in live weight, 2.7% deterioration in feed conversion ratio and an increase in absolute mortality from a standard 5% to 7%. Saleable product would be reduced by 170,753 kg per week or 9% of the theoretical output of 1,869,375 kg from 1 million broilers processed applying these parameters. Assuming unit revenue of €1.20/kg, total weekly revenue would be reduced by €93,176 compared to unaffected flocks.

In reviewing the potential impact of APEC infection in broiler industries with endemic SHS and mycoplasmosis coupled with highly pathogenic IBD and the absence of effective MD vaccination, losses in the field can be severe. Table 4 indicates a decline in the European Efficiency Factor (EEF) from 193 to 167 for affected flocks. Saleable yield would be decreased by 11% from a projected value of 147,200 kg for the operation producing 100,000 broilers per week. Assuming a unit revenue €1.50/kg, weekly revenue would be reduced by €25,176 representing 11.4% of the revenue from unaffected flocks. In the given example if the administration

**Table 1 - The impact of experimental infection with APEC and protection from IP by Poulvac® E. coli vaccine**

Treatment	Suppression in body weight (%)	Colibacillosis	Mortality (%)	Cellulitis score <sup>1</sup>
Unchallenged Control	-0-	-0-	-0-	-0-
Challenged <sup>2</sup> Control	8.0	58.5	5.3	4.8
Vaccinated Challenge	3.4	39.5	2.6	1.9
Protection (%)	60	32	51	60

<sup>1</sup> Lesion: 1=5 cm; 2=20 cm; 3=40 cm in area of breast fascia  
<sup>2</sup> Menu of two experiments with 2 APEC strains

**Table 2 - Beneficial effect of Poulvac® E. coli vaccine in US field trial**

Treatment	Condemnation category				
	Septicemia	Airsacculitis	Cellulitis	Portions	Total of selected categories
US Standard <sup>1</sup>	0.156	0.04	0.020	0.334	0.55
Field Control <sup>2</sup>	0.349	0.35	0.024	0.498	1.22
Vaccinated	0.202	0.13	0.010	0.373	0.73
Protection (%)	42	63	58	25	40

<sup>1</sup> Average US Broiler Complex September 2008  
<sup>2</sup> Values from non-vaccinated broilers (n = 2 million)

**Table 3 - Projection of losses attributed to APEC in US complex producing 1 million broilers per week**

Parameter (US winter)	Non-affected US standard	Projected APEC affected	Difference attributable to APEC
Live weight (kg)	2.50	2.45	0.05
Feed conversion ratio	1.85	1.90	0.05
Mortality (%)	5.00	7.00	2.00
Yield	75%	75%	-0-
APEC downgrades (%)	0.3	0.6	0.3
Production/week (kg)	1,869,375	1,698,622	77,284
Avg. contribution margin (€)	0.50	0.45	0.05
Weekly contribution (€)	887,953	764,380	38,572
Weekly revenue at €1.20/kg (€)	2,131,522	917,256	93,176

**Table 4 - Projection of losses attributed to APEC and SHS in complex producing 100,000 broilers per week**

Parameter	Non-affected international	Projected APEC/SHS	Difference attributed to APEC/SHS
Live weight (kg)			
at 50 days	2.00	1.90	0.10
Feed conversion ratio	1.90	2.00	0.10
Mortality (%)	8.0	12.0	4.0
EEF (points)	193	167	26
Saleable yield (%)	80.0	78.0	2.0
Production (kg)	147,200	130,416	16,784
Unit revenue (€/kg)	1.50	1.50	-0-
Weekly revenue (€)	220,800	195,624	25,176

of Poulvac E. coli vaccine reduced losses by 50%, the financial advantage would be €12,588 for an outlay of €700 per week representing a benefit to cost ratio of 18:1.

**Good benefit to cost ratio**

If APEC infection is responsible for 10% mortality above standard in broiler breeder flocks from 20 week transfer to 65 weeks of age, projected chicks per hen housed would be reduced from an acceptable standard of 125 to 110 chicks. To maintain a constant throughput of 100,000 processed

broilers per week, the operation would have to place and maintain an additional 3,000 laying hens above the required complement of 30,000 hens in production. The cost associated with purchase of an additional 3,000 pullets annually together with rearing these pullets and housing and feeding extra hens would amount to €40,000 per year. The cost of administering two doses of Poulvac E. coli vaccine would amount to €420 each year. If 50% of losses associated with APEC mortality could be averted by vaccination, the benefit to cost ratio would attain 50:1. ■