Poultry Diseases Influenced by Gastrointestinal Health
Traditional Treatments and Innovative Solutions

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INTRODUCTION TO GUT HEALTH

Feed costs represent a large percentage of the operational expenses associated with animal production. It is for this reason that producers should pay close attention to the efficient utilization (absorption) of feed. From a strict point of view the gastrointestinal lumen, from mouth to anus, corresponds to the external environment and the intestinal mucosa represents the barrier that separates the animal from the environment. Besides its absorptive capacities the intestine must provide adequate protection against pathogenic bacteria. Considering the billions of bacteria that populate the intestinal tract this is not a trivial task.

The maintenance of a healthy gastrointestinal tract insures that nutrients are absorbed at an optimum rate and that bacteria are kept in adequate numbers and confined to their natural niches. Whenever the integrity of the intestinal mucosa is compromised, nutrient absorption decreases. In addition, part of the effectively absorbed nutrients are directed to repair the damaged area and to support the immune system which starts working relentlessly until the intestinal insult is eliminated. In case of prolonged activity, inflammatory processes indeed drain plenty of energy which is otherwise stored as body tissue.

For the mentioned reasons it is wise to use all the available means to ensure that our flock counts with the optimal conditions to achieve the best possible feed conversion. This book focuses on gastrointestinal diseases of poultry and on poultry diseases that do not have an intestinal origin but that are somehow influenced by intestinal heath. In countless occasions, improvement in flock management has a huge beneficial impact on several of the conditions that will be covered in this book, and thus technical advice from poultry veterinarians and our team of poultry specialists is given.

The number of countries that are currently banning antibiotics for non-therapeutic purposes in animal husbandry is increasing; new tools are emerging to control or to ameliorate poultry diseases using an environmentally friendly approach. Among the new available tools organic acids, phytogenics, and especially probiotics will be covered in this book. In addition, conventional treatments for poultry diseases are also listed.

We hope that this guide will increment your knowledge of poultry diseases and poultry management, and that at the end of the rearing cycle you may see this reflected on your pay check.

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SECTION I

BASIC INTRODUCTION TO THE ANATOMY AND PHYSIOLOGY OF THE DIGESTIVE SYSTEM
Basic introduction to the anatomy and physiology of the digestive system
Basic Introduction to the Anatomy of the Digestive System

The beak is the first anatomical structure of the gastrointestinal system. Unlike mammals, birds do not have a clear anatomical distinction between the pharynx and the mouth and the complex formed between these structures is called oropharynx. In contrast to mammals, birds do not have soft palate and the palatine cleft or choana, a longitudinal fissure in the palate, connects the oral and nasal cavities (Figure 1).

Figure 1. The roof of the mouth cavity of a juvenile broiler is shown in this picture. Note the presence of the longitudinal fissure (choana).

There are several salivary glands in the roof of the mouth – maxillary, palatine, and sphenopterygoid glands - and in the floor of the mouth – mandibular, lingual, and cricoarytenoid glands. The bucal gland is located in the cheeks (M. Denbow, 2000). Saliva helps to lubricate feed and also contains enzymes (amylase) in some species (not present in chickens or turkeys) that may exert some digestive effect when the feed is stored in the crop (Figure 2) (M. Denbow, 2000). The chicken’s tongue is arrow-shaped and helps to propel feed into a sphincter-less esophagus which is thin-walled and divided into cervical and thoracic regions. The cervical region of the esophagus dilates and opens into the crop which is an expansible structure that allows storing of swallowed feed. Mucus glands are located within the mucosa of the esophagus and crop lubricating feed. After a variable storage period in the crop, feed continues through the thoracic portion of the esophagus reaching the stomach.
Basic introduction to the anatomy and physiology of the digestive system

In birds, the stomach is composed by two chambers: the proventriculus or glandular stomach and the muscular stomach or gizzard. These chambers are separated by a transitional isthmus (zona intermedia gastric). The proventriculus is the homologous counterpart of the mammalian stomach. In comparison to the gizzard, the proventriculus is small and soft-walled. The lumen of the proventriculus is characterized by a granular appearance which is given by numerous papillae. These papillae contain the oxynticopeptic cells responsible for the production of the gastric secretion (hydrochloric acid, pepsin, and mucus). The gizzard grinds and mixes feed with gastric secretions and saliva. The grinding movements are due to the action of two opposing pairs of muscles (named thin and thick pair) that surround the organ. There is a thick cuticle that covers the gizzard which is secreted by the mucosal glands located underneath (Figure 3). This cuticle protects the gizzard from the action of the hydrochloric acid and pepsin secreted by the proventriculus. This cuticle also offers effective mechanical protection against the friction generated in the process of feed grinding. The pyloric portion of the gizzard is small in chickens and contains mucosal glands that secrete mucus to lubricate the passage of the ground feed from the gizzard to the duodenum.

The pyloric region of the gizzard opens caudally into the small intestine which is lined by a monolayer epithelium. The intestinal cells facing the intestinal lumen are called enterocytes. The enterocytes are arranged into villi which are structures that protrude into the intestinal lumen. At the same time the luminal side of the enterocytes also projects irregularly towards the intestinal lumen forming the microvilli (also known as the brush border). The enterocytes have a short life span and are constantly replaced by new enterocytes that migrate from the crypts of Lieberkuhn which are the structures located between the villi (Figure 4).

Figure 2. Left panel: the skin of the neck of a juvenile broiler chicken was removed to expose the esophagus and crop. Right panel: the crop was opened and a forceps was introduced through the esophagus to show the physical connection. The tubular structure located immediately above the esophagus corresponds to the trachea.
Figure 3. Left panel: proventriculus (upper part) and ventriculus (gizzard) of a juvenile broiler. The cuticle was partially removed with a forceps exposing the mucosa of the gizzard. Right panel: proventriculus and gizzard mucosas exposed. Note the granular texture of the proventriculus (upper region of the picture) and the pale transitional zone (isthmus) above the gizzard (arrow).

Figure 4. Histological sample of the small intestine (duodenum) of a broiler chicken stained with PAS hematoxylin observed under a light field microscope (40 X). The upper right corner of the picture shows the intestinal lumen and the top of the villi (stars are placed at the center of the villi). The crypts of Lieberkühn are indicated by black arrows. Courtesy of Ms. N. Reisinger.

This complex anatomical assemble confers the intestine an enormous absorptive surface which allows birds and mammals to efficiently absorb water and nutrients. Intestinal challenges like toxins and pathogens damage the intestinal surface decreasing the absorptive surface.
The small intestine is formed by the duodenum, jejunum, and ileum. The duodenum forms a loop that surrounds the pancreas (Figure 5 and 6). The pancreas synthesizes important digestive enzymes (pancreatic amylase, lipase, trypsinogen, trypsine inhibitor, chymotrypsinogen, and bicarbonate) that are secreted into the intestinal lumen through the pancreatic ducts (three in the chicken) which fuse with the intestine generally in the distal part of the ascending duodenum (Denbow, 2000).

Within the distal portion of the duodenum the common hepatointeric duct (originating in the liver) and the cystic enteric duct (originating in the gall bladder) fuse to allow the incorporation of hepatic secretions (bile) into the intestinal lumen (Figures 6 and 7). Bile emulsifies fat allowing efficient surface contact for the enzymes responsible for lipid digestion (lipases). The main bile acids secreted in the domestic fowl are the cholytaurine and chenodeoxycholyltaurine acids.

**Figure 5.** Duodenal loop and pancreas of a juvenile broiler chicken. The pancreas is located between the ascending and descending duodenum.

**Figure 6.** Hepatoenteric duct and cysticoenteric ducts fusing to the distal part of the duodenum (tip of the forceps).
After the duodenal loop the intestine is continued by the jejunum and the ileum. The Meckel’s diverticulum marks the division between these two anatomical locations. This diverticulum is the remnant of the connection between the yolk sac and the small intestine during embryonic and early life (Figure 8).
At the junction of the small intestine and rectum 2 blind ceca arise (Figure 9). The intestinal content enters into the ceca through the ileocecal junctures. In the proximal portion of the cecal epithelium the villi are well developed and they tend to decrease in length towards the blind end of the ceca. In the middle portion of the ceca the mucosa arranges to form longitudinal folds and close to the blind end of the ceca in addition to the longitudinal folds transversal folds develop (Ferrer et al., 1991). After a variable amount of time the ceca contract and the cecal content is propelled to the large intestine. The large intestine is relatively short in birds compared to mammals and ends into the cloaca which is a common anatomical area for the digestive, urinary, and reproductive tracts.
Basic Digestive Physiology

In this book a short overview of digestive physiology of poultry will be given. The intention of this concise review is to give a basic physiological knowledge that will help the reader to “digest” the importance of maintaining flocks with an appropriate intestinal health to obtain the maximum profitability of the invested resources.

CROP

In poultry, the digestive role of the crop is mainly limited to feed storage (in non-precocious birds crop is important for feeding the hatchlings). Within the context of evolution feed storage is intended to permit rapid intake of feed while birds are in open areas limiting the time in which they are vulnerable for predators. After feed ingestion birds can return to secure areas to continue the digestive process.

STOMACH

Proventriculus: In birds, oxynticopeptic cells from the stomach produce HCl and pepsinogen which is transformed to pepsin after acid-induced cleavage of the molecule. The stomach pH is normally above 2.7 in chickens (Long, 1967). By the action of HCl the ingested protein denatures, exposing cleavage sites where pepsin exerts its action. Chicken gastrin is apparently produced by cells located within the pyloric area of the gizzard. Gastrin is a hormone that stimulates gastric acid and pepsin secretion in birds. Gastrin-releasing peptide is also produced in the proventriculus and it stimulates crop contraction and pancreatic enzyme secretion.

Ventriculus (gizzard or muscular stomach): The gizzard grinds and mixes feed with gastric secretions and saliva.

INTESTINE

The conditions found within the small intestine are radically different from those found within the stomach. The pancreas plays a big role in quickly changing the intestinal environment to one that can be tolerated by intestinal cells. This is accomplished by the pancreatic secretion of water and bicarbonate that dilute and neutralize the acid produced in the proventriculus. Within the small intestine, enzymes synthesized in the pancreas are incorporated to continue the digestive process (amylase, proteases, and lipase). The proportion of the enzymes secreted by the pancreas is influenced by the diet. Diets abundant in carbohydrates stimulate the synthesis and secretion of amylase; diets abundant in protein stimulate the secretion of proteases; and diets containing a high level of fats stimulate increased secretion of lipase (Hulan and Bird, 1972; Bird and Moreau, 1978).
Bile is produced in the liver, stored in the gallbladder and released into the small intestine. Bile is able to emulsify fats thus increasing the surface for the enzymes that are able to digest lipids (lipase). In addition, amylase has also been described as a component of the bile of juvenile chickens and thus a role in carbohydrate digestion is also expected from bile (Denbow, 2000).

Complete digestion of oligo and disaccharides depends on the action of enzymes located on the microvilli of enterocytes. Maltase, sucrose, palatinase, and lactase activities have been reported to be present on the small intestine surface (Siddons, 1969). In contrast, within the large intestine the enzymatic activity seems to be located in the lumen. This can be due to the passage of enzymes from the small intestine or due to bacterial production and secretion of enzymes within the ceca. Actually, lactase activity in the ceca is believed to be from bacterial origin (Siddons, 1969).

The largest proportion of carbohydrate absorption occurs in the duodenum followed by the jejunum and ileum (Riesenfeld, 1980). The ceca are able to absorb glucose: in fact their ability to absorb glucose in low concentrations may be higher than that of the jejunum (Vinardel and Lopera, 1987). As in mammals, glucose transport in birds is an active process coupled to sodium molecules and dependent on the concentration gradient created by the Na+/K+-ATPase.

Amino acids are absorbed in the crop, proventriculus, muscular stomach, small intestine, and ceca. The vast majority of amino acid absorption occurs within the small intestine but some amino acids like methionine can be absorbed even in the rectum (Denbow, 2000). Peptides are also absorbed in the avian intestine. The general absorption mechanism of amino acids is ATP-dependent and coupled with a concentration gradient of sodium created by the Na+/K+-ATPase. In addition, ATP- independent mechanisms have also been described for some amino acids (Moretó et al., 1991). The ceca are of particular importance in amino acid absorption. This is in part because the physiological flow in the avian rectum is governed by the traditional peristaltic waves but also by retro-peristaltic waves. In fact, the retro- peristaltic waves are almost continuous and are only interrupted during defecation (Denbow, 2000). This physiological peculiarity of birds is useful to transport urates from the common chamber of the digestive and urinary tract (cloaca) into the ceca. There, nitrogen from the urine can be utilized by the cecal bacteria to produce amino acids and protein. In addition, proteases are active within the cecal lumen and thus newly synthesized protein can be effectively digested and absorbed by the cecal epithelium (Moretó et al., 1991; Denbow, 2000).

Fatty acids are absorbed mainly in the jejunum and ileum. Fatty acids are transported inside enterocytes, where they are re-esterified into triglycerides, to form portomicrons which pass directly to the portal circulation (in mammals the homologous molecule is transported to the lymphatic circulation; Denbow, 2000). Volatile fatty acids are absorbed by the small intestine and ceca. As mentioned above, the rectal retro peristalsis in birds allows the transport of cloacal uric acid into the ceca. Within the ceca, bacteria are able to synthesize protein starting from the nitrogen contained in the uric acid molecules. The ceca are also important for the production of volatile fatty acids which are produced through
the microbial fermentation of uric acid. The produced volatile fatty acids then accumulate within the ceca and are transported passively to the blood stream down their concentration gradient. The cecal bacteria also have a role in the production of vitamin B6; however, the produced amounts are not enough to cover the requirements in poultry (Denbow, 2000).

Water is absorbed throughout the length of the gastrointestinal tract. Water is absorbed in combination with sodium, glucose, and amino acids. The rectal retro-peristalsis also makes the ceca a place where water is reabsorbed from the urine.

References


