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Pathology of the Exotic Companion Mammal Gastrointestinal System

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KEYWORDS

• Chinchilla • Gerbil • Hamster • Mouse • Rabbit • Rat • Sugar glider
• Gastrointestinal disease

KEY POINTS

- A variety of disease agents can affect the gastrointestinal tract, some of which can pose zoonotic health concerns.
- Many conditions are present with nonspecific clinical signs (lethargy, variable degrees of diarrhea, and for most sick rodents, presenting hunched with spiky fur), necessitating additional laboratory testing to reach a diagnosis.
- Primary tumors of the digestive tract are also presented as well as miscellaneous conditions ranging from toxins to trauma.

INTRODUCTION

This review covers gastrointestinal and select oral diseases from rodent submissions to the author's laboratory[1] as well as some classic diseases from the literature. There is limited information on clinical sign presentations and potential therapies. The disease agents cover viruses, bacteria, fungi, protozoans, and metazoan parasites. Primary tumors of the digestive tract are described as well as miscellaneous conditions ranging from toxins to trauma.

CHINCHILLA

Oral Disease

Chinchillas have continuously growing open-rooted (hypsodontic) teeth. Malocclusion of these teeth can involve the incisors, premolars, and molars. Overgrowth and abnormal wear may result in sharp points and edges to the teeth as well as fractures of the tooth. These sharp edges traumatize the oral cavity, leading to gingivitis, stomatitis, and glossitis. The common presentation of dental disease is lethargy, anorexia,

Disclosure: This article originally appeared in similar form in the proceedings of the 2013 Association of Exotic Mammal Veterinarians Conference in Indianapolis, Indiana, USA.
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Vet Clin Exot Anim 17 (2014) 145–164
http://dx.doi.org/10.1016/j.cvex.2014.01.002 **vetexotic.theclinics.com**
1094-9194/14/$ – see front matter

and hypersalivation.[2] Radiographic studies have proved to be a valuable tool to completely evaluate malocclusion.[3] The cause(s) may be familial or the result of trauma or inappropriate dietary items or infections.

Gastrointestinal Tract

Bacteria

A variety of bacteria are reported to cause enteritis. Published reports describe *Klebsiella pneumoniae*,[4] *Yersinia enterocolitica* (classically producing a fibrinous enterocolitis),[5] *Listeria monocytogenes*,[6] *Staphylococcus*,[7] *Pseudomonas aeruginosa*, and *Proteus mirabilis*[8] as agents of disease.

Gastroenteritis caused by *Klebsiella pneumoniae* also resulted in an acute systemic infection in a chinchilla breeding colony.[4] The author has found that *Klebsiella pneumoniae* remains a common cause of enteritis and systemic infections in young chinchillas.

Yersinia enterocolitica has been associated with sporadic outbreaks of deaths in chinchilla colonies. The lesions were of granulomatous hepatitis, splenitis, and fibrinous enterocolitis, closely resembling the classic lesions of *Yersinia pseudotuberculosis*.[5]

Listeria monocytogenes is an obligate intracellular bacterium that causes 3 distinct clinical entities: septicemia, encephalitis, and abortion. The septicemic form affects the viscera with or without meningoencephalitis and is common in monogastric animals, whereas encephalitis and abortion occur principally in adult ruminants. Historically, chinchillas are considered one of the species more susceptible to visceral listeriosis, especially when reared in confinement. The lesions include emaciation, multiple white foci on the capsular/serosal surfaces and parenchyma of the liver, mesenteric lymph nodes, and intestines, including the cecum and colon. Rectal prolapses and colonic intussusception also occurred (**Fig. 1**).[9] These lesions grossly resemble infections by *Salmonella* sp as well as *Yersinia pseudotuberculosis*. Histologically, the intestines have transmural inflammation effacing the Peyer patches of the small intestine and multifocal inflammation of cecum and colon.[6] The source of infection is usually from foodstuffs.[9] *Listeria ivanovii*, a more common isolate from cattle and sheep, has also been identified in chinchillas, resulting in septicemia. The intestines were noted to have mucoid contents.[10]

Fig. 1. Rectal prolapse in a chinchilla. Bacterial enteritis, enteropathy caused by *Clostridium perfringens* type A enterotoxin, and severe pinworm infections are associated with prolapses in rodents.

Staphylococcal enterocolitis is a complication of antibiotic therapy, particularly broad-spectrum antibiotics, in chinchillas.[7] The bacterial overgrowth results in a fatal diarrhea and lesion of an ulcerative pseudomembranous enterocolitis.

A *Pseudomonas aeruginosa* and *Proteus mirabilis* disease outbreak resulted in gastritis with a grossly noted excessive mucus accumulating in the lumen as well as an enteritis.[8] It was thought that these animals may have been exposed to contaminated water as the source of the infection.

Protozoa

Cryptosporidia is associated with severe diarrhea in young chinchillas.[11] The small spherical protozoa can be found on the epithelial surface of the stomach, small intestine, and colon. Mucosal villus atrophy is noted with the infection.

It is reported that chinchillas normally have low numbers of intestinal *Giardia*, and the prevalence in pet populations can be significant (30%–66%).[12–14] Age, stress, and poor husbandry are responsible for proliferation of the protozoa and the development of diarrhea. From a survey by the author, most cases were of young animals (6–12 months) and most had other more significant lesions responsible for death.[1] The parasite, *Giardia duodenalis*, should be considered a zoonotic threat, although this issue is unresolved. The organisms are piriform, flattened, 5 to 6 μm long lining the brush border of the villi in the small intestine, duodenum, and cranial jejunum (**Fig. 2**). Transmission is fecal-oral.

Metazoan

The literature has few reports on metazoan enteropathies in chinchillas. Rarely, cases of *Hymenolepis nana* var fraterna are described. The clinical signs are nonspecific, with weight loss and terminal diarrhea. The cestodes reside in the small intestine. One associated lesion was an intussusception.[15] The life cycle of this cestode is unique; infections can occur by direct ingestion of the eggs, or by eating grain beetles infected with cysticercoids, or by autoinfection.

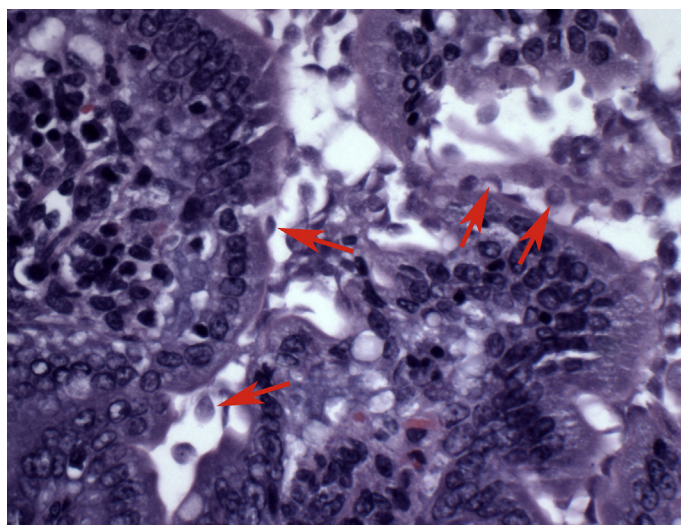

Fig. 2. *Giardia* protozoa are indicated by the red arrows. *Giardia* infections are more commonly described in chinchillas, hamsters, mice, and sugar glider (hematoxylin-eosin, original magnification ×400).

Miscellaneous

Outbreaks of unexpected death in colonies of chinchillas with gastrointestinal clinical signs (diarrhea, rectal prolapses) have been caused by *Clostridium perfringens* type A enterotoxin. Mortality was high. The predominant findings at postmortem were inflammation of the gastrointestinal tract, hepatomegaly, and splenomegly. Microscopic changes consisted of centrilobular necrosis of the liver, edema, congestion and necrosis of the large intestine mucosal, and proliferation of the white pulp of the spleen. The toxin was detected in gastric contents.[16]

Clostridium perfringens (type D) toxin generally results in unexpected death in young chinchillas (2–4 months).[17]

Some cases of typhlitis have a history of cecal stasis. Abrupt diet change, stress, low-fiber diet, and inappropriate antibiotic use have been reported as causes.

Intestinal strictures and intussusceptions are also described, without identifying a definitive cause.[1]

Neoplasia

Of the rare tumors reported in chinchillas,[18] 1 poorly differentiated carcinoma of the salivary gland[19] and an infiltrative gastric adenocarcinoma are described.[20]

The salivary gland tumor presented as a slow-growing, soft, nonpainful mass on the ventral neck. This older chinchilla (12 years) was euthanized 8 months after the mass was identified. The large tumor supported a pleomorphic cellular pattern with pseudocysts. Metastases were present in the submandibular lymph node, liver, lungs, and spleen.[19]

A 5-year-old female chinchilla died after a short period of lethargy and anorexia. On gross examination, the gastric wall was markedly thickened and the lumen almost completely filled with a firm, white, transmural mass. The tumor mass was an infiltrative adenocarcinoma and was not identified in other tissues. Polymerase chain reaction for *Helicobacter pylori* on a section of the stomach was positive; however; this bacterium was not found by silver stains or immunohistochemistry. *H pylori* has been associated with gastric adenocarcinomas in hamsters[21] and induced in gerbils.[20,22]

GERBIL

Gastrointestinal Tract

Bacteria

Gerbils are reported to be very susceptible to *Clostridium piliforme* (Tyzzer disease) infections. These young animals, less than 3 months of age, present with an acute onset of dyspnea, dehydration, and lethargy. Most animals have a triad of lesions, with enteritis/colitis, hepatitis, and myocarditis. The lesions include multifocal hepatic necrosis, necrotizing ileotyphlitis, and colitis with focal myocardial necrosis (**Fig. 3**).

Miscellaneous

Stress-induced gastric ulcers are generally found in the glandular portion of the stomach. The lesion is also seen in rats, hamsters, and guinea pigs.[23] The stressors can include abrupt changes in dietary items, overcrowding, poor housing sanitation, and transporting the animals.

Neoplasia

Tumors in gerbils are uncommonly reported. A squamous cell carcinoma arose from the gingival in 1 gerbil. No metastases were found.[24]

Two adenocarcinomas and 1 cystadenocarcinoma were identified in the cecum of gerbils older than 1 year. The tumors all filled the lumen of the cecum with invasion to

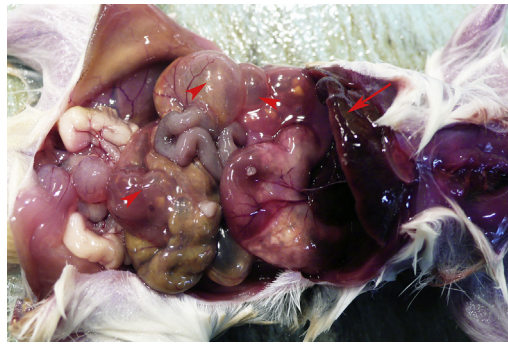

Fig. 3. The liver is swollen with rounded edges and irregular brown areas of hepatic necrosis (*red arrow*). The intestines are gas filled in this gerbil (*red arrowheads*).

the outer muscular wall.[25] One of the cases had a metastasis to the liver.[26] An adenocarcinoma of the stomach also metastasized.[24]

Systemic mastocytosis developed in a 10-month-old female. Although many organs systems were involved, the gastrointestinal tract mucosa was thickened with the proliferating mast cells. The gerbil presented emaciated and with diarrhea.[27]

GUINEA PIG

Oral Disease

Malocclusion results when the continuously growing, open-rooted teeth are not aligned and therefore do not wear properly. Premolars and molars are most often affected. Nutritional or toxic factors (eg, fluorosis) have been incriminated, but it is considered by most to be an inherited condition. As with chinchillas, the points and sharp edges can traumatize the soft tissue of the oral cavity. Severe overgrowth can even trap the tongue (**Fig. 4**). Guinea pigs are at increased risk of tongue entrapment, because of the more acute normal angle of their cheek teeth compared with other exotic mammal species.

Fig. 4. Malocclusion of the molars has entrapped the tongue of this guinea pig. (*Courtesy of* Teresa Lightfoot, DVM, Tampa, FL.)

Gastrointestinal Tract

Bacteria

Salmonellosis is probably the most important disease of guinea pigs maintained in colonies. It is uncommon in the pet population. Many serotypes may be involved, but usually it is *Salmonella typhimurium* or *Salmonella enteritidis*. The portal of entry is generally by ingestion of food or water contaminated by excreta from wild rodents and birds and rarely through the conjunctiva. *Salmonella* infections can range from latent to acute, subacute, or chronic infections. Latent infections can become overt with stress. Acute infections are generally systemic. Chronic infections are the most common, and by the time they are diagnosed, they can be well established in a colony. Morbidity may approach 100%, and recovered animals may become carriers. Clinical signs are often nonspecific, and diarrhea is uncommon. In chronic disease, there are disseminated pyogranulomas.[28]

Protozoa

Eimeria caviae is identified as an infection of young animals. There is moderate morbidity and mortality. The large intestine and cecum are generally dilated, with dark green to brown fluid feces. In severe infections, the colonic wall is hyperemic, and the mucosa has petechial hemorrhages. Microscopically, there are many developmental stages causing necrosis in the epithelium. In clinically affected guinea pigs, diarrhea, dehydration, weight loss, and death may occur. *E caviae* has a typical eimerian life cycle. Sporulation takes 2 to 11 days, with an average under most conditions of 5 days, so frequent cleaning can prevent reinfection.

Cryptosporidium wrairi may result in death in young guinea pigs. There is poor weight gain and, uncommonly, diarrhea. The organisms can be identified in the small intestine; they are very small, round to oval, and are embedded in the brush border. Infected villi are shortened, broadened, and sometimes flattened. Mild inflammation is occasionally present.

Miscellaneous

Use of some antibiotics that have activity against gram-positive bacteria can suppress normal flora and permit overgrowth of anaerobic and gram-negative bacteria. Toxins produced by 1 anaerobe, *Clostridium difficile*, can result in diarrhea, depression, and death. The intestines are distended with gas and fluid.

Imperforate anus results from failure of anal membranes to perforate, which normally occurs during the first trimester. This condition is not always externally evident in newborn guinea pigs. These animals do not survive long. Intussusceptions are common concurrent lesions.

Dilation or torsion of the stomach or cecum is not uncommon (**Fig. 5**). These guinea pigs are generally found dead, with no clinical signs. An underlying cause is not always determined.

Extensive soft tissue mineralization of the stomach and intestines can suggest several causes. Renal failure resulting in uremia commonly leads to soft tissue mineralization. The mechanism is complex but involves tissue death and secondary mineralization. In guinea pigs, exposure to excessive vitamin D is a common mechanism if renal failure is not present.[29] Such exposure frequently occurs when feeding guinea pigs commercial rabbit pellets. Rabbit diets are formulated with more vitamin D than is safe for guinea pigs. Ingestion of some plants could also result in excessive vitamin D. These plants include many varieties such as *Cestrum diurnum, Trisetum flavescens*, and *Solanum malacoxylon*.[30]

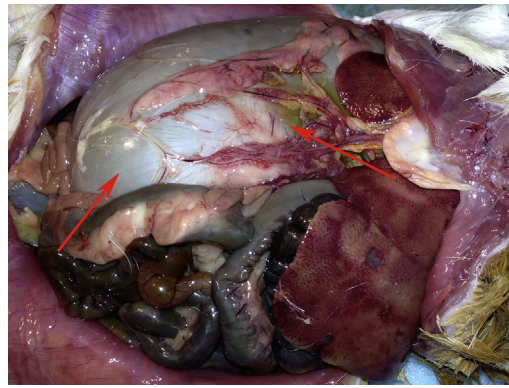

Fig. 5. The stomach is distended and torsed, resulting in displacement to the right side of the abdomen in this guinea pig. The *red arrows* indicate the stomach.

HAMSTERS

Gastrointestinal Tract

Bacteria

Hamster enteritis, also known as proliferative ileitis, transmissible ileal hyperplasia, and wet tail, can result in high morbidity as well as mortality. This is a most common and important disease. The cause is not completely determined, and multiple factors can affect the disease. It is frequently associated with a change in feed, housing, or husbandry practices in younger animals after weaning. It can present as acute, subacute, to chronic. The acute form results in death within 48 hours. The chronic form results in emaciated cachectic animals, with palpable ropey intestines. One common agent associated with this disease is a *Campylobacter*-like organism, *Lawsonia intracellularis*. The gross lesions are of thickening of the terminal ileum caused by hyperplasia of the crypt epithelium (Fig. 6).

Salmonella enteritides have all been caused by *Salmonella typhimurium*, which was serotyped to strains in concurrently infected children. The infections in hamsters resulted in unexpected death. On gross examination, there are fluid-filled and gas-filled small intestines and cecum. This infection is systemic, and the lungs also present with a patchy hemorrhagic grayish appearance with small white foci in the liver. These lesions are caused by bacteremia as well as thrombi, particularly to the lungs (Fig. 7).[1]

Protozoa

Giardiasis in hamsters ranges from subclinical to chronic wasting with diarrhea. The chronic form is associated with amyloidosis. The hamster protozoa are *Giardia muris* and their zoonotic significance is unknown.

Spironucleus (Hexamita) muris is common in some colonies of hamsters; it is found in small intestine and cecum and is considered nonpathogenic (Fig. 8).[1]

Metazoan

Hymenolepis nana (dwarf tapeworm) is the primary organism found in the small intestine of rats, mice, and hamsters. This common tapeworm has a direct and indirect life cycle. The clinical signs with heavy infestation include poor weight gains, abdominal distention, and diarrhea. The other cestode *Hymenolepis diminuta* infects hamsters with a moderate rate of incidence. Most adult rodents have developed immunity to these parasites (Fig. 9).

Fig. 6. The typical appearance of wet tail in a hamster. (*Courtesy of* Peter Fisher, DVM, Virginia Beach, VA.)

Hamsters are commonly infected with the mouse pinworm, *Syphacia obvelata*, although they have their own, *Syphacia mesocriceti*. The nematodes are generally found in the cecum and, to a lesser extent, colon. Syphacia has a direct life cycle, with eggs deposited around the anus. Mild enteritis may be associated with the infection.[1]

Miscellaneous

Antibiotic-associated colitis develops after treatment with antibiotics, particularly clindamycin. The normal bacterial flora are altered, and an overgrowth of *Clostridium*

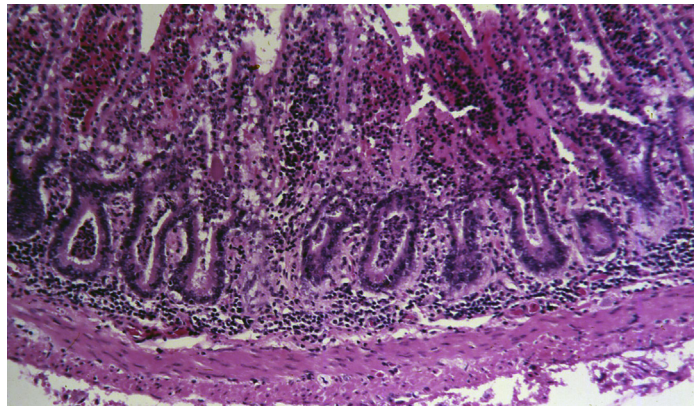

Fig. 7. *Salmonella* enteritis in the intestines. The inflammation extends throughout the mucosa (hematoxylin-eosin, original magnification ×40).

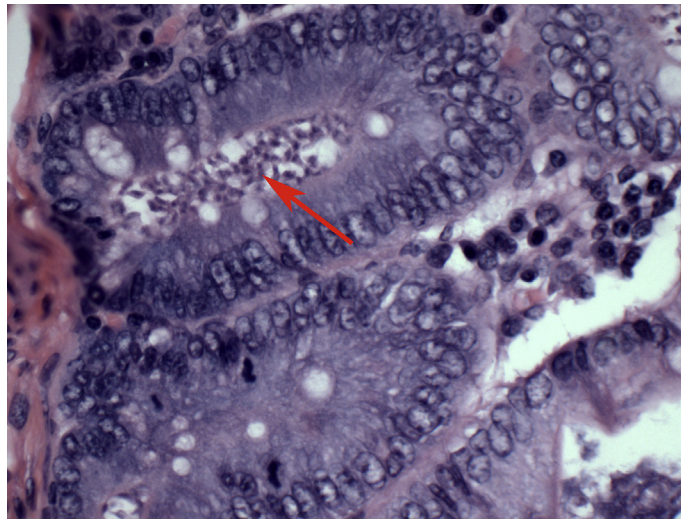

Fig. 8. Clusters of *Spironucleus* (*Hexamita*) *muris* (*red arrow*) within the lumen of the mucosal crypt. These bacteria are recognized in hamsters, mice, and rats (hematoxylin-eosin, original magnification ×400).

difficile is typical. There is a fatal colitis and, on gross examination, a distended food-filled cecum. The predominant bacterial flora of the hamster intestine are *Lactobacillus* and *Bacteroides*.

Intussusceptions have been reported in hamsters as a result of nutritional disturbances (Fig. 10). Intussusceptions also occur with existing or resolving enteritides. The clinical signs can include constipation.

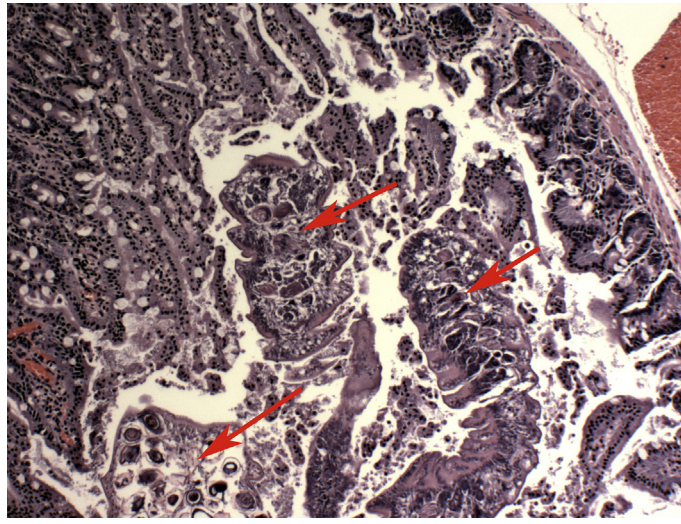

Fig. 9. *Hymenolepis* species (*red arrows*) within the intestinal lumen. These cestodes are common in hamsters, rats, and mice (hematoxylin-eosin, original magnification ×100).

Fig. 10. Enteritis from many causes can result in intussusceptions. (*Courtesy of* Chris Griffin, DVM, Kannapolis, NC.)

Rectal prolapses are also common lesions of the digestive tract. Rectal prolapses have been induced by dietary changes or hypermotility associated with acute enteritis in hamsters. There is a dark red tubular protrusion from the anus. The prognosis is generally poor.[1]

Neoplasia

Intestinal carcinomas are occasionally described in hamsters. Some cases metastasized to the regional lymph nodes.[31]

MICE

Gastrointestinal Tract

Virus

Mouse hepatitis virus is one of the coronaviruses in mice. Many coronaviral strains, with varying virulence and organotropism, have been identified in mice. Those strains that have a primary tropism for enteric mucosa result in disease in mice less than 2 weeks of age or in immunocompromised mice. There is generally low mortality but high morbidity. The typical gross lesions are multifocal hepatic necrosis, icterus, ascites, and intestinal hemorrhage.

EDIM (epizootic diarrhea of infant mice) virus is caused by rotavirus and also has low mortality but high morbidity. The disease is present in mice infected at 12 or less days of age, and the lesions are of vacuolar degeneration of villus absorptive epithelium. Malabsorption, diarrhea, and runting are common clinical signs. The infection in older mice is subclinical.

Bacteria

The most common bacteria associated with gastroenteritis are *Citrobacter freundii, Clostridium piliforme* (Tyzzer disease), *Salmonella*, *Helicobacter*, and *Proteus*.

Transmissible murine colonic hyperplasia is associated with *Citrobacter freundii*. This infection results in low morbidity and mortality. Rectal prolapses are identified as well as runting. Thickening and rigidity of the distal colon are typical.[32]

Focal hepatic necrosis and enterocolitis are associated with Tyzzer disease in this species (*Clostridium piliforme*). Colitis with dissemination to liver (focal hepatitis)

and occasionally heart (myocarditis) are the typical lesions. Special stains (silver, Giemsa, periodic acid-Schiff) can show intracytoplasmic bacteria.

Salmonella infections are a rare event and most infections are by *Salmonella enteritidis*. The bacteria invade Peyer patches of ileum and spread to the mesenteric lymph nodes, liver, and spleen.

Fungus

Gastric yeast is an incidental lesion identified in mice, hamsters, guinea pigs, gerbils, chinchillas, and rats. Morphologically, these yeast organisms appear consistent with *Candida albicans*. They have been identified in both glandular and squamous portions of the stomach (Fig. 11). They are typically associated with contaminated food or bedding.

Protozoan

Spironucleus (*Hexamita muris*) is frequently present in the alimentary tract of normal mice. This particular protozoon feeds on bacteria. Clinical disease, when it occurs, is in young animals at 3 to 6 weeks of age. There are predisposing factors. Clusters of the piriform protozoa accumulate along the mucosa of the intestines and can be seen associated with a neutrophilic enteritis.

Giardia muris is a flagellate that normally resides in the duodenum lumen. Mice are the natural hosts.

Coccidiosis is an uncommon protozoal disease in young mice. When clinical signs are noted, there is bloody diarrhea and runting of juvenile animals. Several *Eimeria* species have been described in murine intestinal infections, although *Eimeria falciformis* is most common. Lesions have been more commonly recognized in the large intestine and are associated with diffuse subacute colitis (Fig. 12).

Cryptosporidium muris and *Cryptosporidium parvum* are infections recognized in young poor-doing mice, generally suffering multiple diseases. In mice, *Cryptosporidium parvum* colonizes the upper small intestine and *Cryptosporidium muris* is within the stomach. Both are mildly pathogenic and lead to malnutrition (Fig. 13).

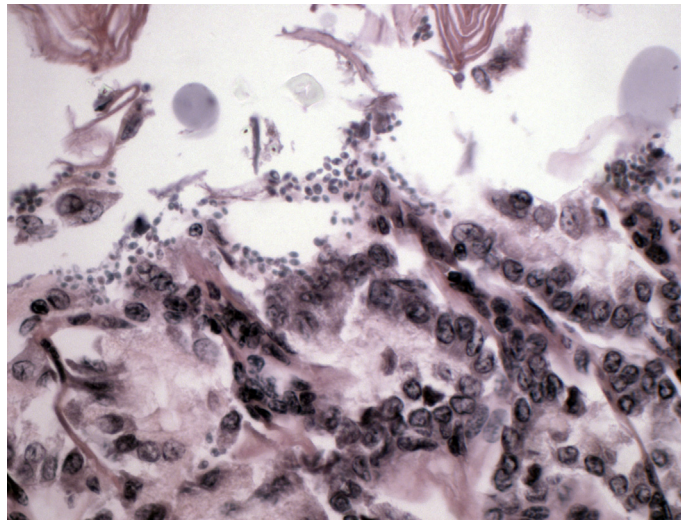

Fig. 11. Clusters of oval yeast are massed along the border of the mucosa of the glandular stomach. This condition has been reported in mice, hamsters, guinea pigs, gerbils, chinchillas, and rats (hematoxylin-eosin, original magnification ×400).

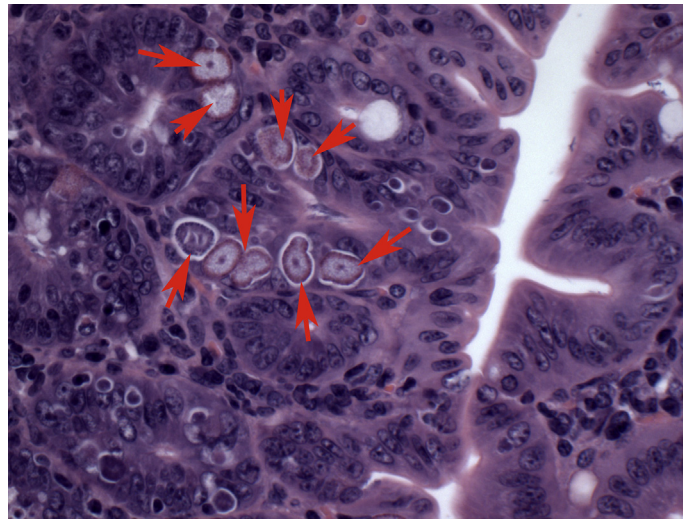

Fig. 12. *Coccidia* (*red arrows*) in various stages of development within the enterocytes (hematoxylin-eosin, original magnification ×400).

Metazoan

Syphacia obvelata and *Aspicularis tetraptera* (pinworms) nematodes are generally found in the cecum and, to a lesser extent, in the colon. *Syphacia* has a direct life cycle, with eggs (banana shaped) deposited around the anus. A mild enteritis may be associated with the infection, and many cases also have a perineal dermatitis. *Aspicularis* does not deposit eggs (symmetrically shaped) around the anus. Resistance to infection develops with age. Treatment is generally unrewarding. Rectal prolapse has been reported (Fig. 14).

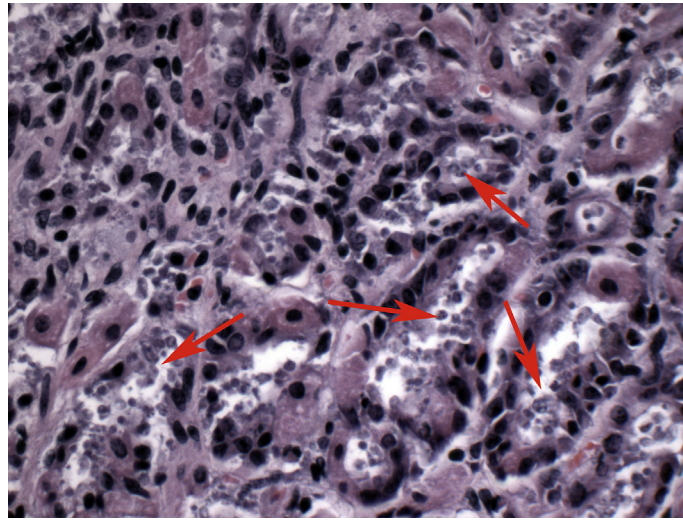

Fig. 13. Cryptosporidia are proliferating along the cytoplasmic borders of the lining mucosal epithelium (*red arrows*) (hematoxylin-eosin, original magnification ×40).

Fig. 14. The egg of *Syphacia* (pinworm) in a fecal float from a mouse. (*Courtesy of* Peter Fisher, DVM, Virginia Beach, VA.)

Heavy infestation with *Hymenolepis nana, Hymenolepis diminuta*, and *Hymenolepis microstoma* is associated with poor weight gains, abdominal distention, and diarrhea. *Hymenolepis nana* (dwarf tapeworm) is the primary organism found in the small intestine of rats, mice, and hamster. *Hymenolepis nana* is considered zoonotic. Most adult rodents develop an immunity to these parasites.

Neoplasia

Odontomas are rarely described in mice. Odontomas include ameloblastic fibro-odontoma[33] and a bilateral complex odontoma.[34]

Adenocarcinoma has been reported in the colon of mice.[35]

RABBIT

Oral Disease

Edematous to erythematous macules or papules around the mouth and on the lips are the typical lesions of acute rabbit syphilis. The cause is *Treponema cuniculi*, a helical rod-shaped bacterium that has the ability to penetrate intact mucous membranes.[36,37] The lesions also develop on the vulva and prepuce, anus, nose, scrotum, eyelids, and base of the ears. More chronic lesions appear as crusty ulcerative sores (**Fig. 15**). On histologic examination, there are epidermal acanthosis, erosions and ulcerations, microabscesses or vesicle formation, and a dermal infiltrate of numerous plasma cells and macrophages. Special stains may be necessary to identify the *Treponema* organism. This organism is spread primarily horizontally during breeding of adults. It may also be spread vertically from dam to offspring during vaginal delivery or suckling.

An oral papillomatosis virus has been identified in young rabbits.[38,39] Lesions involve the nonkeratinized mucous epithelial surfaces. These lesions are present primarily on the ventral aspect of the tongue, especially in areas abraded by malocclusion teeth (**Fig. 16**). They are typically solitary papillary growths, which regress. On histologic examination, there may be small basophilic intranuclear inclusions within the stratum spinosum, consistent with rabbit oral papillomavirus.

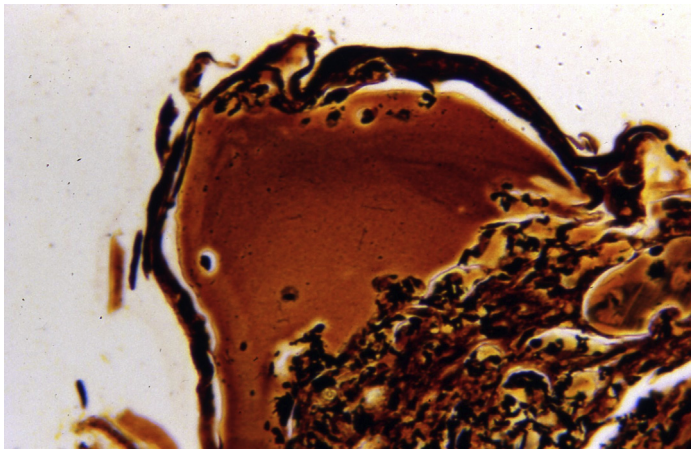

Fig. 15. A silver stain highlights the thin, spiral bacteria of *Treponema cuniculi* (Grocott methenamine silver, original magnification ×400).

Gastrointestinal Tract

Bacteria

Small intestinal proliferative enteritis in the domestic rabbit presents with soft, watery diarrhea, which often contains mucus and blood.[40,41] The rabbits, primarily weanlings, have distention and mucosal thickening of the small intestine, with enlarged mesenteric lymph nodes. The histologic appearance includes an infiltrate of macrophages

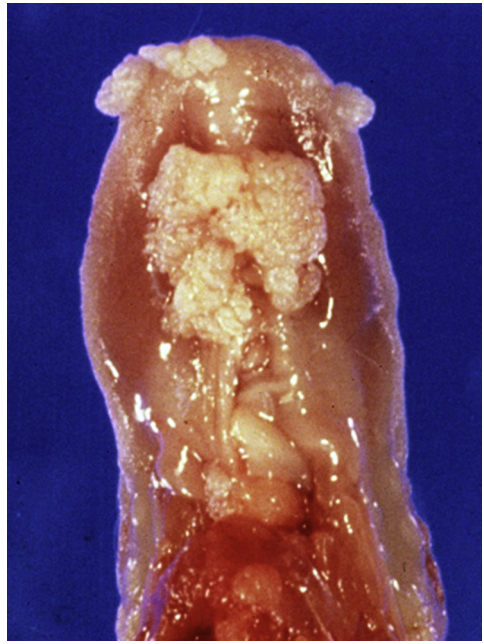

Fig. 16. Papilloma on the ventral side of a rabbit tongue. (*Courtesy of* Robert Schmidt, DVM, Anthem, AZ.)

and lymphocytes and a mucosa thickened with elongated tortuous and sometimes branched crypts. One report identified an uncharacterized bacterium in apical cytoplasm. Warthin-Starry stains in another report identified numerous rod-shaped to spiral bacteria in the apical cytoplasm. This bacterium morphologically is consistent with *Lawsonia intracellularis*, the cause of proliferative enteropathy in other species.

Protozoa

Intestinal coccidiosis, which uncommonly results in disease, can be diagnosed with a fecal parasitic examination. Occasionally, an ulcerative enterocolitis is described. Hepatic and biliary *Coccidia*, which are uncommon in other animal species, are common in domestic and wild rabbits. *Eimeria stiedae* is the *Coccidia* of rabbits. There may be clinical signs with heavy infestations, although young rabbits may experience some mortality. On gross examination, the liver is generally enlarged, with multiple raised firm, yellow-white to gray lesions on the surface. The cut surface may have enlarged bile ducts, which are thickened, fibrotic, and dilated, and occasionally filled with green bile and debris. The liver has a chronic proliferative cholangitis with biliary ectasia. A lymphoplasmacytic periportal infiltrate may be recognized. This condition may resolve to portal fibrosis and bile duct hyperplasia.

Miscellaneous

Intestinal smooth muscle hypertrophy presents as a uniform hypertrophy of the smooth muscle tunics in the intestinal section, with mild mucosal hypertrophy. No cause for this disease has been determined, although similar intestinal stenotic lesions have been described in young dogs, cats, and horses.

Mucosal rectoanal papilloma is an uncommonly reported lesion in rabbits. It has been described primarily in older male rabbits and shown to be nonviral in origin. These papillomas are usually well-differentiated growths, and the few cases reported have been benign (**Fig. 17**). Complete surgical removal is recommended, because these lesions are reported to undergo neoplastic transformation in other mammalian species.

Neoplasia

Of the neoplastic diseases, lymphoma is most frequently identified within the liver. Other reported locations include the gastric fundus, the spleen, mesenteric lymph

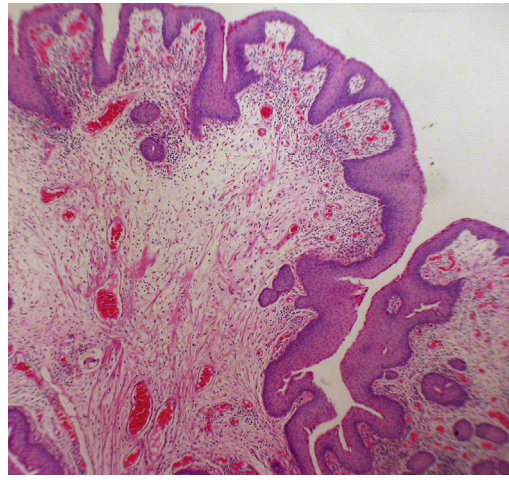

Fig. 17. Rectal papilloma from a rabbit (hematoxylin-eosin, original magnification ×400).

nodes, bone marrow, pulmonary interstitium, and adrenal glands. In some reports, this disease is considered to be the second most commonly occurring neoplastic condition.[42] Lymphomas in rabbits are usually associated with an aleukemic hematologic profile. The neoplasm is most commonly seen in juvenile and young adult rabbits. Histologic appearance is of infiltration and effacement of the normal architecture by neoplastic lymphocytes.

RAT

Oral Disease

The long rat incisors can be broken or trimmed too short by caretakers, resulting in dental disease and inflammation/infection of the surrounding soft tissues. If foreign material from feedstuffs or caging materials becomes impacted in the pulp cavity and the periodontal space, this may lead to endodontitis or periodontitis.

Gastrointestinal Tract

Bacteria

Tyzzer disease, caused by *Clostridium piliforme* (formerly known as *Bacillus piliformis*) results in a unique dilation of the terminal small intestine of rats. This particular bacterial infection has a wide host range, which includes rats, hamsters, and guinea pigs. There is generally low morbidity but high mortality. Other lesions include focal areas of hepatic necrosis.

Metazoan

Rats serve as intermediate hosts for the cat tapeworm *Taenia taeniaeformis*. Rats, mice, and hamsters ingest the eggs, which hatch and migrate through the bowel and encyst in the liver. The cysticercoid cyst (*Cysticercus fasciolaris*) embeds in the liver and may develop large cysts.

Miscellaneous

Gastric ulceration and erosions can be identified in the glandular or nonglandular region. There is generally no specific cause, although these conditions are not uncommonly associated with a stress response or trauma from gavage feeding.

Neoplasia

Several variations of odontoma have been described in rats. These tumors consist of cementum, dentin, enamel, and pulp tissue, which may be arranged in the form of teeth. Odontomas are further divided according to morphologic features and degree of organization. A complex odontoma and an ameloblastic odontoma have both been recognized.[43,44]

One gastric carcinoid tumor developed in the glandular stomach of an older rat. It appeared as a focal raised mass.[45]

Colonic adenocarcinoma has been described many times in the literature. These lesions appear as constrictions typically just below the ileocecal junction (proximal colon). The tumor mass fills the lumen of the colon. Mucosal ulceration and metastases to adjacent lymph nodes or local implantation on serosal surfaces are commonly associated lesions.[46–48] There has been 1 report of a gelatinous carcinoma of the cecum.[46]

SUGAR GLIDER

Gastrointestinal Tract

Bacteria

From the author's review, acute to subacute enteritis and colitis are common lesions. These lesions are usually associated with inflammatory lesions in the liver, heart,

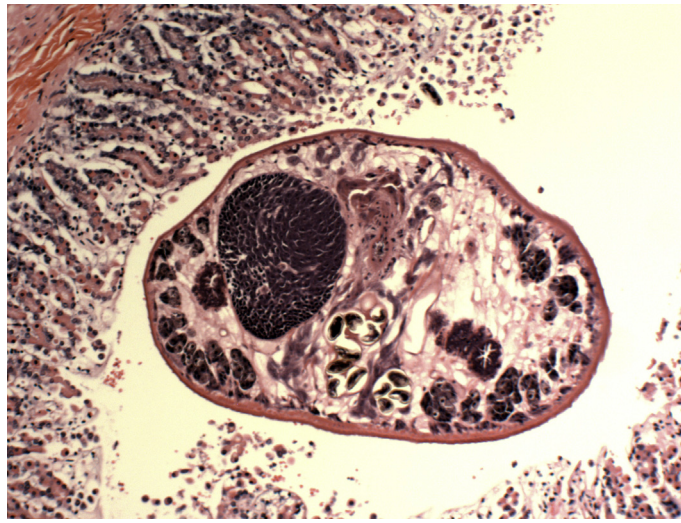

Fig. 18. A trematode within the lumen of the stomach (hematoxylin-eosin, original magnification ×100).

kidney, and brain. Specific microbes are seldom recognized, and many cases are suspected to be caused by endotoxemias. A common history is of unexpected death, occasionally with terminal neurologic clinical signs.

Clostridium piliforme has been reported. Giardiasis and cryptosporidia are also described as a cause of diarrhea.[49] All these causes have been described previously.

Metazoan

Intestinal metazoans are rarely reported in sugar gliders. The author has identified gastrointestinal trematodiasis. The trematodes were identified as from the genus *Plagiorchis* and were associated with enteritis (**Fig. 18**).

Miscellaneous

Gastric dilatation and volvulus was diagnosed in 2 adult sugar gliders presenting for acute illness featuring abdominal distention. Confirmation was made at necropsy. Histopathology of multiple tissues showed several underlying disease conditions, but gave no specific direct cause.[50]

Neoplasia

There is scant literature about neoplasia in sugar gliders. One pericloacal transitional cell carcinoma resulted in severe cloacal narrowing and intestinal distention. The tumor arose from the urothelium of the urethra and urinary bladder and encompassed the colon and cloaca.[51]

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