

University of Veterinary Science, Budapest

Cause of the death of the golden hamster

Literature review and necropsy evaluation of pathological findings of golden hamsters

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This thesis is dedicated to my parents, Susanne and Dirk and my sister Sina-Louisa. For their amazing love support and help in all kind of situations.

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Introduction

The Golden hamster (*Mesocricetus auratus auratus*), also called Syrian hamster is part of the order rodents (*Rodentia*) and belongs to the subfamily hamster (*Cricetinae*)- (Wilson und Reeder 2005.)

The 25 species of hamsters differentiate in the morphology, biology and the occurrence. The golden hamster, the most common pet and research hamster, counts with 90-150g-body weight and 15 – 18 cm body length to the medium sized hamsters. The origin of the nocturnal animal is located at the Turkish-Syrian border. They are omnivores and have their houses between branched dens or on fertile fields.

Golden hamsters are predisposed for hereditary diseases. Nowadays it is believed, that all domesticated golden hamsters are originated in 3 or 4 siblings, which have been taken from the wilderness, in Aleppo, Syria, in the year 1930 (Smith 2012).

Often described hereditary diseases of laboratory golden hamsters are hydrocephalus, valvular abnormalities and idiopathic, spontaneous seizures (Karolewski et al. 2012).

A common problem is the late visiting of the veterinarian by the owners. Most of the diseases are already processed. Symptoms are apathy, inappetence, a humid or gluy anogenital region, conjunctivitis, skin diseases and problems with the locomotor system. Mainly in female hamsters cannibalism is seen.

Especially wrong nutrition or sudden changes in the nutrition and wrong husbandry are the reasons for following diseases and pathological changes.

This thesis ‘Cause of the death of the golden hamster’ outlines the pathological changes caused by infectious or non-infectious diseases.

At the Department of Pathology, at the Szent István University, Budapest, all the data’s regarding aetiology, anamnesis, clinical signs and necropsy findings have been collected from 1993-2001. The statistics are based on the age, gender, diagnosis and the frequencies of the diseases.

1. Anatomy and characteristics of the golden hamster

1.1 The locomotion system of the golden hamster

The golden hamster has 7 cervical vertebrae, 13 thoracic vertebrae, 6 lumbar vertebrae and 13-14 sacral vertebrae (*Bivin et al. 1987*).

The front limbs are well adapted for their functions. The keratinized epidermis covers the hairless palmar site of the hand and gives together with the strong claws the ability to burrow dens. To ensure a proper stability are the upper- and underarm shortened and the scapular is powerfully built. Because the first phalanx of the front limbs is formed back only 4 phalanxes are counted compared to the hind limbs, which show 5. The tibia and fibula are grown together at the distal end. The plantar site is also hairless and has a big pad, which helps for easy climbing.

1.2 The outer skin of the golden hamster

The golden hamster has a half-length, smooth coat in different kinds of colours. Only a few hairs cover the short tail, a stumpy tail and the grey-blue ears. Because of a very soft subcutis the skin abuts very loosen on the body. Instead of sweat glands the golden hamster has sebaceous glands in the skin. Only at the region of the genitals and anus are oil glands which means they are located in the skin without being in contact with hairs. 5-7 mm in diameter, black-pigmented site glands are found at the level of the flanks, in male hamsters. These oil glands are surrounded by strong, dark hairs and play a big role in case of territory marking and secret production. (*Salomon et al, 2003*).

The golden hamster has occasionally two lacrimal glands. The big Gl. orbitalis externa is placed at the lateral site of the M. masseter and the M.temporalis and the Gl. infraorbitalis, in the shape of a triangle gland package, ventral of the orbita.

1.3 The oral cavity an the teeth of the golden hamster:

The symphysis of the mandibular may be unclosed for the whole life. Very popular characteristics are the cheek pouches, saccus paraoralis. They reach from the oral cavity to the beginning of the costal arch. These with cutaneous mucous membrane covered structures

serve as a storage of up to 20 g food for the transport. They dispose about triangular shaped skin parts, which ensure a proper closing during unopened oral cavities. The function of the muscle, musculus tensor sacci paraoralis, is to draw pack the cheek pouches and has its origin in the last two thoracic vertebrae and its insertion on the dorsocaudal part of the pouches (*Salomon et al., 2003*).

The yellow incisors in the mandibular and maxilla are each two permanent growing teeth without dental roots and an open pulp cavity. In contrast, the molars with deep surfaces and dental roots are 6 in the upper and 6 in the lower jaw. All 16 teeth of the golden hamster do not change, so they are monophyodont.

1.4 The gastro-intestinal system of the golden hamster

The stomach consists of a pars cardiaca, which forms the proventriculus located on the left side. It has a finger shaped pattern and a brighter, inner keratinized mucous membrane layer. In The other part, the pars pylorica, a glandular stomach located medially is detectable in ruddier colour. The strong sequestration and the margo plicatus make these two different parts clearly visible.

The main bacterial flora of the intestines as described by (*Hagen et al., 1965*) are the bacteroides - and lactobacilli species, and according to (*Engelen et al., 1990*) are lactobacilli-, streptococcus and clostridia species.

The abdomen takes the biggest part in the abdominal cavity. The jejunum is placed in the right ventral part and names the longest part of the gut. The caecum is the main organ for the digestion. It is found in the caudal abdomen and shows a septa structure (*Ewringmann und Glöckner,2008*).

The liver is a clearly lobulated organ and has its location in the intrathoracic part of the abdomen, next to the diaphragm. A linguiform spleen clings to the left lateral and caudal part of the proventriculus.

1.5 The urinary organs and the genitals

The kidneys of the golden hamster show a very long unipapillar pattern, which reaches into the ureter. Caudal of each kidney you can find the ovaries in case of an female hamster. The mesometirum and the mesovar contain a large amount of fat tissue. The uterus is in the shape of an uterus duplex.

The male hamster has a very wider inguinal channel. Between April and October the in scrotal pockets located testicles move through this channel. During the winter months they pull back into the abdominal cavity, seasonal descensus testis, and shrink. The epididymis indicates a big structure, especially the caput epididymis, which resembles the size of the testicles.

The penis has a s shape and is directed to the caudal site. Ventral to the urethra the os penis is findable.

The urine has basic conditions and contains a lot of crystals (*Tomson u. Wardrop, 1987*).

table 1. Physiological data's of the golden hamster:

Parameter	Golden hamster
Body temperature	36,1-38,9°
Heart rate	200-500 / min
Breathing rate	35-135/ min
Sexually mature	6-14 weeks
Breeding mature	8-12 weeks
Length of the cycles	4-5 days
Gestation	15-18 days
Litter size	6-12 nestlings
Suckling period	20-25 days
Biological data's	
Life expectancy	2-3 years
Body weight <ul style="list-style-type: none"> • Male, adult • Female, adult 	<p>85-130g</p> <p>95- 130g</p>
Dental formula	<p>16 teeth</p> <p>I1 C0 P0 M3</p> <p>I1C0 P0 M3</p>
Feed consumption	150 g/kg/d
Water consumption	50-150 ml/kg/d

(in accord with Mulder 2012, Bauer and Besch-Willford 2012)

2. Bacteria

A diagnosis based on clinical signs only is impossible. Microbiological tests, especially in case of diarrhoea, are absolutely necessary for a proper and purposeful treatment. This is important to prevent the distribution of bacteria, as *Salmonella* spp. (*Swanson et al. 2007*), *Campylobacter* spp. and *Francisella tularensis* (*Fox et al. 1983*), bacteria with human pathogenic potential.

2.1 Staphylococcus spp.

The bacteria of the species staphylococcus, the most common one is *Micrococcus pyogenes*, may be the reason for formation of furuncles, abscesses and arthritis. Clinical signs are deep red- violet discolorations, inflammations around the mammary glands and teats, conjunctivitis and abscesses under the skin. In some cases spasms and dyspnoea are seen.

2.2 Streptococcus spp.

The symptoms of an infection with these bacteria are inconclusive, due to the frequent appearance of mixed infections with *Staphylococcus* spp.

An evidence for infections with Streptococci might be purulent arthritis, abscess formation and swollen lymph nodes. Most of the affected animals are of young age, and in 40% of the diseases lead to death.

The Enterococci species, like *S. faecialis* are found in the digestion tract and lead to severe infections of the intestines. The leading symptom is diarrhoea with the consequence of dehydration and apathy in bad cases.

Streptococci spp. with haemolytic effect show clinical signs like a curved back, fuzzy hair, anorexia, diarrhea, pleuritis, peritonitis, conjunctivitis and purulent nasal discharge. 80-100% of the infected animals die within the first 3 days. The disease is highly infectious and a spread out through a whole litter may happen within 48h.

Bronchitis and pneumonia are often caused by *Diplococcus* species, for example *Diplococcus pneumoniae*. It's a droplet infection, often occurring together with other bacteria like mycoplasma species. In this case though, dyspnoea, forced breathing, lacrimation and nasal discharge are often visible. Following the swallow of the bacterial rich nasal discharge, a

gastro-intestinal catarrh as a secondary disease can occur. After an illness of approximately 8 weeks this infection leads to death in 55%.

2.3 Lawsonia intracellularis

Diarrhoea, also known as 'wet tail', may occur in golden hamsters of any age. Because of the high mortality proliferative ileitis is the most significant intestinal disease of 3 to 10 weeks old animals. This entity is caused by the intracellular bacterium *Lawsonia intracellularis*. Sequelae of the proliferative ileitis in surviving hamsters can be obstruction, intussusception or rectal collapse.

2.4 Clostridia

Enterotoxaemia caused by *Clostridium difficile* is one reason for diarrhoea in adult golden hamsters. It may occur 3-5 days after administration of antibiotics like penicillin, lincomycin or bacitracin.

Clostridium piliforme is the causative agent for the Tyzzer disease and especially immunosuppressed animals are at risk. It is initiated by stress factors as overcrowding, high environmental temperature and humidity, heavy internal and external parasite load and inadequate diets (*Donnelly, 2015*).

2.5 Coli bacteria

Escherichia coli are normal, usually harmless habitats of the gut flora. But, after the uptake of infected food or water the number of bacteria can increase enormously. The outbreak of the disease is also connected with the hyperplastic ileitis or long-term treatment with antibiotics against preferably gram positive bacteria. Mainly newborn's and after weaning animals are predisposed. The infection may lead to a higher breathing rate, fever, severe watery diarrhoea, salivation and bloating. After 6-72 hours the disease leads to death in most of the cases. The pathological findings are haemorrhages and oedema formations in the caecum, watery-slimy gut content and enlargement of the gut lymph nodes.

2.6 Klebsiella pneumoniae

These bacteria lead, compared to the *Diplococcus pneumoniae* to a more severe pneumonia, show similar but more expressed symptoms. Also humans can be affected.

It's a droplet infection with an incubation time of 18 hours and a high risk of contamination. The mortality is quite high. In hamsters, especially diarrhoea and otitis are seen.

2.7 Salmonellosis

Hamsters can be the reservoir for the multi-resistant human pathogenic salmonellosis species. Even though it's a seldom occurring disease, a very severe, most of the times lethal disease can develop, especially if it's a mixed infection of *S. typhimurium* and *S. enteritidis*. The animals are infected via oral uptake of the infected faeces or with faeces contaminated food. The clinical signs are acute septicaemia and sudden death. In milder forms anorexia, diarrhoea, apathy, cachexia and fuzzy hair are observed. Subclinical carriers are often the reason for the spreading of the bacteria. Pathological findings are pale discoloration of the liver, enlargement and dark discoloration of the spleen, necrosis of the gut and darkening of the lung tissue.

3. Viruses

Just a very few of specific virus diseases are described in case of laboratory golden hamsters. Because of the usually subclinical course of the diseases, there is also no accurate number known concerning the occurrence in pet-golden hamsters (*Parker et al, 1987*).

3.1 Lymphocytic choriomeningitis (LCM)

Beside the risk of zoonosis the LCM is one of the most important viruses of golden hamsters. The direct infection way with the –ss RNA virus can be through biting wounds, inhalation, contact with urine or intrauterine (*Cassano et al, 2012*).

Weight loss, reduced activity, fuzzy hair, photophobia, tremor, spasms and blepharitis with a duration from weeks to months are typical signs for this viral infection. But, in the majority of the cases mainly subclinical courses are seen. The diagnosis is made by ELISA, neutralising antibodies or the immunofluorescence test (IFT) (*Thacker et al, 2007*).

3.2 Hamster- polyomavirus (HaPV)

This virus is an unenveloped double-stranded DNA virus of the polyomavirus family. The clinical signs appear in two manifestations. Either in epizootic lymphoma formation together with enlargement of the abdominal organs and enlargement of the mesenteric and peripheral lymph nodes which is common in young hamsters between 17 and 19 weeks. The other form is a trichoepithelioma formation in adult hamsters between 3 months and more than 1 year. It can be diagnosed by pathological changes, histopathology, electron microscope, PCR or immunohistochemistry (*Cassano et al., 2012*).

4. Fungi and yeasts

A mycosis infection in golden hamster is rarely diagnosed. Due to the lack of specific clinical symptoms the diagnosis is often hard to be made (*Hata et al., 2000*.)

4.1 Dermatophytosis

The Trichophyton mentagrophytes is the most common dermatophyte of golden hamsters causing dermatophytosis (*Stenwig, 1985*). There is a possible risk for humans, especially children and immunosuppressed people are susceptible to this zoonotic disease.

The infection happens through direct or indirect contact with the spores, carried by an alive or a dead vector. Stress is a predisposing factor.

Round-oval skin parts, at the beginning with less hair, later with complete alopecia are the main clinical signs, together with reddening, vesicle-, scale- and crust formation.

5. Parasites

5.1 Endoparasites

5.1.1 Protozoa

Because of the large number and variety of organisms protozoa can be found in a faecal smear. The faeces of the golden hamsters are literally a ‘gold mine’. Because these organisms are found in both, healthy and sick animals, the etiologic role in enteric diseases remains a matter for speculation.

Giardia spp., Spironucleus muris and Entamoeba muris are habitats of the small intestines of the golden hamster. Sometimes species of Trichomonas and Cryptosporidia can also be found, but with a higher prevalence in the caecum and colon. Initiated through stress, caused by wrong husbandry and deficiency problems it leads to an increase of these parasites. They are most of the time apathogenic, what means clinical signs are lacking. Young animals may show problems in the development, adults have chronic proliferative enteritis of the small intestines, both problems normally without signs of diarrhoea.

The reported prevalence and usual locations are listed in the table below.

Organism	Prevalence	Location
Trichomonas sp.	99%	Cecum, colon
Entamoeba muris	12%	Cecum
Giardia sp.	9%	Small intestine
Chilomastix bettencourti	1%	Cecum

(in accord with Wantland, 1955)

5.1.2 Cestodes

The most common and most important internal parasite of the golden hamsters is the Rodentolepis (Hymenolepis) nana, the dwarf tapeworm. Other species that infect hamsters are Hymenolepis diminuta and Rodentolepis microstoma.

R. nana can have a direct or indirect life cycle with flour beetles or fleas as intermediated host. The direct lifecycle has a duration of just 14-16 days. The length of the adult worm is approximately 5,5cm. The host range includes mice, rats, nonhuman primates and man.

In the life cycle of *H. diminuta* the eggs develop in an intermediated host. These are insects; the most common ones are fleas. The adult worms can reach a size of 6 cm. Both worms are parasites of the small intestines and often subclinical. The consequences of an infection are usually benign, although the effects depend on the number of parasites and the degree of internal occlusion. Symptoms may be inappetence, weight loss, developmental problems, diarrhoea or obstipation (*Beck u. Pantchev, 2013*). The diagnosis can be made on the base of the demonstration of the eggs in a faecal sample or of the mature worm in the intestines at post-mortem. *R. nana* is equipped with hooks on the scolex, which makes possible a differentiation from *H. diminuta*.

5.1.3 Nematodes

Syphacia species are members of the Oxyuridae family and have a direct life cycle. The mouse pinworm, *Syphacia obvelata*, can have high infection rates in selected colonies even though the reported prevalence is less than 1%. As a consequence of direct contact with infected rats, uninfected hamsters can become infected with *Syphacia muris*, the rat oxyurid. They are often symptomless, the worms appear in the caecum and colon. Seldom symptoms as diarrhoea, obstipation, invagination and rectum prolapse may occur (*Ross et al., 1980*).

5.2 Ectoparasites

5.2.1 Mites

Acariasis in golden hamsters is predominantly associated with two species of the genus *Demodex*. Although infections with ear mites (*Notoedres* sp.), the tropical rat mite (*Ornithonyssus bacoti*) and a nasal mite (*Spleorodens clethrionomys*) have also been reported. A diagnosis can be established by the demonstration of mites in skin scrapings, also the prove of *Demodex* sp itself (*Fox et al., 1984*).

5.2.1.1 Demodicosis

Without major clinical relevance the *Demodex aurati* and *Demodex criceti* are the species affecting the golden hamster. The in most of the cases symptomless disease can lead, initiated by stress, other diseases and immunosuppression, to skin problems. Dilated hair follicles, which contain debris and mites, are followed by loss of the hair shaft, an increase in thickness of the corneus. They have little evidence of inflammation. These areas, with mild to severe alopecia, are mainly located on the dorsal region of the body, the hind limbs and face. Additionally scales and dark, bloody crusts may be found. It is not itching and predominantly seen in male animals.

5.2.1.2 Notoedres mange

In female animals notoedres mange affects only the ear (pinnae). In males it is also found in the face - especially the nose, in the anogenital area, at the tail and the limbs. The most common species are the *Notoedres notoedres* and the *Notoedres cati*. In some cases a generalised form is described. The symptoms are severe itching, erythema, erosions and hyperpigmentation. Untreated animals can die within 2-3 months.

5.2.2.3 Ornithonyssus

The tropical rat mite, *Ornithonyssus bacoti* can be found in golden hamsters. In case of an infection with the northern fowl mite, *Ornithonyssus sylviarum*, the hamster is a dead end host (Burr et al., 2012).

The infection especially of breeding animals and animals of the pet shop may happen with contaminated food or litter.

These bloodsuckers can affect humans also. During the day they try to find safe places between narrow gaps and clefts (Beck and Pantchev, 2013). Full of blood mites can be detected with naked eye, especially around soft skin areas. Clinical signs are itching, cachexia and, in severe cases, death.

6. The skin

6.1 Alopecia

Alopecia is a regularly occurring problem. Caused by ectoparasites, dermatophytes, hyperadrenocorticism, cutaneous lymphoma and behaviour disorders.

6.2 Dermatitis

A secondary infection with *Staphylococcus*, *Streptococcus* and *Pasteurella pneumotropica*, infected bite wound dermatophytes, ectoparasites and increased salivation caused by a disease of the oral cavity. Stereotyped movements can be a reason for dermatitis as well. For example chafing the nose against a stanchion.

6.3 Skin abscesses

Often appears after injuries settled with *Staphylococcus aureus*, *Streptococcus* spp or *Pasteurella pneumotropica*. It can be diagnosed based on a lump, mainly around the face (Frisk et al., 1976).

6.4. Biting wounds

Biting wounds are mainly found on male animals around the head and hindquarters. It often happens after putting a male golden hamster together with a aggressive female animal.

For prevention of biting wounds, it is advisable, to put the male animals only together with females, which are ready for mating. A neutral ground with escape possibilities is also helpful.

6.5 Foot necrosis

Stiches in litter, even stiches originated from cotton wool can loop around the legs. They can grow into the skin and may lead to wounds. In bad cases one or more feet or parts of the leg

necrotize. The treatment can be a simple removal of the irritating material but also amputation of the leg can become necessary.

6.6 Neoplasia of the skin

Lymphosarcomas are the most frequently reported malignant tumour of the Syrian hamster. The cutaneous lymphoma, resembling mycosis fungoides (an epidermotropic T-cell lymphoma in people), is seen in adult golden hamsters. Affected animals show anorexia, weight loss, and patchy alopecia. Cutaneous lymphoma can be misdiagnosed as hyperadrenocorticism (Cushing disease), because affected hamsters initially show patchy alopecia and dermal hyperpigmentation. However, cutaneous lymphoma show rapid progression of the disease, with a mean time from the first presentation to euthanasia of approximately 10 weeks (*Aiello et al., 2016*).

Beside the cutaneous Lymphosarcomas also Trichoepitheliomas and other melanomas or cutaneous neoplasia can be detected. Noteworthy is the observation of a 10:1 male to female ratio in a total of 30 reported melanomas (*Van Hoosier and Trentin, 1979*).

7. Muscle- and skeletal system

Fractures around the spine and limbs, especially of the tibia are the most common problems. Causes for the fractures can be falls and injuries in connection with the hamster wheel. Fractures can be provided with a surgical treatment or an amputation of the whole limb. In some cases the injuries can heal without therapy. Occasionally, neoplastic diseases as a cause for fractures (pathological fractures) are described (*Strandberg, 1987*).

8. Sensory organs and the nervous system

8.1 Diseases of the eyes

Eye diseases are not often reported in golden hamsters. For most of the owners it is hard to notice such diseases e.g. retina dysplasia, which might explain the rare description (*Williams, 2007*).

8.1.1 Conjunctivitis

Conjunctivitis is a common bacterial infection with Pasteurella and Streptococcus species. Causes for the infection can be caries or a dental root inflammation with the consequence of abscesses in the maxilla, biting wounds, dust- and dirt particles or Lymphocytic choriomeningitis. It's not always possible to figure out the causative agent.

Clinical signs are epiphora, reddening of the conjunctiva, periorbital or half sided facial swellings or exophthalmos.

During the treatment with eye-ointment or drops, attention should be paid to the reabsorption of the ingredients. This process may lead to a fatal enterocolitis.

8.1.2 Keratoconjunctivitis sicca

The aetiology is often not clear. Causes might be Sialodacryoadenitis or ammoniac, because of unclean husbandry. Clinical signs are blepharospasm, hyphema, exophthalmos respectively buphthalmos, dehydration of the cornea, bleeding from the eye or shrunken, fallen back eyes. In most of the cases an enucleation is necessary.

8.1.3 Exophthalmos

An exophthalmos can arise due to trauma, retrobulbar abscess, neoplasia or Sialodacryoadenitis. It has a constant appearance. The clinical sign is a protruding eye. An enucleation is necessary.

8.1.4 Bulb prolapse

Appears sometimes after a veterinarian examination. The problem is the dislocation of the upper and lower eyelid behind the bulb. This may happen because of the skin elasticity around the eye. The eyes are protruded and can dehydrate. Depending on the condition of the eye I can be repositioned or needs to be enucleated.

8.1.5 Neoplasia of the eye

The neoplasia of the eye is most of the time a melanoma. Often the animals have already developed lung metastases.

8.2 Diseases of the ears

8.2.1 Otitis

An infection with *Pasteurella pneumotropica*, *Streptococcus* or *Salmonella* spp. can cause an inflammation of the inner ear or otitis media. The clinical signs are abnormal posture of the head or head shaking.

The diagnosis of an progressed otitis media can be realised with an x-ray of both bullae tympanicae.

8.2.2 Neoplasia of the ear

The appearance is rare and associated with the Polyomavirus. Mainly a trichoepithelioma in the meatus acusticus is seen. A surgical treatment is necessary (*Percy and Barthold, 2007*).

8.3 Diseases of the nervous system

Diseases of the central nervous system play a minor role in the golden hamsters. Central nervous symptoms, like cycling or stall walking, can appear as a consequence of commotio cerebri or intracranial bleedings. Causes for these lesions are traumata or diseases like otitis media/ inflammation of the inner ear.

Sometimes hamsters with partial paralysis of unknown genesis are described. In these animals it is believed that traumata and disc prolapses are of importance.

Golden hamsters with a congenital hydrocephalus don't show signs of neurological problems (*Karolewski et al., 2012*).

The already mentioned Lymphocytic choriomeningitis can be one reason for failures of the nervous system, too.

9. The alimentary organs

9.1 Diseases of the cheek pouches

9.1.1 Injury and abscess formation of the cheek pouches

Hard food particles, foreign bodies or biting wounds, in bad cases colonized with *Staphylococcus* or *Streptococcus* species can cause injuries or an abscess formation of the cheek pouches.

For the treatment the pouches need to be opened and cleaned. In case of an abscess a cleavage of the abscess is necessary. Antibiotic treatment, infusions and forced feeding need to be contemplated.

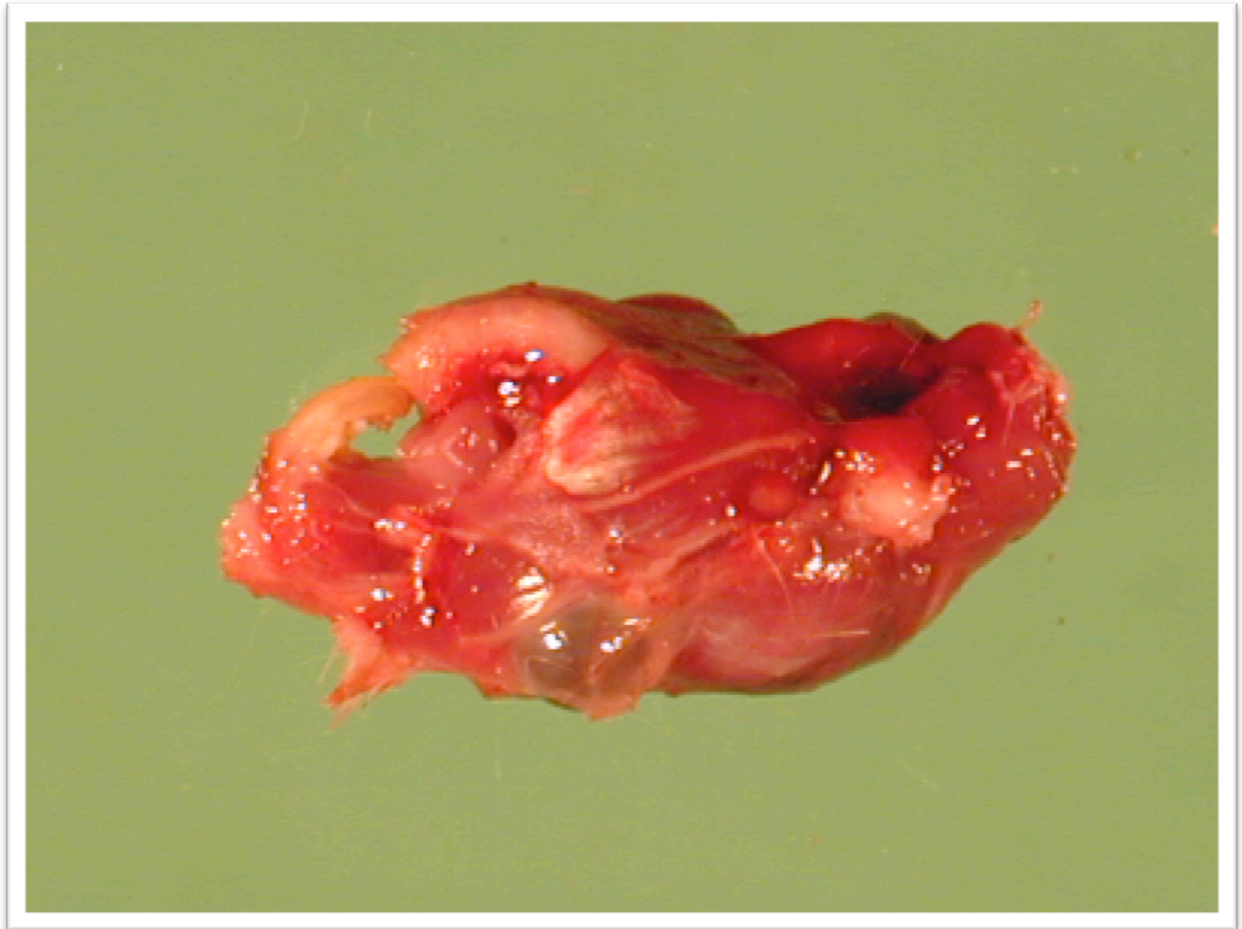
9.1.2 Cheek pouches prolapse

Is a sometimes occurring problem caused by trauma. A lump at the angle of the oral cavity is a visible symptom. The treatment is based on the retrocession of the pouches. In some cases it needs to be fixed at the outer skin, with the help of U-stiches. In severe injuries an amputation might be necessary.

9.2 Dental diseases

Dental diseases are very often seen problems, which are caused by wrong nutrition, traumata or infections. Also genetic aspects can play a role, e.g. growth disturbance and breaking of teeth which is followed by excessive growing in the length. Fractures in the jaw area or of the dental alveoli and age-related falling out of the teeth can be a reason for paradontopathy. Carious changes are mainly seen in molar teeth, caused by a carbohydrate and sugar rich nutrition. If the caries leads to an opening of the pulp, abscess of the teeth root can be a consequence.

Clinical signs are problems in food uptake or no uptake at all, anorexia and abscesses.



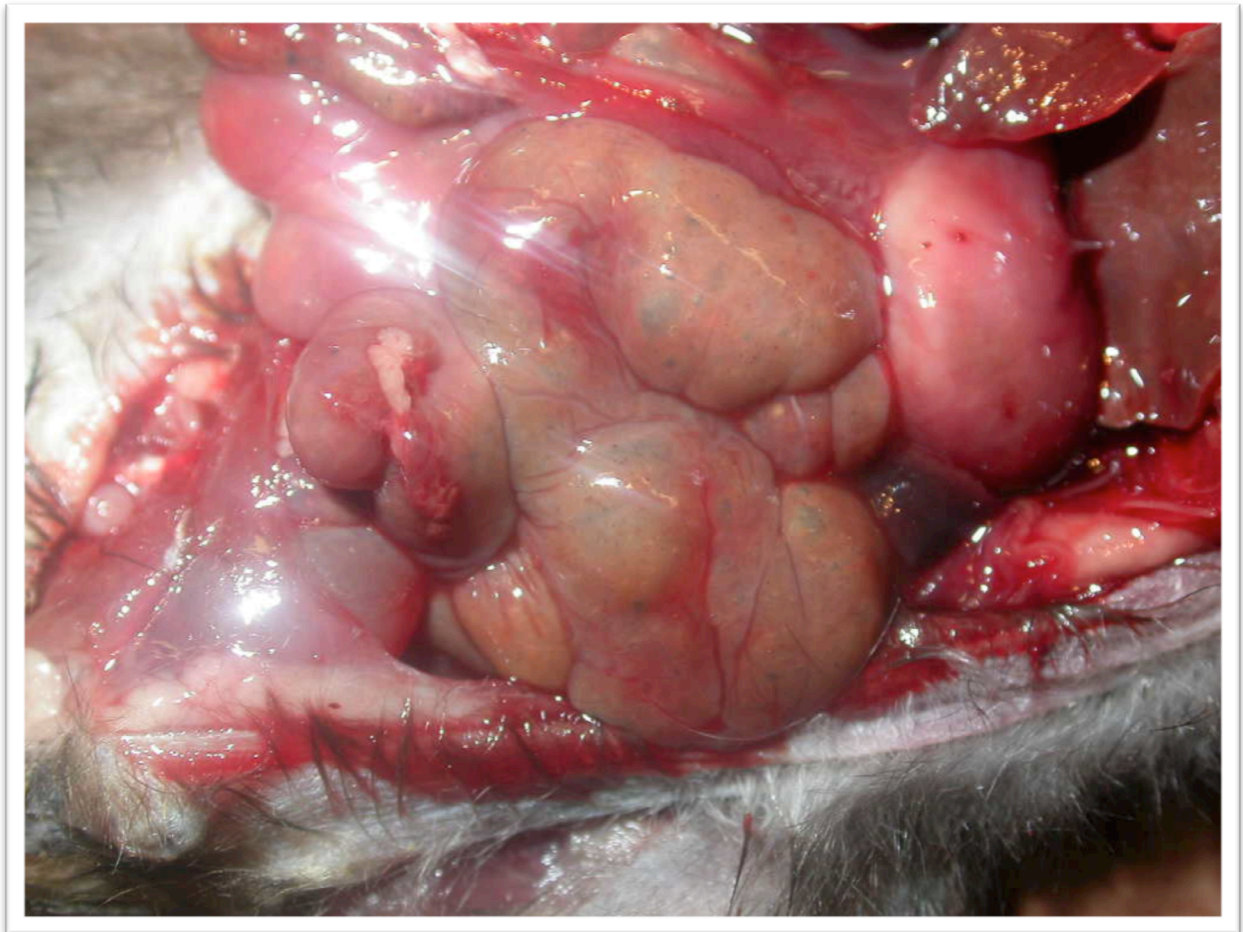
Picture 3: overgrowth of the incisors

9.3 Enteritis

A lot of bacterial pathogens are possible agents for enteritis in the golden hamster. The expression 'wet tail', often mentioned in the literature, is not one specific disease, it's more a description of the symptom watery diarrhoea. For this symptom different diseases can be the cause. Often described diseases are, the already mentioned proliferative ileitis, Tyzzer's disease and enteritides, which are caused mainly by *E.coli*, *Salmonella* or *Pasteurella*. Also stress, changing of the nutrition or long-term treatment with antibiotics can be conditions leading to diarrhoea. Clinically it's difficult to differentiate them. Extra intestinal causes for diarrhoea in golden hamsters are difficult to diagnose. In many cases reasons for a wet

anogenital region are diseases of the urogenital tract, endometritis or a pyometra. This is only diagnosable by a very detailed clinical examination.

Clinical signs are diarrhoea, weakness, anorexia, dehydration or death. Not uncommonly enteritides may lead to an invagination or rectum prolapse. The therapy of diarrhoea diseases starts with an infusion and administration of well-tolerated broad-spectrum antibiotic.



Picture 4: Enteritis acuta caused by E. coli

9.4 Obstipation

Obstipation can occur after an infection with Endoparasites or as a consequence of proliferative Ileitis. Also insufficient food and water administration induce the animals to eat litter materials. The outcome is an intestinal obstipation.

The treatment consists out of an infusion, anti spasmodic's and prokinetics. Sometimes surgical procedures become necessary.

9.5 Rectum prolapse

It's a regular upcoming failure. The main causes are enteritides and wrong husbandry or feeding.

It might be possible to do a reposition of fresh rectum prolapses into the original position. After reposition they have to be fixed using a purse-string suture for 3 to 4 days. In older or more severe cases necrotized parts of the intestines need to be removed. In addition a symptomatic treatment with infusions, antibiotics and analgesia is necessary.

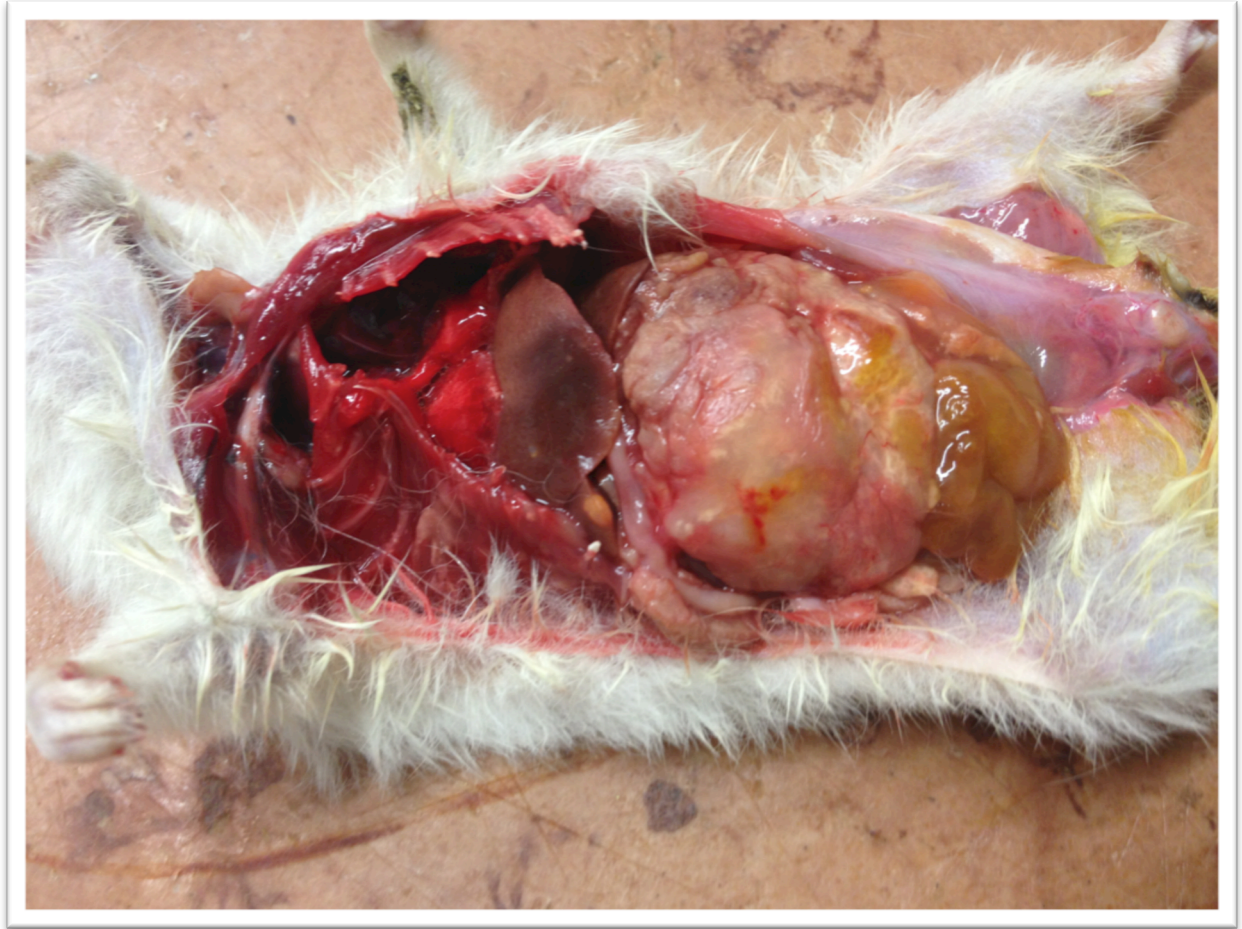
9.6 Polycystic diseases – Hepatic cysts

Is in most cases diagnosed pathologically and of unknown cause. It is expected to be cause of a developmental problem of the liver and gallbladder formation. In the rare cases of a cystic liver, massive functional disorders are described. Beside the cysts in the liver, also cysts can be found in the pancreas, epididymis, seminal glands, endometrium, ovary, oesophagus and adrenal gland (*Karolewski et al., 2012*).

The clinical signs are a lump of the abdominal cavity, ascites, emaciation and weakness. The diagnosis is based on a palpation, puncture, x-ray or ultrasound examination.

9.7 Neoplasia of the alimentary tract

In golden hamsters the most commonly found neoplasia are the adenocarcinoma of the caecum and colon, the cholangioma, leiomyoma and liposarcoma. There is no described therapy jet.



Picture 5: Tumor mass in the abdominal cavity

10. The respiratory tract

10.1 Rhinitis

It is a regular upcoming disease together with pneumonia, sometimes as an accompanying effect of a *Trichosomoides-nasalis* infestation. Also bacteria and viruses can be the causative agents. The clinical signs are nasal discharge, conjunctivitis, dyspnoea, losing weight, a fuzzy coat and in some cases fever.

10.2 Bronchopneumonia

Causes for this often occurring disease are bacterial infections with *Pasteurella pneumotropica*, *Streptococcus* and *salmonella* species. Viruses like the Sendai virus and the

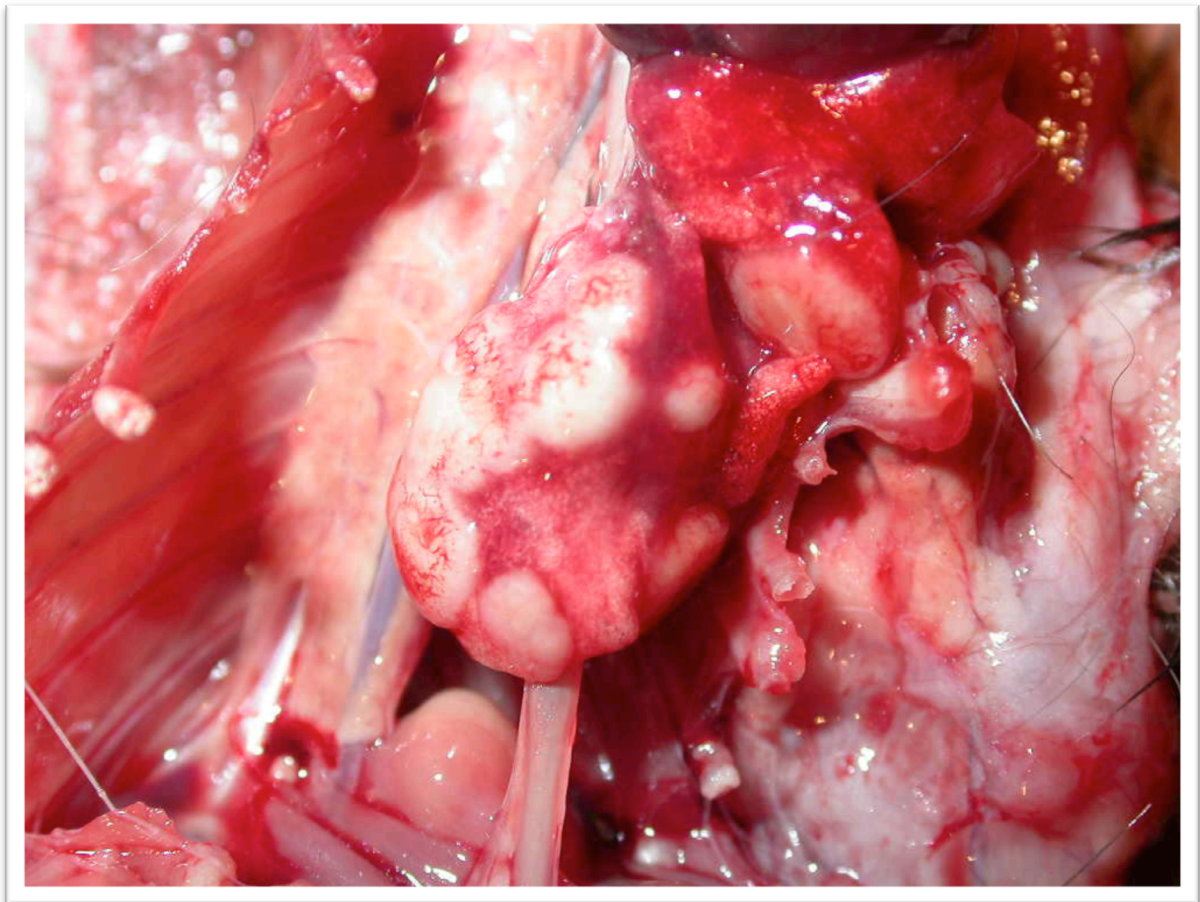
Lymphocytic choriomeningitis or bad husbandry, such as coldness and draft, can promote this disease as well.

The clinical signs are similar to those of the rhinitis.

10.3 Neoplasia of the respiratory tract

Only a few primary neoplastic diseases of the respiratory tract of the golden hamsters are described. The adenoma and the carcinoma of the bronchia are two of these rare cases. Also the polyps of the nasal cavity and the trachea are counted to these primary neoplastic diseases as well.

Metastases of adrenal gland carcinomas, melanomas of the skin and other neoplasia can be found in the lungs of the golden hamsters (*Strandberg, 1987*).



Picture 6: Lung tumor - carcinoma

11. Heart- and circulatory problems

11.1 Heart diseases

Heart diseases can lead to a hypertrophic cardiomyopathy, endocardiosis or atrium thrombosis. The clinical signs are dyspnoea, weakness, inappetence and cyanosis. The diseases can be diagnosed with the help of clinical signs, x-rays and echocardiography. The cardiac diseases in hamsters have a poor prognosis.

11.2 Neoplasia of the cardiac cycle organs

It is a very rarely occurring phenomenon in golden hamsters (*Strandberg, 1987*).

12. Urinary tract- and reproductive organs

Diseases of the urinary tract in golden hamsters play a secondary role only. Hamsters can have a pseudo pregnancy. It has a duration of around 7 to 13 days and is noticeable because of the intensive nest-building. It's ending with the physiological oestrus, so is without clinical importance. In the reproductive organs polycystic diseases can develop (*White, 1949*).

12.1 Glomerulonephropathy

It's a common disease of laboratory golden hamsters, the occurrence in pets is not clear.

Up to now, also the aetiological aspect remains unclear. Clinical signs are apathy, polydipsia, curved back and anorexia. A clear diagnostic pathway is not described yet. Advanced diseases might be diagnosed based on azotaemia or proteinuria.

12.2 Endometritis

The causative agent of an endometritis can be *Pasteurella pneumotropica*, *Staphylococcus* or *Streptococcus* species, more seldom *Corynebacteria*. It's often subclinical. The animals can

show inappetence, apathy or purulent vaginal discharge. By help of cytology a differential diagnosis is possible to exclude oestrus secretion.

12.3 Ovary cysts

The ovarian cysts in golden hamsters are commonly polycystic diseases, which are also found in other organs.

Big cysts can lead to respiratory problems, lump of the abdomen, abdominal pain, intestinal problems and anorexia.

The treatment can be a puncture or ovary hysterectomy (*Karolewski et al., 2012*).

12.4 Mastitis

Infections with beta –haemolysing *Streptococcus*, *Staphylococcus aureus* and *Pasteurella* can be the causative agent for an infectious disease of the breast (*Frisk et al., 1976*).

A palpation shows a harder appearance of the reddened mammary glands. The treatment can be a combination of antibiotics, analgesia and infusions. Sometimes a surgical treatment is necessary.

12.5 Cannibalism

Cannibalism is a sign of negligence, wrong husbandry or due to failure in the nutrition. That means, simple problems, as protein deficiency or Vitamin E deficiency can be the reason for cannibalism. The goal of the treatment is to stop these causes. It's important to guarantee enough food and water, soft litter materials for the nest building and dry litter.

12.6 Neoplasia of the urinary- and reproductive tract

Tumours of the urinary tract are rare neoplasias in golden hamsters and described post mortem only. In most of the cases nephroblastoma, renal adenoma and adenocarcinoma occur. However, neoplastic diseases of the reproductive tract are more common. There are found unilateral granulosa cell – or theca cell tumours of the ovaries. Leiomyoma, polyps of the uterus, adenocarcinoma of the mammarian glands and other neoplastic diseases of the male reproductive tract are rare (*Strandberg, 1987*).

13. Metabolic- and endocrine diseases

Metabolic diseases are quite uncommon in golden hamsters. If occurring, golden hamsters show inappetence for a longer period, which can result in a ketosis. For this reason diseased animals need to be forced-fed.

13.1 Hyperadrenocorticism (Cushing)

During pathological examinations adrenocortical hyperplasia and –adenoma are found regularly in male golden hamsters.

In studies it's a not often described clinical disease. The owners bring their animals to the veterinarian because of a severe alopecia. By the owners the occurring polydipsia, polyuria and polyphagia are often not observed. In some cases an increase of the action potential and the elevated cortisol concentration can be noticed in the plasma (*Strandberg, 1987*).

14. Age related diseases

Besides amyloidosis age related diseases can be a thrombus formation in the heart, caries, periodontitis, ulceration of the stomach, nephrotic syndrome and polycystic changes of the liver. Clinical signs are a curved back, a dull coat, exsiccosis, agglutinated eyes and unbalancement. No therapy is known jet.

14.1 Amyloidosis

Is a more common phenomenon in laboratory hamsters compared to pet- golden hamsters. The aetiology is unknown. Many organs like liver and kidneys are involved. Mainly females are affected by amyloidosis, because of the Amyloid P (AP), a female protein (*Karolewski et al., 2012*).

Materials and Methods

In this study all the noticed values concerning ‘the cause of the death of the golden hamsters’ were collected in the Department of Exotic Animals and Wildlife Medicine and the Department of Pathology, Szent István University, Budapest. The post mortem examinations of the 31 golden hamsters were performed during the period between the years 1993- 2001.

For this study the methods are divided in a detailed description and examination concerning the different age, gender affected organ systems and post mortem findings.

1. The external examination of the golden hamster

Like in mammals and other animals the post mortem examination of the golden hamster starts with the external examination. The first step is to check the animal’s identification number, followed by the determination of the bodyweight, sex and age. Then the entire body surface and orifices are observed for abnormalities. The fur quality needs to be checked for parasites dull hair or other salience. The condition of nourishment is of importance as well. The orifices are examined for discolorations and alterations including problems of the teeth. Especially disorders of teeth and cheek pouches play a role in hamsters with cachexia. Alterations of the nose can be a sign for problems with the respiratory tract and sunken eyes may indicate dehydrated or cachectic animals. The so called ‘wet tail’ can be observed during the external examination of the anus area.

The entire body needs to be palpated for superficial swellings, injury’s beginning from the head and proceeding posteriorly to the neck, chest, abdomen and appendages. Attention is paid for enlarged organs or masses within the abdomen and problems with the joints, fractures or missing digits.

Before starting with the internal examination all necessary samples and biopsies have to be collected.

2. The internal examination of the golden hamsters

2.1 Preparation of golden hamsters carcasses for dissection

The animal is positioned in dorsal recumbency. Standing on the right side of the carcass, the animal’s head in the direction of the left hand is needed for the dissection.

After finishing the external examinations the skin and subcutaneous tissue is split from the perineum to the chin. The skin has to be striped back till the vertebral column.

After exposing the hip joints, the ligamentum teres major is cut on the head of the femur.

The connection between the shoulder blades and the thorax is severed.

2.2 Internal examination of mammals till the opening of abdominal cavity

Before opening the abdominal cavity the subcutaneous connective tissue is examined. The amount of fat (ample/ medium/ poor) is checked. Also discolorations like icterus, haemorrhages (fresh = dark red, older = grey-red – yellow-brown) or oedema due to cachexia or blood congestion, needs to be detected.

For describing the blood, the vena jugularis is cut. Details like clotting, colour and covering ability are important.

The next step is to check the regional lymph nodes (Ln submandibularis, Ln cervicalis superficialis, Ln inguinalis superficialis and Ln inguinalis). The shape, size consistency, degree of attachment, cut surface, structure and fluid content are examined.

For the skeletal muscles the colour, fluid content, structure and tear ability (strength) are important.

As a last step before opening, the state of the abdomen needs to be described (drum-like, medium, flaccid).

2.3 Dissection of the abdominal cavity

The opening of the abdominal cavity starts with a three cm long incision behind the xyphoid process. The peritoneum is pierced with a finger. Then the third and forefinger is slipped under and a cut along the linea alba is performed. Holding the knife with the right hand and fixing the left abdominal wall with the left hand, the abdominal wall is cut along he ribs to the loin.

The right abdominal wall is opened in a similar fashion.

After opening the abdominal cavity the kind of liquid (congestive, inflammatory serum, fibrinous suppurative, ichorous exudate, blood, urine), the amount of liquid, the quality (watery, thick, viscous, gelatinous) and the colour are determined. The next step is to examine the state of the peritoneum and to ensure the position of the organs.

The spleen is removed first and put on the table, with the cephalic end away and the visceral surface on the table. The shape, size, capsule (slightly wrinkled), colour (light red),

consistency (flaccid), edges (normally sharp) and cut section lengthways (colour, moisture content, scrap ability (medium) are examined.

For removing the rest of the abdominal organs the oesophagus is cut behind the diaphragm, and drawn back holding the oesophagus with two fingers, of the left hand. Coronary, falciform, and triangular ligaments are cut.

The whole intestinal tract is drawn back, and cut at the rectum at the end of the pelvic cavity.

The patency of biliary duct, the duct from the gall bladder to the duodenum, is checked next. From the pylorus, lengthways along the duodenum a cut is needed. Then the gall bladder is pressed slightly. In case of patency influx can be seen.

The stomach (with a small part of duodenum) and the liver are separated from the intestines. The stomach is opened along the curvature major, starting at the pylorus. The shape, fullness, quality, quantity, consistency, smell, folds and the appearance of foreign objects are examined. To judge the thickness of the mucous membrane and the muscle a cut is necessary. The occurrence of erosions, ulcers, necrosis, parasites or pseudo membranes have to be noticed.

The entire length of the intestines are laid out on the table and cut along their length with the scissors, right next to the mesentery. The mucous membranes are observed for reddening, vascular injection, haemorrhages or ulcers and the mesenteric lymph nodes are checked for their shape, size, colour, feel, attachment, structure, cut surface and moisture.

The liver is placed in front of us with the round surface up, and right lobe at left hand. The shape, size, colour (light brownish-red), structure (feels slightly gritty), moisture content (cut surface is moderate moist), friability (easy/ medium/ difficult) and the hepatic (periportal) lymph nodes are examined. Also the shape, fullness and thickness of the gall bladder needs to be described.

The pancreas is checked for the forked shape, grey-yellow colour and the loosen, lobular structure.

2.4 Dissection of the thoracic cavity

First the shape of the thorax and the position of the diaphragm are examined. Then a cut through the muscles and the ribs, on their upper third is performed. After the pericardium is striped off.

The same as in the abdominal cavity the position of the organs, and the appearance of foreign contents needs to be checked.

The parietal and visceral sheets of the pleura should be smooth, shiny and transparent.

Continue by pressing out the tongue with the third and forefinger of the left hand.

The tongue is held with the left hand. Then the oral organs are pulled backwards. Sever the hyoid bone.

The soft palate is cut in form of a semi circle and striped off together with the larynx trachea and oesophagus in the direction of the thoracic inlet (including the thyroid and parathyroid).

The lungs and the heart are pulled out of the thorax together.

They are placed on the table with the rounded side upwards.

The tongue is treated as a normal muscle, cut longitudinal on the ventral surface.

The oesophagus is cut down through its entire length. The content needs to be checked for mucous or abnormal content and the mucous membranes should be examined for the thickness, lesions or ulcers.

The trachea is opened along its entire length till the bifurcation, following then the bronchi into each lobe, as far as possible. The wall, mucous membranes and content are described.

Attention is paid for the colour, fluid content, structure and tear ability.

The lungs are examined regarding their shape, size, surface, colour (normally pale, brick red) and how they feel (soft spongy texture). A cut section is necessary on each lobe, to check the crepitation. Also the fluid content is important.

The dissection of the heart starts with describing the state of the pericardium.

After remove the heart from the pericardium by grabbing a fold of the pericardium

Continue with describing the shape, circumference, and apex.

The epicardium should appear smooth, shiny and transparent.

The coronary and longitudinal groove should be inspected with a small amount of fat.

Positioning the heart with the apex towards you and the left ventricle up. After palpating interventricular septum, two deep incisions are performed on both sides of the septum, for entering the ventricle. The clotted blood is removed, and the heart is turned round so the incisions are underneath.

Continuing the cut in the right ventricle until pulmonary trunk.

The valves of the pulmonary trunk are examined for the thickness, a membranous appearance and intact edges.

Opening the right atrium between the cranial and caudal vena cava. Now inspect the tricuspid valve, the cordae tendinae, and the papillary muscles

Following the incision on the left ventricle to the orifice of the aorta.

Examine the aortic valves the same way as the other valves. For the examination of the left atrioventricular valve continue the incision into the left atrium.

Describe the endocardium (smooth, shiny, transparent).

For checking the foramen ovale, the interventricular septum from the side of the right atrium needs to be checked.

The thickness of the ventricles is measured under the coronary groove. For possible dilatations, the volume of the chambers is examined.

2.5 Dissection of the skull

Only two cuts are performed from the either sides of the foramen magnum that should join at the midline at the level of the orbits.

2.6 Dissection of the middle and external ear

The skull mandible is laid down. With a knife and a hammer the skull is halved in the middle. Now the internal ears and the tympanic cavity can be inspected.

Evaluation of the results

In the Department of Exotic Animals and Wildlife Medicine and the Department of Pathology at the Szent István University, Budapest, 31 different golden hamsters were examined during the period from 1993 to 2001. The collected necropsy findings are listed in the table, which is in the appendix.

1. Diseases to gender relation

The relation of gender and diseases is based on all founded diseases.

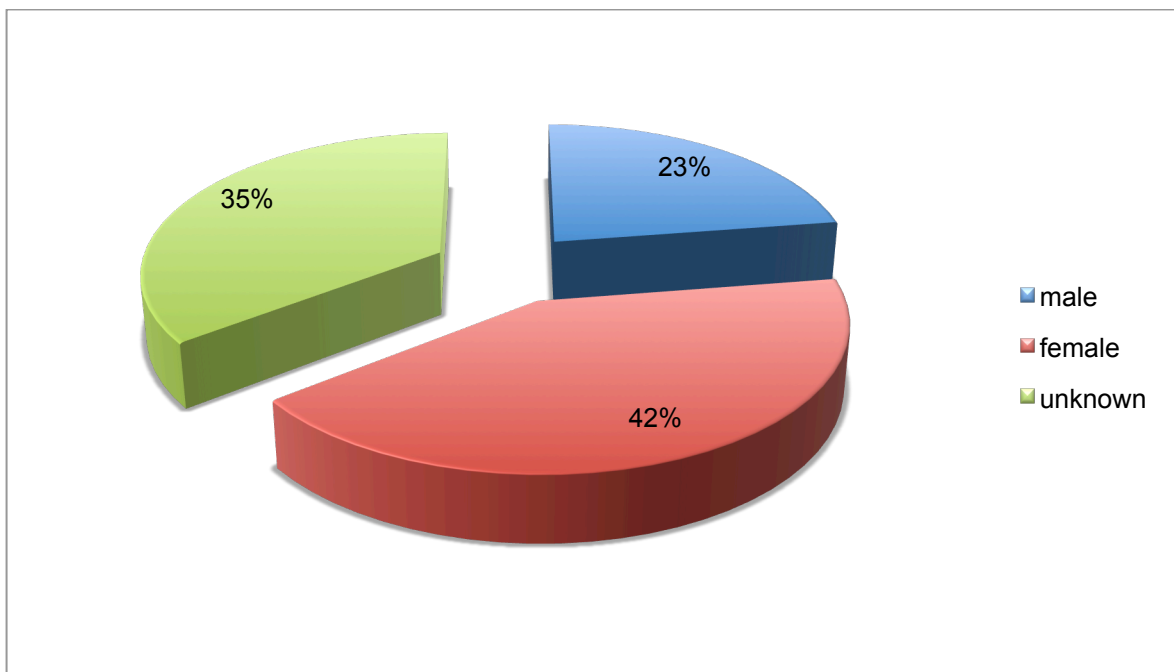


Figure - 1 - Diseases to gender relation

2. Diseases sorted by infectious and non-infectious diseases

For all diseases the relation between infectious and non-infectious diseases are demonstrated, independent from age and gender.

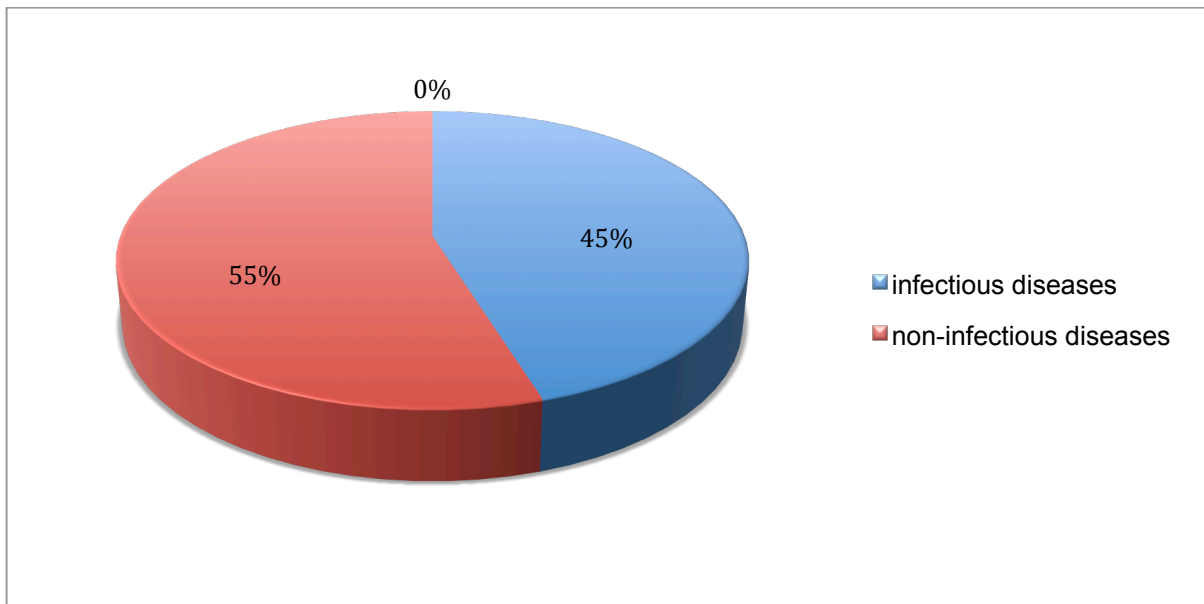


Figure - 2 - Diseases sorted by infectious and non-infectious diseases

3. Diseases according to the appearance in the different organisms

All diseases are arranged according to their location of appearance. The diagram is grouped with regard to the different organs.

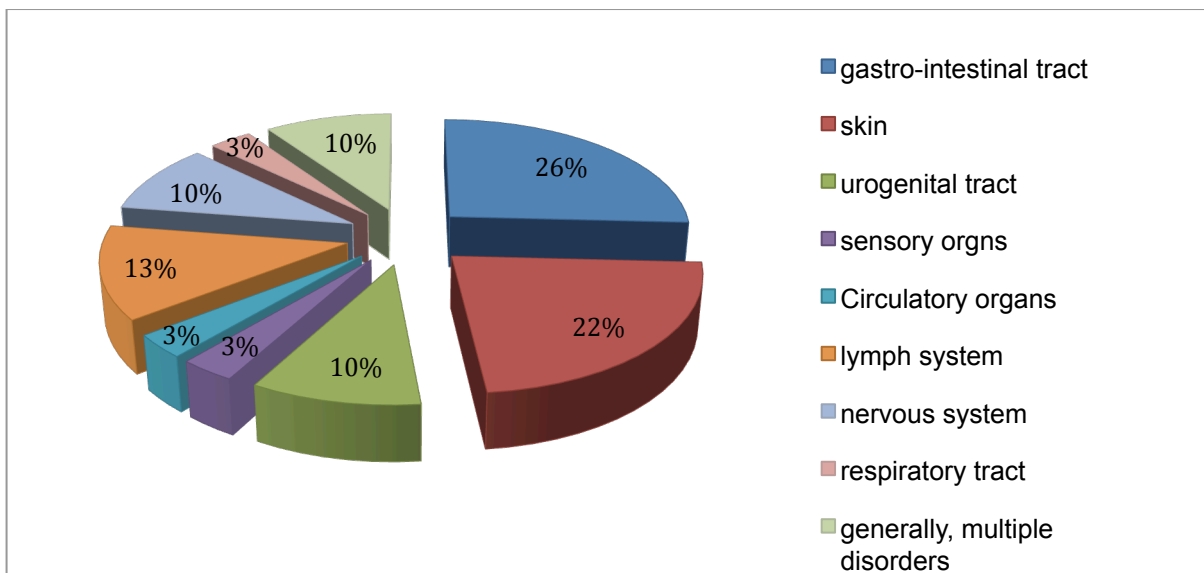


Figure - 3 - Diseases according to the appearance in the different organisms

4. Diseases diagnosed

Disease	Number of cases described	Percentage (%)
Cachexia, teeth anomalies	3	9,68
Purulent encephalitis caused by Staphylococcus sp.	2	6,45
Lymphosarcomatosis	2	6,45
Chronic interstitial nephritis and uremia	2	6,45
Enteritis caused by E.coli	2	6,45
Purulent otitis interna caused by Streptococcus	1	3,23
Phlegmon on the leg caused by Staphylococcus sp.	1	3,23
Oxyuris sp. cause heavy infection and consequential cachexia	1	3,23
Hepatopathy caused by mycotoxins	1	3,23
Acute septicaemia caused by Pasteurella multocia	1	3,23
Dysbacteriosis	1	3,23
Hystiocytoma of the skin	1	3,23
Malignant Melanoma of the skin	1	3,23
Carcinoma simplex in the skin	1	3,23
Fibrosarcoma under the skin	1	3,23
Scabies and chronic dermatitis	1	3,23
Multiplex purulent dermatitis	1	3,23
Buccal sac inflammation caused by foreign body	1	3,23
Abscess formation in the lymph node of submandibular region	1	3,23
Generalised lymphoma	1	3,23

Obstipation	1	3,23
Purulent pneumonia	1	3,23
Myocardial fibrosis and consequential lung oedema	1	3,23
Purulent nephritis	1	3,23
Multiplex encephalomalatia, myeloid leucosis	1	3,23

5. Diseases to age relation

The age of the examined golden hamsters was divided into 5 groups. Regarding the age of the diseased animals this diagram shows the most affected age groups.

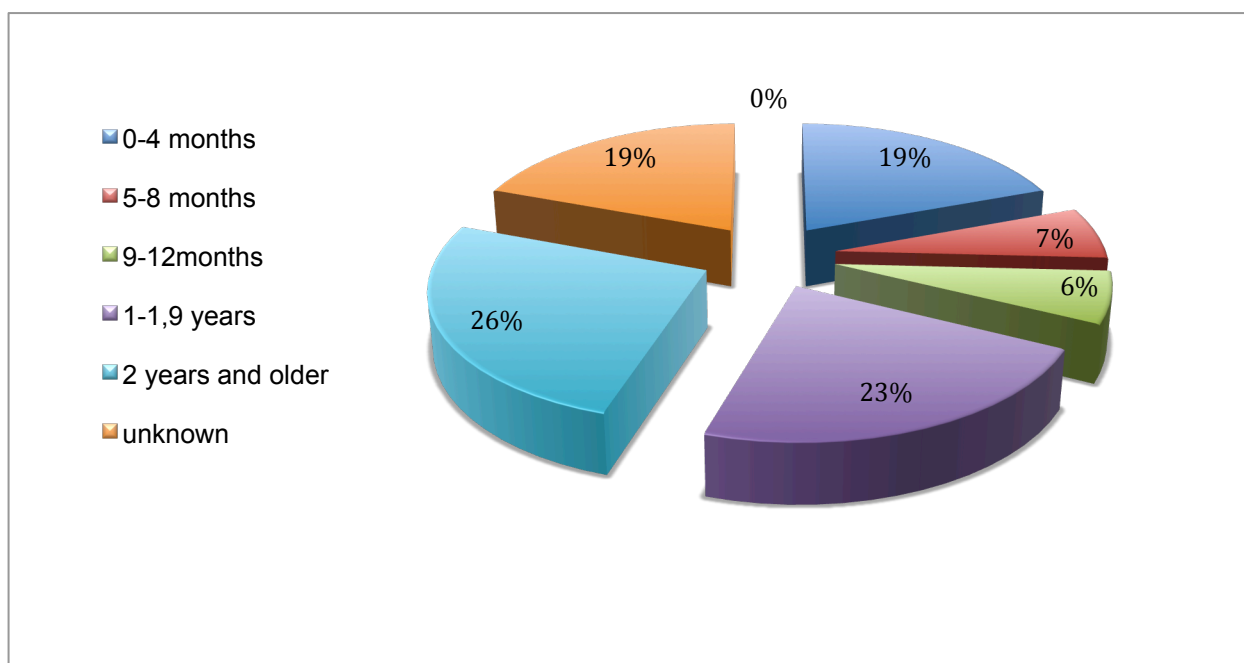


Figure - 4 - Diseases to age relation

The 3 most affected organ groups are shown in relation to the age of their occurrence

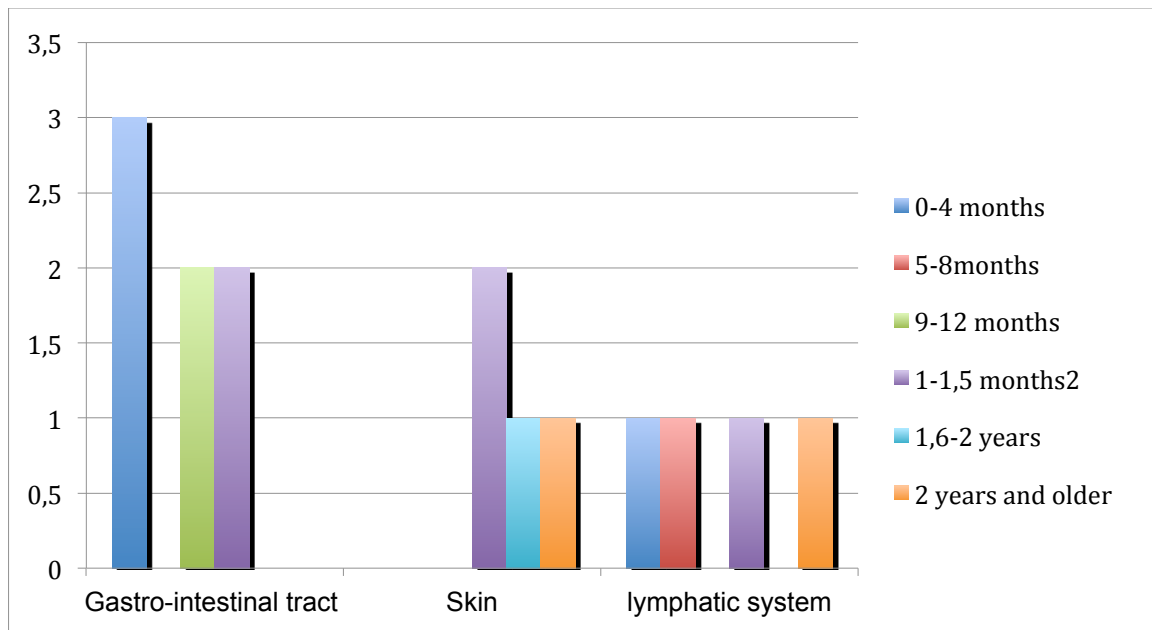


Figure - 5 - The 3 most affected organ groups are shown in relation to the age of their occurrence

Conclusion

This thesis deals with the study of the necropsy findings of the golden hamsters. Between the years 1993 to 2001 in the Pathological Department 31 golden hamsters were examined and dissected. Due to the low number of examined animals it is difficult to make a clear conclusion. All the hamsters involved in this study belong to the species 'Golden/ Syrian hamsters'.

Figure 1: 42 % of the affected animals are females. In this population only 20 genders are known. Of the known genders 13 were female. Because of the high number of 11 unknown genders in this respect a significant conclusion cannot be drawn. Resulting from this fact it's not possible to classify the diseases according to the genders they affect preferably as well.

Figure 2: A balanced illustration shows the diagram regarding the infectious and non-infectious diseases. With 55 % the non-infectious diseases are slightly higher in number than the infectious diseases. In this group the bacterial infections dominate with 78,52%. The problems of bacterial diseases might be explained with wrong husbandry, bad hygiene and wrong nutrition or changes in the nutrition.

Nowadays parasites and fungal infections seldom play a role in the breeding golden hamsters. Even with the small number of examined hamsters with 31 animals, the diagram shows quite clearly the low level of infections with parasites with 14,29%, and fungi, with 7,41 % respectively.

Figure 3: The tableau with the diagnosed diseases shows clearly the heterogeneous appearance of the diseases. Only cachexia, resulting of teeth problems is with 3 described cases a more then once repeated disease. The 4 diseases, purulent encephalitis caused by *Staphylococcus* sp., Lymphosarcomatosis, chronic interstitial nephritis and uraemia and enteritis caused by *E. Coli* occurred twice while the 26 other diseases appeared only once.

Figure 4: The most affected age group with 26 %, is the group of 2 years old and older animals. Overall the diagram shows a slightly higher number of affected animals in older golden hamsters from the groups 1-1,9 year and 2 years and older. But there is also a tendency in this cohort that younger animals in the age of 0-4 months have a higher risk of getting lethal diseases.

According to the diagram 3.5.1 there was no predisposed affected organ regarding the age groups.

Summary

The thesis 'Cause of the death of the golden hamster' outlines the pathological changes caused by infectious and non-infectious diseases.

At the Department of Pathology, at the Szent István University, Budapest, all the data's regarding aetiology, anamnesis, clinical signs and necropsy findings have been collected from 1993-2001.

The used pathological examination methods followed the guidelines, described in the dissection book of the Department of Pathology at the Szent István University, Budapest.

In order to compare the findings to the literature, it was attempted to summarize the diseases found in golden hamsters and to sort them according to organ systems affected.

31 golden hamsters were examined and dissected.

All the data's have been collected regarding aetiology, anamnesis, clinical signs and necropsy findings.

The 4 diseases, purulent encephalitis caused by *Staphylococcus sp.*, Lymphosarcomatosis, chronic interstitial nephritis and uraemia and enteritis caused by *E. Coli* occurred twice while the 26 other diseases appeared only once.

Finally conclusions were attempted from the collected findings, based on the age, gender, diagnosis and the frequencies of the diseases. Due to the small number of examined animals it is impossible to draw clear conclusions.

Appendix

Results of dissected golden hamsters at the Department of Pathology between 1993 and 2001

Data	Case number	Age	Gender	Diagnosis
1993	2488	unknown	unknown	Multiplex encephalomalatia, myeloid leucosis
	2517	unknown	unknown	Fibrosarcoma under the skin
1994	2	3 months	male	Cachexia, teeth anomalies
	2434	1 month	unknown	Oxyuris sp. cause heavy infection and consequential cachexia
	2495	3 weeks	unknown	acute enteritis caused by E. coli
1995	193	6 months	female	Lymhosarcomatosis
	376	4 months	unknown	Lymhosarcomatosis
	402	2 years	female	Acute septicaemia caused by Pastuerella multocida
	1089	8 months	unknown	Purulent encephalitis caused by Staphylococcus sp.
	1743	unknown	unknown	Teeth overgrowth and cachexia
	2380	unknown	unknown	Enteritis caused by E. coli
	2611	1,5 years	female	Purulent encephalitis caused by Staphylococcus sp.
1996	3452	3 years	male	Scabies and chronic dermatitis
1999	354	unknown	female	Infection of the leg caused by Staphylococcus sp.
	1014	2 months	unknown	Purulent nephritis

	1357	unknown	unknown	Carcinoma simplex in the skin
	1387	1,5 years	male	Obstipation
	1938	1,4 years	male	Abscess formation in the lymph node of the submandibular region
	2218	4 months	female	Dysbacteriosis
	3133	2 years	female	Myocardial fibrosis and consequential lung oedema
2000	1042	3 years	female	Hepatopathy caused by mycotoxins
	1188	3 years	female	purulent otitis interna caused by Streptococcus sp.
	1261	1,5 years	female	chronic interstitial nephritis and uraemia
	2417	1 year	female	Purulent pneumonia
	2663	2 years	female	Melanoma malignum in the skin
	2765	10 months	unknown	Teeth overgrowing and consequential cachexia
2001	660	11 months	male	Buccal sac inflammation caused by foreign body
	1751	2,5 years	male	Chronic interstitial nephritis and uraemia
	2093	1,5 years	female	Hystiocyoma of the skin
	3053	1,5 years	male	Multiplex purulent dermatitis
	3464	2 years	female	Generalised lymphoma

Picture reference

Picture 1- Dr. Gál János, Department of Exotic Animal and Wildlife Medicine,
University of Veterinary Science, Budapest

Picture 2- Dr. Gál János, Department of Exotic Animal and Wildlife Medicine,
Szent István University, Budapest

Picture 3- Dr. Gál János, Department of Exotic Animal and Wildlife Medicine,
University of Veterinary Science, Budapest

Picture 4- Dr. Gál János, Department of Exotic Animal and Wildlife Medicine,
University of Veterinary Science, Budapest

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