Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Faculty of Veterinary Medicine and Animal Science
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Diseases and causes of death among camelids in Sweden

- A retrospective study of necropsy cases 2001-2013

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Diseases and causes of death among camelids in Sweden

- A retrospective study of necropsy cases 2001-2013

Sjukdomar och dödsorsaker hos kameldjur i Sverige

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SUMMARY

Camelids, especially alpacas, have increased in popularity during the last decade, with the result that they are more frequently encountered by field practicing veterinarians and pathologists. Knowledge regarding their health care and their diseases under Swedish conditions is, however, limited. This became clear in a postal survey among Swedish alpaca owners conducted in 2008. To improve knowledge about camelids in Sweden, this study has examined 107 necropsies, including 93 alpacas and 14 camels, conducted at the National Veterinary Institute (SVA) in Uppsala and at Eurofins in Kristianstad and Skara during the period 2001-2013. The study has shown that camelids in Sweden suffer from diseases similar to those previously reported in other countries in Europe and North America. The digestive tract was the most common organ system affected, with parasitic gastroenteritis and liver disease being especially prevalent. Perinatal deaths were also common, especially in alpacas where abortions and neonatal septicaemia were common causes. One interesting group of animals identified in the study was weaning alpacas of which the majority had died from emaciation during late winter or early spring. For adult alpacas and camels, causes of death were almost equally divided between medical and infectious causes. Many of the diseases were considered acute by the owners and veterinarians but were later shown to be chronic conditions that had become acute. This study has revealed similarities with camelid populations in other European countries as well as in North America regarding diseases but it has also identified some areas of concern regarding mainly diagnostic and pathological procedures for which specific applications have been listed.

SAMMANFATTNING

Kameldjur och då framförallt alpackor har ökat i popularitet i Sverige under de senaste tio åren vilket resulterat i att distriktsveterinärer och patologer allt oftare stöter på dessa djur. Kunskapen om kameldjurens sjukdomar och behandling under svenska förhållanden är dock begränsad vilket blev uppenbart efter publiceringen av en enkätstudie utförd bland svenska alpackaägare 2008. För att förbättra kunskapsbasen gällande kameldjuren i Sverige har denna studie undersökt 107 obduktionsfall inkluderande 93 alpackor och 14 kameler. Obduktionerna har utförts vid Statens veterinärmedicinska anstalt (SVA) i Uppsala och vid Eurofins i Kristianstad och Skara mellan åren 2001-2013. Studien har visat att kameldjuren i Sverige i stor utsträckning lider av sjukdomar som tidigare rapporterats hos kameldjur från andra länder i Europa och Nordamerika. Digestionsorganen utgjorde främsta sätet för sjukdomar där parasitär gastroenterit och leversjukdom var särskilt vanligt förekommande. Perinatal dödlighet var också vanligt förekommande, framförallt hos alpackorna där aborter och neontal sepsis var vanliga orsaker. En intressant grupp som identifierades genom studien var alpackor under avvänjning där majoriteten hade avlidit till följd av utmärgling under sen vinter och tidig vår. Bland vuxna alpackor och kameler var sjukdomarna relativt väl fördelade mellan medicinska och infektiösa orsaker. Många av fallen ansågs akuta av ägare och veterinärer men visade sig senare vid obduktion vara kroniska besvär som akutiserats. Studien har visat på likheter med kameldjurspopulationer i andra europeiska länder och i Nordamerika gällande förekommande sjukdomar men har också identifierat problemområden inom framförallt diagnostiska och patologiska metoder för vilka en lista med åtgärdsförslag presenteras.

CONTENT

ABBREVIATIONS USED IN THE TEXT

BVDV – Bovine Viral Diarrhoea Virus

FPT – Failure of passive transfer

NWC – New World Camelids (other name for SAC)

OWC – Old World Camelids (Dromedary and Bactrian camels)

PEM – Protein Energy Malnutrition

SAC – South American Camelids (alpaca, guanaco, llama, vicunja)

SvDHV – Svenska Djurhälsovården (eng. Swedish Animal Healthcare)

SVA – Statens veterinärmedicinska anstalt (eng. National Veterinary Institute)

VTEC – Verotoxgenic *Escherichia coli*

VLA - Veterinary Laboratory Agency (Great Britain)

INTRODUCTION

The most frequently seen camelids in Swedish farms are the alpacas. They are mainly kept for their fine fibre but also as pets and companion animals (Bornstein & de Verdier, 2010). A small number of camels and llamas can also be found: these animals are kept as pets or as tourist attractions. The first South American camelids (SAC) arrived in Sweden as late as the mid 90's (Svenska Alpackaföreningen). Since then their popularity has grown steadily and interest for the alpaca especially has grown during the last decade. The Swedish Alpaca Association estimated the number of alpacas in Sweden to between 1500 and 2000 individuals in spring 2013. Most herds consist of about ten animals but there are larger herds of up to 100 animals (Bornstein & de Verdier, 2010). Since 2009 a part of Svenska Djurhälsovården (Swedish Animal Healthcare programme) has been dedicated to camelids. This healthcare program offers veterinary consulting, test for endoparasites and free necropsies among other things and currently has 84 farms as members ((http://www.svdhv.org/sv/andra-djurslag/kameldjur/halsovardsprogram, November 2013). Five of the farms have camels, the rest have alpacas: the organization currently cares for an estimated 1000 alpacas and 20 camels (personal communication Kerstin de Verdier, Hälsovården för kameldjur, November 2013).

The climate in Scandinavia is new to the animals and the animals are new to the Scandinavian veterinarians. This combination poses several risks. A new climate means health problems including a variety of infectious diseases as well as medical issues and nutritional diseases. The difference in housing also poses a problem. In Sweden camelids are kept outdoors although in smaller pastures than in South America. Often the same pastures are used all year round, which increase the parasite burden. During cold winters they are sometimes kept indoors, which predisposes them to infections and parasitism. A new species means difficulties in establishing a diagnosis for the unfamiliar veterinarian who is unaware of the health issues of this animal and also unfamiliar with the camelids' behaviour when ill and the most effective drugs available for treating illness. A postal survey conducted among Swedish alpaca owners in 2008 made this very clear; only 10% were satisfied with the help they received and 50% of owners thought veterinarians lacked sufficient knowledge about camelids (Bornstein & de Verdier, 2010). This shows the need for education, and education in turn requires scientifically based facts about these animals' needs and diseases in the environment where it is held. This lack of knowledge precludes the development of both effective treatments for the clinically ill camelid as well as preventive strategies.

The aim of this study was to identify diseases and causes of death in camelids living under Swedish conditions by examining necropsy reports from the last decade. This was done to provide a knowledge-base for Swedish veterinarians and to see how the Swedish data compares with the available information based mainly on North American and European conditions. This information is vital for the growing population of camelids in Sweden as well as for the growing number of veterinarians treating camelids. The information gathered through necropsy reports was not only limited to causes of death but also gave valuable insight into the prevalence of subclinical conditions affecting the overall health of camelids in Sweden, such as endo- and ectoparasites, signs of metabolic imbalances and nutritional deficiencies. This information is valuable for any owner or treating veterinarian who wants to

work prophylactic for better herd health and for the veterinarian diagnosing and treating the clinically sick camelid. The information is also important if we want to improve animal welfare for camelids in Sweden.

LITERATURE REVIEW

The camelids

Camelids are divided into two groups; Old World Camelids (OWC) and New World Camelids (NWC) (Fowler, 2010). The former include Dromedary and Bactrian camels, while NWC include alpaca, llama, vicuña and guanaco. The latter group is also known as South American Camelids (SACs) because of their native continent; this name will be used hereafter. The alpaca and the llama are domesticated and they are thought to be relatives of the wild vicuña and guanaco, respectively. Both OWCs and SACs share a long history with humans and have for centuries provided people with wool, meat, milk, leather and fuel as well as functioning as riding (camels) and pack-animals (Fowler, 2010). Special nomenclature is used for SACs; males and females are known as machos and hembras, respectively, neonatal SACs are called crias and weaned youngsters are called tuis. Both groups of camelids have evolved from the same ancestor but different habitats and susequent breeding, have shaped the different camelids we see today (Fowler, 2010).

Old World Camelids

The OWCs are large animals measuring around 190 centimeters at the shoulder, with adults weighing 300-700 kilos. The OWCs evolved in a semi-desert environment; the Dromedary (one-humped) camels are adapted to the warm and dry climate of Northern Africa and the Middle East with their lean bodies. Breeding for speed (racing camels) and for milk production has shaped the Dromedary camels. Bactrian (two-humped) camels, are adapted to the cooler climate of Central Asia. A wild relative now lives in Mongolia. They have a more compact and massive body structure and grow thick winter coats during cold periods which is then shed this to cope with hot summer months.

South American Camelids

The SACs are much smaller than the OWCs. The llama is the larger of the two domesticated SACs measuring between 100-120 centimeters at the withers, with a weight of between 100-250 kilos. The alpaca measures only 80-90 centimeters the withers and weighs between 55-90 kilos. The vicuñas, from which the alpaca originates, are only found high up in the Andes whereas the guanaco are distributed over a large area ranging from the Andes of Peru in the north to the sea level of the southern parts of South America. On the Altiplano plateau where the llamas and alpacas are mainly concentrated, the climate is mainly dry with a short wet season during winter months. The temperature often falls below zero at night resulting in frost (maximum night time temperatures of about -12°C) but during the day the high altitude causes strong solar radiation to produce a milder climate with daytime temperatures reaching a maximum of 18°C.

Camelid anatomy and nutrition

Despite their differences in size and appearance, all camelids have similar anatomy (Fowler, 2010). All camels ruminate but their stomachs are not structurally or morphologically equivalent to the stomachs of the advanced ruminants. Fowler (2010) emphasizes the fact that camelids should not be considered as ruminants, pseudoruminants or modified ruminants. Their stomach is divided into three compartments (C1-C3) (Vallenas et al., 1971). All three compartments contain glandular mucosa which makes the digestive system of the camelids highly efficient. The first two compartments are fermentation chambers. In the elongated C3, fermentation also takes place but only in the proximal portion. In the distal part of C3 gastric secretion of proteolytic digestive enzymes and hydrochloric acid makes it more similar to a human stomach. The camelid diet is based on grass and other forage (Fowler, 2010). The habitats in which the camelids have evolved have forced them to develop a more efficient system for extracting energy and protein out of their forage compared to true ruminants. The long dry season and the short wet months of the Altiplano have adapted the SACs to a feast-and-famine situastion. Camels have adapted to a more constant supply of small amounts of dry harsh forage. In commercial farms the camelid diet is often complemented by grain to provide extra energy for pregnancy or lactation in females as well as for energy-demanding situations such as cold temperatures, hard work as pack animals or as racing camels. Llamas and alpacas have been found to have a lower energy and protein requirement than ruminants but a higher protein requirement per unit of energy (Van Saun, 2006). It is also suggested that SACs have a higher requirement of Vitamin D than true ruminants.

Previous studies and reports on diseases and causes of death in camelids

There are few reports or articles regarding causes of death and diseases in camelid populations. Most of the information available is in the form of case reports or studies of specific disease processes such as neoplastic or nutritional diseases. The only information regarding overall health in camelids held under Swedish conditions is the information provided through the postal survey conducted among alpaca owners in 2008 (Bornstein & de Verdier, 2010). The questionnaire contained questions regarding everything from housing, pasture acres and numbers of animals to questions regarding the health status on the farm. In total, the survey covered the life and health of 551 alpacas. Most of the farms were small, with an average of 13 alpacas, and the majority of farms were located in the southern parts of Sweden. Many of the owners (60%) were relatively inexperienced; keeping alpacas for less than four years, but at the same time breeding took place in 80% of the farms. Only about 10% of the owners were satisfied with the help they had received from practicing veterinarians and close to 50% of the owners complained that the veterinarians had too little knowledge of alpacas. Many owners also complained about veterinarians treating the alpacas as something in between ruminants and horses instead of the camelids they are. Specific health issues were raised in the questionnaire, with the most commonly encountered health problem, as experienced by the owners, being skin conditions. Other issues concerning the owners were related to reproduction. Many had experienced difficulties in getting their females pregnant; others had problems with abortions and vulvar discharge.

Studies of post mortem findings in camels are only available in a small number of reports from countries in Europe and North America. One German study, only available as a conference proceeding, included 222 post-mortems on camelids, mainly alpacas but also other SACs and camels. The study showed that apart from the thorax (e.g. pulmonary oedema as a part of the death process), most problems were located in the liver, the digestive tract or the abdomen as a whole (Gunsser et al., 2006). The causes were mainly endoparasitism, other infections and feeding faults. The most common cause of death was infectious disease followed by euthanasia, emaciation and fatty degeneration of the parenchyma. In a short disease report from Canada, diagnoses in necropsy reports from the years 1998 to 2004 were presented including 93 SACs, mainly alpacas (Shapiro et al. 2005). In this report diagnoses were presented for different age groups. Among neonatal crias systemic bacterial infections were a common cause of death followed by developmental anomalies. For the animals that had died during their first year diagnoses were distributed among infectious causes, neoplasia, malformations, nutritional diseases and abdominal emergencies. In camelids over one year of age, digestive tract disease was the most frequent diagnosis with gastric ulcers being a common finding. The second most common diagnosis was neurological disease followed by hepatic disease in third place. Of the abortions submitted during this time period only one of 21 could be diagnosed through necropsy, microscopic examination and tests for infectious agents.

A short presentation of the main findings in camelid submissions to the Veterinary Laboratory Agency (VLA) regional centres was made during the British Veterinary Camelid Society's annual conference 2003 (Jones, 2003). It included all submissions made since November 1998 and involved 944 alpaca submissions and 162 llama submissions. Of these, 185 and 17 cases were carcass submissions of alpacas and llamas, respectively. The majority came from the south of England. Many of the submissions were aborted foetuses. Of 60 alpaca and nine llama foetuses, an infectious cause for the abortion was only found in two alpaca cases. Infectious diseases observed in the submissions were cryptosporidiosis (mainly neonatal camelids), clostridiosis, parasitic gastroenteritis, fasciolosis, tuberculosis, Johne's disease, salmonellosis and ectoparasitic disease. Most of these infections were found in just a few sporadic cases but parasitic gastroenteritis was regularly recorded. Nematodes usually seen in sheep were a frequent observation. Fasciolosis had only been recorded since 2001 but was also quite common in submissions, seen in 17 alpacas and four llamas. The chronic form of disease was the most common.

Later in 2009 a more comprehensive annual report on camelid submissions to VLA was provided by the Department for Environmental, Food and Rural Affairs (Defra) in the United Kingdom. It reported high numbers of camelid samples positive for tuberculosis (*Mycobacterium bovis*), an increase in bovine viral diarrhoea virus (BVDV) cases as well as an increase in skin samples positive for parasitic mange. Also, a high proportion of samples positive for verotoxigenic *Escherichia coli* (VTEC) were found in three investigated farms. Other diseases mentioned were liver fluke infestation, parasitic gastroenteritis, coccidiosis, gastric ulcers and neoplasia (e.g. lymphosarcoma). Parasites found in cases of enteritis were similar to those presented in the report from 2003 and included nematodes commonly encountered in other domestic ruminants in the UK such as *Nematodirus* spp.,

Trichostrongylus spp., *Trichuris* spp., *Ostertagia* sp. and *Haemonchus* spp. Parasitic gastroenteritis was considered to be a significant cause of mortality among the carcass submissions at VLA during 2009; of the 28 alpaca carcasses examined, 11 deaths could be directly linked to intestinal parasitism. Coccidiosis caused by *Eimeria* spp. was also reported as a common find. Of 630 samples tested, 36 cases of coccidiosis were found among both young and adult alpacas. A further three cases of coccidiosis were found in adult llamas, the coccidia being identified as *Eimeria macusaniensis*, *Eimeria punoensis* and *Eimeria llamae*. Mixed nematode and coccidial infection was diagnosed in several cases. Gastric ulcerations could, in several cases, be linked to stressors such as transportation, new animals in the herd and concurrent diseases. Several cases involving perforating ulcers causing peritonitis was seen in both crias and adult alpacas. Among crias, septicaemia due to *E. coli* was a prominent finding.

A UK survey among owners to SACs carried out between late 1992 and mid 1993 resulted in the first report on population statistics, mortality rates and causes of deaths in UK camelids (Davis et al., 1998). In all, the study included 689 camelids; 66% were llamas, 21% were alpacas and 13% were guanacos. The highest mortality rate was found among animals less than six month old and over ten years of age. This survey also showed that young llamas were more at risk from accidents and injury than the young alpacas that more often died during their first week due to infections. Better diagnostics were needed due to the fact that a third of all deaths were of unknown cause and a veterinary diagnosis was reported in less than half of all cases. Causes of death in 18 alpacas between 1990 and 1992 included one case of trauma, two cases of gastrointestinal disease, four cases of perinatal problems, two cases of non-infectious causes including one stress-induced heart attack and four cases of vitamin E/selenium deficiency and six cases without known cause. In the 38 cases of llama deaths during the same time period the causes of death included seven cases of trauma, six cases of gastrointestinal problems, three cases of perinatal deaths, three cases of infectious diseases such as pneumonia, four cases of non-infectious causes and 12 cases with unknown cause. However, it should be noted that many of these diagnoses had not been confirmed by a veterinarian. There was no difference in sex-specific mortality or in the monthly pattern of deaths in llamas and alpacas.

In a later UK survey conducted between the years 2000 and 2001 the population had increased dramatically and the survey now included 3520 camelids of which 2719 were alpacas and 726 were llamas (D'Alterio et al., 2006). This survey focused on population statistics, husbandry procedures and skin diseases. It did not report mortality rates but provided information regarding the diseases or clinical signs observed by the owners. Skin diseases were the major concern, observed by 51% of all respondents with 317 animals reportedly being affected. Camelids affected by different skin conditions were found in almost half of all the herds and 81% of affected animals were alpacas. Apart from skin conditions, 32 diseases or clinical signs were reported, the most common was neonatal death and intestinal problems followed by clostridial disease, coccidiosis, emaciation, liver damage and sudden death.

An international survey regarding disease issue concerns was presented in 2003.The survey included camelid owners and veterinarians from Australia, Argentina, Canada, Italy and

several states in the USA. There are no exact numbers describing the respondents or the camelid population the survey covers. However, the major concern among camelid owners in the survey were parasitism, neonatal disease, congenital defects, reproductive disorders, skin disease, nutritional imbalances and gastrointestinal disease. Interestingly, veterinarians considered oral health to be the main problem followed by parasitism, neonatal disease/congenital defects, reproductive disorders, skin diseases, nutritional imbalances and gastrointestinal disease. Apart from the oral health pointed out by veterinarians it was clear that some diseases stood out as major concerns for both owners and veterinarians.

MATERIAL AND METHODS

In this descriptive study information has been gathered from necropsies in order to describe and categorise pathological characteristics in the Swedish camelid population.

A total of 107 necropsy reports from February 2001 through October 2013 was collected from the two major pathology centers in Sweden, the National Veterinary Institute in Uppsala (55) and Eurofins (formerly AnalyCen) in Kristianstad and Skara (52). Remittance reports were also collected for each necropsy case as well as any other information available for the case in the archives (mail correspondence, notes, letters from the owners etc.). In addition, from the same time period the reports for 31 biopsy and organ samples were collected from the National Veterinary Institute (SVA). These samples were sent to SVA mainly from Eurofins in Kristianstad and Skara but some came from private veterinarians.

For each case a number of basic facts were documented including species, age, sex, body condition, means of death (euthanased or found dead), history, main symptom, if the animal had been diagnosed and treated for its condition, as well as the referring veterinarian's referral notes. Owner, farm or zoo connection was documented if this information was provided, in order to estimate the number of owners in comparison to the number of cases. Furthermore, pathology diagnosis, macroscopic and microscopic finds, incidental findings, the results of laboratory tests performed, as well as the pathologist final comments were documented. For the basic structure of the Excel file used, see Appendix I.

The information provided in the referrals varied between cases but for the majority of necropsy cases the basic facts have been compiled from the referral and the pathologist's report. In some cases it was necessary to use private letters, e-mail and other documents found in the archives to complete the picture. Nevertheless, for some cases basic facts such as age, body condition, gender and information regarding treatments and diagnoses before death have not been retrievable. For animals found dead the cause of death has been identified in the cases were it was possible; either as an interpretation of the findings presented in the report when clear enough or in rarer cases as the pathologist's own opinion regarding the cause of death.

Affected organ system or organ systems was documented and characterized as one of the following categories: cardiovascular, digestive, reproductive, skin, hematology/lymphatics, neurologic, respiratory, locomotor (skeleton and muscles) and urinary. For the predator kills, the emaciation/starvation cases and the cases of malformations, no specific organ system

could be identified and therefore these cases have been classified as predator kills, wasting and malformation, respectively. Cases without diagnosis are categorized as unknown. Furthermore the pathology diagnosis was classified as infectious, medical or traumatic and as acute or chronic.

While processing the information in the final reports as well as the pathologist's notes and the treating veterinarian's referral, several difficulties have been identified. One major difficulty was the interpretation of the referring veterinarian's thoughts of the case and in particular the existence of any kind of diagnosis, either confirmed through clinical findings and blood samples or as a working diagnosis from which the veterinarian had chosen a treatment plan. Defining chronic versus acute disease in young animals has caused some concern as well as infectious versus medical issues in those cases where an existing infection cannot be concluded as primary or secondary to the actual condition at the time of death. Where the information is lacking to such a degree that any interpretation is only a guess, the post was left blank.

RESULTS

Excluded material

In total, 31 cases were only available as organ samples; 21 were alpacas, seven camels and three llamas. Neither necropsy reports nor referrals have been found for these cases and they have therefore been excluded from the study.

Camelid necropsies in general

Species, age and gender distribution

Of the 107 necropsies investigated, 87% (93) were alpacas and the rest, 13% (14), were camels (Bactrian, Dromedary and unspecified camels). No llamas were among the cases. The number of camelid necropsies has increased in numbers over the period, especially after 2009 due to a rapid increase in the number of alpaca necropsies (Figure 1). The largest age group comprised individuals, both alpacas and camels, between one and five years of age (33) followed by newborn up to five months (25) (Table 1). The majority of all necropsy cases were females but the proportion varied between age groups (Figure 2). For detailed information on the cases in each age group, see Appendix II.

Table 1: Alpaca and camel necropsy cases by age. A: alpacas, C: camels, h: hours, d: days, w: weeks,m: months, y:years.

	Prenatal	Crias/calves				5-12 m	1-5 y	6-9 y	≥10 y	Unknown adults
		0-24 h	1-10 d	2-3 w	1-4 m					
A	10	5	3	3	6	11	30	13	8	4
C	0	2	5	0	0	0	3	2	1	1
All	10	7	8	3	6	11	33	15	9	5

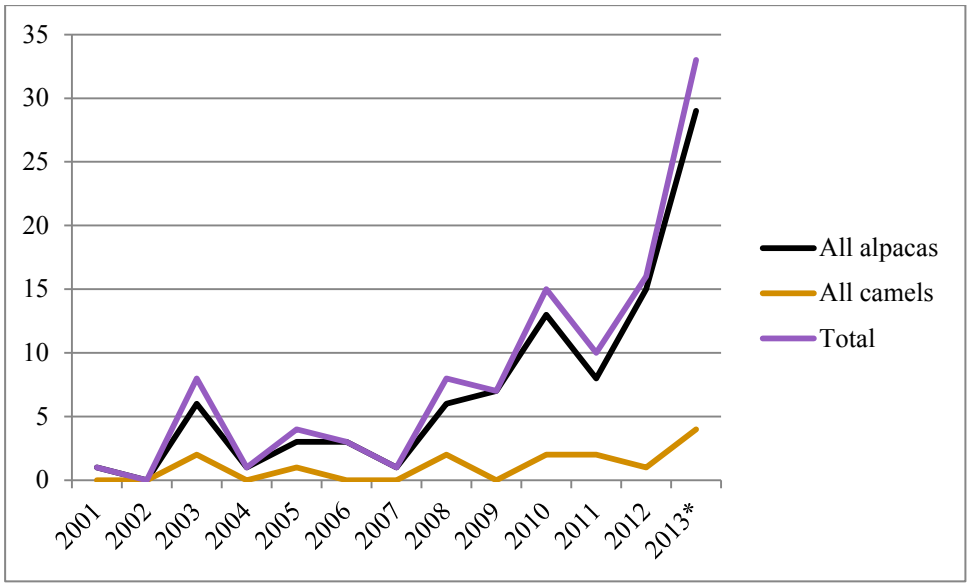

Figure 1. Camelid necropsies at SVA and Eurofins between February 2001 and October 2013, completed by year.

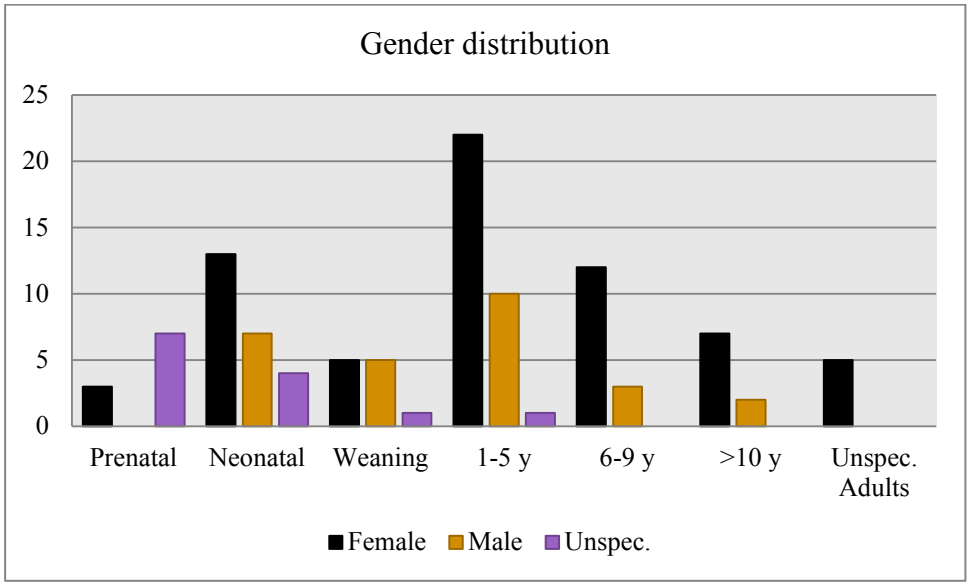

Figure 2. Gender distribution among alpacas and camels in different age groups.

Camelid necropsies in relation to number of owners and SvDHV

For 85 alpaca cases the owner could be identified and these belonged to 33 different owners. Twelve of the camels had identified owners and these belonged to five different owners. All alpaca necropsies in this study, performed between 2009 and 2013, with identified farm origin (two unidentified), were funded by SvDHV. Only two of the nine camel necropsies performed during the same period were funded by SvDHV.

Disease history

Symptoms of disease

Reported symptoms in referrals to necropsy are displayed in Table 2. Wasting, sudden death, weakness and inappetence were the most commonly reported symptoms overall. Wasting was most commonly reported in weaning animals and animals aged 1-5 years. Sudden death was the most commonly reported symptom in neonatal animals.

Table 2. Reported symptoms in referrals for alpacas and camels: number of cases in each age group and in total.

		Neonatal	Weaning	1-5 years	6-9 years	≥10 years	Unspec. adults	Total
Fever		1	-	1	1	-	-	3
Swollen lymph nodes		-	-	-	-	1	-	1
Inappetence		-	1	3	1	4	1	10
Wasting		2	7	11	3	4	1	28
Weakness		5	1	5	1	1	1	14
Diarrhoea		1	-	1	-	-	-	2
Colic		-	1	2	1	-	-	4
Recumbency		-	1	-	1	1	-	3
Collapse		-	-	-	1	-	-	1
Anaemia		-	-	1	-	-	-	1
Resp.*	Dyspnoea	2	-	1	2	-	-	4
	Coughing	1	-	1	-	-	-	2
	Unspecified	-	-	2	-	1	-	3
Neuro.**	Staggering	2	-	-	-	-	-	2
	Seizures	-	-	-	-	-	1	1
	Paresis	-	-	2	1	-	-	3
	Blindness	-	-	2	-	-	-	2
	Behavioural changes	-	2	1	-	-	-	3
	Unspecified	1	-	2	-	-	-	3
Anuria		-	1	-	-	-	-	1
Lameness		-	1	2	-	-	-	3
Heart murmur		-	-	1	-	1	-	2
Dermatitis		-	-	2	1	-	-	3
Sudden death		11	-	5	4	-	1	21

* Respiratory. **Neurological.

Ante mortem diagnoses and recorded treatment

In 22% of cases, 23 alpacas and one camel, had some kind of ante mortem diagnosis been documented. In the majority of cases the diagnosis was limited to an organ system and was based on the symptoms and clinical evaluation without further diagnostic investigation.

Examples of diagnoses found in the referrals are colic, dermatitis, pneumonia, malformation, fracture, lameness and nerve damage.

Of the 93 alpacas, 33 had received treatment for their illness before death. More than half (20/33) died of natural causes despite being under treatment. The most common treatment among alpacas were antibiotics (17) followed by B vitamins (13), non-steroidal anti-inflammatory drugs (9), selenium (3), glucose (3), cortisone (2), analgesics (2), A and D vitamins (2), coccidiostats (2) and deworming drugs (2). Furthermore, four alpacas received iv-infusion of saline solution or Ringer's acetate solution. In three cases the treatment was not specified. The administered antibiotics included penicillin, streptomycin, engemycin (oxytetracycline), clindamycin, sulphadoxine and trimethoprim,

Nine camels received treatment, four of these died of natural causes despite being under treatment. The treatment was specified in six cases. The drugs and treatments used were antibiotics (4), selenium (2), cortisone (2), B vitamin (1), A and D vitamins (1), deworming drugs (1).

Cause of death and diseases in general

A majority of the alpacas, 62% (prenatal deaths not included), died of natural causes. Among the camels the corresponding number was 50%. The most common cause of death in animals that had died of natural causes was circulatory failure followed by septicaemia, emaciation and fatty degeneration of parenchyma (e.g. fatty liver). A large portion of these cases had acute disease (54%) but many of these were later identified as suffering from chronic disease that had become acute. The majority of these animals therefore only showed signs of disease for a day or a few days before they died.

Distribution between classifications of the main pathology diagnosis

The most common classification of the main pathology diagnosis in all camelids as well as in all alpacas was digestive followed by circulatory (Table 3). The most common classification among camels was systemic followed by circulatory and digestive. A large portion of alpaca cases were classified as unknown. The majority of these cases were abortions.

Table 3. Classification of main pathology diagnosis for alpacas, camels and camelids in total.

	Alpacas		Camels		Total	
	Frequency	%	Frequency	%	Frequency	%
Circulatory	10	10.8	3	21.4	13	12.1
Digestive	27	29.0	3	21.4	30	28.0
Emaciation	4	4.3	-	-	4	3.7
Genitalia	3	3.2	-	-	3	2.8
Haematology/Lymphatic	5	5.4	-	-	5	4.7
Locomotor	3	3.2	-	-	3	2.8
Malformations	2	2.2	-	-	2	1.9
Neurological	4	4.3	-	-	4	3.7
Predator kills	6	6.5	-	-	6	5.6
Respiratory	5	5.4	1	7.1	6	5.6
Skin	4	4.3	-	-	4	3.7
Systemic	6	6.5	5	35.7	11	10.3
Unknown	11*	11.8	-	-	11	10.3
Urologic	3	3.2	-	-	3	2.8

* All but two in this category were abortions.

Distribution between infectious and medical conditions in different age groups

Infectious diseases were the major cause of disease and death among alpacas and camels up to four months of age while medical problems dominated among the weaning animals (Figure 3). For adult alpacas and camels (over one year of age) the distribution between infectious and medical issues was relatively even.

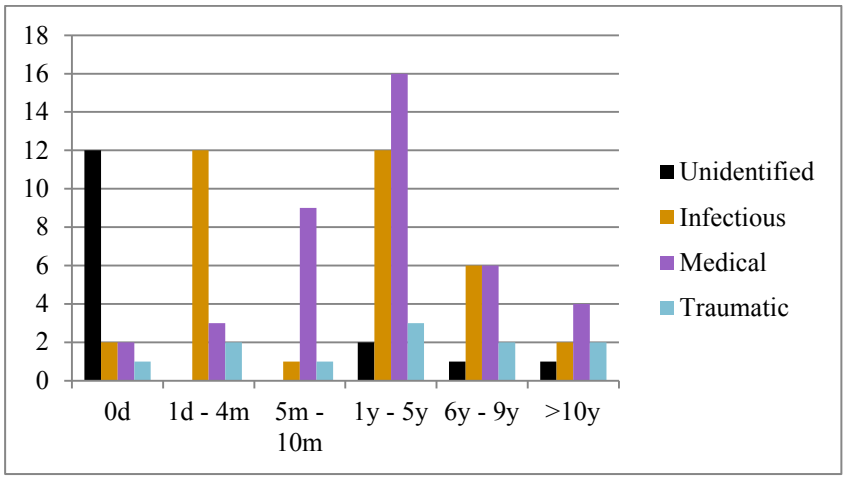

Figure 3. Distribution unknown/infectiou/medical/traumatic causes of disease in alpacas and camels.

Important contagious diseases

Tests for important contagious diseases (tuberculosis, paratuberculosis, brucellosis, bluetongue, pseudotuberculosis) were conducted in several animals (Table 4). All tests were

negative. Many of these tests were carried out as a part of a surveillance program but several animals were tested for tuberculosis and paratuberculosis as a result of suspicious clinical signs or necropsy findings. For more test regarding infectious agents causing abortions, see Reproductive disorders.

Table 4. Number of animals tested for important contagious agents post mortem and the cause for conducted tests. Number of animals tested (positive tests/negative tests).

	Suspected disease	Surveillance	Abortion	Other
Mycobacterium bovis (tuberculosis)	1 (0/1)	0	0	1 (0/1)*
M. avium subsp. *paratuberculosis*	0	7 (0/7)	0	0
Mycobacterium spp.**	5 (0/5)	0	0	0
Brucella spp.	0	1 (0/1)	7 (0/7)	0
Bluetongue virus	1 (0/1)	0	0	0

* reported positive offspring after export

** not specified in necropsy report

Diseases of specific organ systems

Diseases of the digestive organs

Gastrointestinal disease was the most common case among all investigated necropsy reports (Table 3). It was also the most common case among alpacas, the second most common in camels in general but the most common case in adult camels. Most cases were chronic (23/30) but the majority of these cases (9/21) showed no signs of imminent fatal disease until their chronic conditions suddenly became acute shortly before death. All acute cases died of natural causes. The majority of the chronic cases also died of natural causes (13/23). The most common diagnosis was enteritis (13/29) followed by hepatic lipidosis (9/29). Other diagnoses were gastric ulcers, hepatitis and mechanical gastrointestinal emergencies.

Enteritis

All enteritis cases but one were found among the alpacas. One of four enteritis cases in neonates was parasitic, the remaining three were bacterial. In two cases the causative agent was *E. coli.* One case was caused by coccidia but the situation was further complicated by *E. coli* infection. One was unspecified. The majority of enteritis cases among adults (alpacas and camels over one year) could be linked to parasitic infestation (7/9). This was mainly determined by the histological image with many eosinophils in the affected intestinal tissue of these cases. In two of these seven cases a faecal sample was taken that could support the histological image. One case was not determined as either parasitic or bacterial due to severe cadaverous decay. The remaining case was due to an unspecified bacterial infection.

Intestinal parasites

Intestinal parasitism were identified or strongly suspected in 17% (15/90) of all examined necropsies performed in camelids over one day of age (abortions and animals who died within their first 24 hours excluded). In the majority of these cases intestinal parasitism were identified by positive faecal samples. In others the assumption was made due to strong eosinophilic elements or a history of positive faecal samples and deworming shortly before death. Intestinal parasites as the cause of enteritis were identified or strongly suspected in 69% (9/13) of all cases with enteritis as final diagnosis. The causative parasites were identified in four of these cases. Identified parasites were *Eimeria* spp., *Trichuris* sp. and and unidentified *Trichostrongyloidea*. Eight cases of enteritis lack faecal samples. Of these eight, seven had enteritis that was commented on as parasitic or most likely parasitic.

Among the animals with identified intestinal parasites that died of other causes than intestinal disease, the identified intestinal parasites were *Eimeria* spp. (4), *Nematodirus* spp. (2), *Trichostrongyloidea* (2), *Trichuris* spp. (1), *Ostertagia* sp. (1) and *Haemonchus* sp. (1). Two of these animals had signs of diarrhoea, either reported in their history or observed as dried faeces around the anus at necropsy. Both had moderate to severe parasitic infestation but no macroscopic or microscopic signs of enteritis. *Eimeria* spp. was commonly found together with nematodes. Identified Eimeria-subspecies were *E. macusaniensis*, *E. punoensis* and *E. alpacae*.

Gastric ulcers

Four necropsy cases (all alpacas) had gastric ulcers as either the sole pathology diagnosis (1) or as one of two pathology diagnoses (3). However, the gastric ulcers were the ultimate cause of symptoms and pathology leading to death in all four cases. Gastric ulcers were seen in both young and old animals (6 months – 13 years) and were often severe when observed. Two cases had large deep perforating ulcers causing peritonitis and disseminated infection. The perforating ulcers were located in the third compartment of the stomach in one case and in the first compartment at the transition to the oesophagus in one case. The two remaining cases had either large or deep ulcers in C1. None were perforating but one case had caused severe abscessation in the gastric mucosa. These ulcers had caused months of wasting, colic and behavioural changes. One case of perforating gastric ulcers was seen in the context of uraemia caused by chronic interstitial nephritis. This individual also had ulcerative stomatitis and esophagitis.

Mechanical gastrointestinal emergencies

Three cases of acute mechanical gastrointestinal emergencies were seen in alpacas; two as small intestinal strangulations and one as intussusception. All had died of natural causes. One strangulating intestine was the result of half a meter of small intestine being trapped within a hole in the omentum of a pregnant female. For the other case of intestinal strangulation the cause could not be determined and no further comments were available. This individual, a six month old female of poor body condition, had been treated several times for lameness and bad general condition. The intussuscepted intestine occurred in a nine-month old alpaca female which had been suffering from a short period of colic and inappetence. No cause for the intussusception, such as inflammation or foreign body, could be found. One case of enteritis

was linked to a chronic partially obstructing stricture thought to be causing decreased motion of ingesta through the intestine. This individual was imported from Chile and had been suffering from relapsing colic. The alpaca was euthanased during a colic attack likely caused by an obstipation at the stricture site.

Hepatitis

Only one necropsy case, a female alpaca, had hepatitis as the sole pathology diagnosis. Necropsy revealed suppurative granulomatous hepatitis with findings of liver fluke (*Dicrocoelium dendriticum*). However, in eight other cases, seven alpacas and one camel, hepatitis was seen as an incidental finding. In these cases the hepatitis was classified as granulomatous and parasitic in three cases and lymphocytic in three cases. All but one of the cases was of chronic character. Furthermore, reactive hepatitis was a common finding in cases of septicaemia.

Hepatic lipidosis

In eight cases (seven alpacas and one camel), hepatic lipidosis was the sole pathology diagnosis. Furthermore, in two cases of enteritis in alpacas hepatic lipidosis was the second pathology diagnosis after enteritis. Hepatic lipidosis was histologically confirmed in 9% of all camelid necropsies examined. The age range of this group was widespread with individuals from new-born to nine years old with 50% being under the age of twelve months. Two cases were females in late pregnancy. The most common symptoms seen in these individuals were wasting (4) and inappetence (3). Other signs were icterus (1), ascites (1) and general weakness (1).

Liver fluke infestation

Signs of liver fluke infestation were observed in 15 cases. *Dicrocoelium dendriticum* was identified in two cases and *Fasciola hepatica* in one case. For the remaining cases the infestation was diagnosed according to findings such as typical multiple calcifications, bile duct proliferation and fibrosis.

Cardiovascular disease

Ten cases of alpaca deaths and three cases of camel deaths were caused by diseases or incidents related to the cardiovascular system. Cardiac disease including myocarditis, endocarditis, cardiomyopathy, myocardial degeneration and congenital heart malformation was diagnosed in for 54% of cases, the rest died from acute circulatory failure without cardiac disease being present. The majority of the cases with cardiac disease was chronic conditions and most died of natural causes. The individuals in this group were between two weeks and nine years old at the time of death. Both females and males were represented. Symptoms documented in the history of these cases were sudden death, wasting, respiratory distress, inappetence, coughing, staggering, hind limb paresis, severe heart murmur and blindness. Three cases had a history of treatment but in none of the cases was cardiac disease mentioned as a differential diagnosis. The majority (7/13) were medical conditions, followed by infectious diseases (4), trauma (1) and unknown (1). The body condition of these animals was

relatively poor; only two individuals were documented as in good condition, four were under ideal weight. The body condition of the remaining individuals had not been recorded.

Myocarditis/endocarditis

This was the most common cause of disease among the cardiology cases (4/8), with myocarditis being the more frequent of the two (3/4). These animals were young; the oldest being two years old at the time of death. Wasting and inappetence were recurring symptoms. Two alpacas had chronic myocarditis of unknown cause, but with a mononuclear cellular infiltrate in the myocardium indicative of a viral agent. One was euthanased and the other died of acute circulatory failure. The euthanased male's heart was dilated with a discoloured endocardium and with a large coagulum filling the left atrium. The thorax contained one litre of fibrinous yellow fluid.

The other two cases were more likely caused by bacterial infections; one fibrinous suppurative endocarditis of the right ventricle with almost the entire ventricle being filled with fibrinous inflammatory material and a suppurative myocarditis localised to the apex of the heart causing hydropericardium and hydrothorax. In both cases *E. coli* was reported in lung samples but the exact cause of the myocarditis was never established. These two cases were more acute; one was found dead and the other died after a short period of inappetence and bad general condition post-partum.

Cardiomyopathy

One case of dilated cardiomyopathy with secondary left-sided heart failure was diagnosed in a nine-year-old female which died after exhibiting progressively worsening respiratory distress for a month. She had not been examined by a veterinarian or received any treatment other than deworming. She was below ideal weight with a rounded heart and signs of left sided heart failure in the lungs. Further investigation showed all four chambers of the heart to be dilated In addition; one case of uremic cardiomyopathy was among the necropsy cases classified as urologic disease. This was an 11-year-old alpaca with severe uremia due to chronic interstitial nephritis. The heart was pale and patchy with bilateral ventricle dilation.

Myocardial degeneration

A two week-old male cria died due to myocardial degeneration after one day of staggering and respiratory distress. Myocardial degeneration was identified at necropsy but there were no signs of infection or inflammation and the pathologist proposed selenium/vitamin E deficiency as a cause, although no measurement of selenium was made.

Malformated heart

A four-year-old female was euthanased because of hind limb paresis and a loud heart murmur. She had been diagnosed with a heart murmur at a young age but had had no history of clinical illness before the paresis and she was in good body condition at the time of death. Necropsy showed a malformed heart with an atrial septal defect, a diminished right ventricle and dilated left ventricle. A coagulum was also found in the aortic bifurcation in the pelvic region, possibly indicating a thrombosis causing the hind limb paresis. The female had chronic stasis in liver and lungs as well as dystrophic muscle degeneration.

Multiple bleeding disorders

A 1-year-old alpaca male died two days after being in a fight with another male. He was under treatment for lameness and initially improved but worsened the following day with recumbency and dyspnoea. Despite treatment (B vitamin, selenium and penicillin) the alpaca died and at necropsy multiple haemorrhages were found in the musculature, in all joints and in several internal organs (lung, liver, pancreas, stomach, intestine, heart and kidneys). The haemorrhages varied from petechial to larger confluent areas. Bacterial culture from samples of lung, intestine and spleen only revealed mild to moderate growth of *E. coli* in mixed culture and test for Bluetongue virus were negative. The cause for the massive bleeding was not identified but the pathologist discussed several possible causes such as idiopathic, toxic (bacterial toxins or toxins from toxic plants etc.), coagulation defects/thrombocytopenia or viper bite.

Acute circulatory failure due to stress or trauma

Five cases of death due to acute circulatory failure from stress or trauma were identified. Three were neonatal camels; two died in connection to their birth and one died due to a liver rupture after being badly bitten by an older camel. One of the neonates who died at birth had signs of chronic circulatory failure (e.g. chronic liver stasis). The pathologist suspected that the circulatory failure had begun in utero. The remaining two cases were adult alpacas. One died during handling due to acute myocardial damage leading to circulatory failure, most likely caused by stress. The other female was found dead without prior symptoms. Necropsy revealed acute circulatory failure without signs of inflammation or infection in the heart. Toxicity or stress could not be excluded and the actual cause for the circulatory failure in this alpaca could not be identified.

Sarcocystis sp. in myocard

Sarcocystis sp. was found in the myocard of nine camelids. All but one had been submitted for necropsy at Eurofins facility in Kristianstad. All were classified as incidental findings and were not related to the disease or the death of these animals.

Neurologic diseases

Thirteen cases had a history of neurological signs before death (Table 2). However, there were only five cases of disease involving the nervous system. Four of these five were classified as neurological; the remaining case was classified as systemic. Two of the four cases classified as neurological were acute, one was chronic and one was a congenital defect. The symptoms observed were staggering, shaking, blindness and progressively worsening general condition.

Encephalitis

Two cases of non-suppurative encephalitis were found among the alpacas; one nine-year-old male and one two-year-old female, both of which died of natural causes. The male had a very acute disease progression; according to the history he suddenly started shaking, had difficulties standing up and died within 45 minutes. The female on the other hand had a more chronic condition with progressively worsening general condition, culminating in apparent

blindness in the last few days. Both individuals had perivascular infiltrations of mononuclear cells in both grey and white matter. In the female the meninges were also involved. Samples from the male were tested for equine herpes virus but tests were negative. The female had ample amounts of so-called Splendore-Hoeppli phenomenon: deposition of amorphous, eosinophilic, hyaline material around pathogenic organisms. These changes led the pathologist to suspect an immune-related process with a previous infection (parasite, fungi or bacteria) as the trigger. The actual aetiology could not be established in either case.

Polioencephalomalacia

One case of polioencephalomalacia was identified in a young adult female alpaca of about two years of age. The exact symptoms were not mentioned in the referral but the veterinarian suspected listeriosis or polioencephalomalacia. The female, who was in good body condition at the time, was treated with antibiotics (penicillin) and B vitamins but eventually died despite treatment. At necropsy the body showed signs of acute circulatory failure but the main finding was in the brain tissue which revealed a cerebrocortical necrosis typical for polioencephalomalcia seen with thiamine deficiency in ruminants.

Nerve damage

One case of suspected nerve damage was seen in a nine-year-old female camel. After a supposed accident in the pasture she had been paralyzed and recumbent for one month. The necropsy did not reveal any cause for her paralysis and nerve damage was suspected as the most probable cause.

Brain abscesses and suppurative processes in the brain seen in systemic infections

In four cases of systemic infections in neonatal animal, both alpacas and camels, the brain was the site for a suppurative process mainly localised to the brain ventricles. In two cases the pus/abscess had caused pressure atrophy of the brain tissue and thereby the observed neurological symptoms. One of these two cases involved a secondary hydrocephalus interna due to the abscess obstructing the outflow of fluids from the ventricles, further increasing the pressure inside the brain.

Respiratory disease

Pneumonia

Four deaths in three alpacas and one Bactrian camel, aged between three and eleven years, were caused by pneumonia. In two cases the main signs of disease were prolonged wasting together with respiratory symptoms such as coughing, abdominal breathing and harsh breathing sounds. The two remaining animals fell acutely ill; one had respiratory distress and progressive neurological sign during the last twenty-four hours before death, the other one was found dead in the pasture. Two were in good body condition, the other two were moderately to severely under weight. The pneumonias were identified as ascending pleuropneumonia (2), suppurative/necrotizing bronchopneumonia (1) and interstitial pneumonia (1). *Corynebacterium pseudotuberculosis* was identified as the causative agent in one case of ascending pleuropneumonia. *E. coli* was grown from lung tissue in the case of bronchopneumonia but it was uncertain if this was contamination or the causative agent. In

the case of the interstitial pneumonia an airborne agent were proposed due to the localisation to the cranial parts of the lungs.

Skin conditions

Chronic dermatitis

Four alpacas had dermatitis as the sole pathology diagnosis. These individuals were between two and six years of age and the female:male ratio was 1:1. They all had a history of dermatological issues for at least six months before they were euthanased. Two were in good body condition and two were under weight. The latter two also had a history of wasting. In one case the symptoms appeared after the animal had been kept in isolation. All four cases were classified as chronic dermatitis but with some individual specifications; idiopathic hyperkeratotic dermatitis (1), hyperplastic eosinophilic dermatitis with intradermal pustules (1), deep pyoderma (1), active ulcerating eosinophilic dermatitis (1) and lymphoplasmic dermatitis (1).

The dermatitis was localised to the dorsal aspect of the body in one case (head, neck, back, pelvic region and hind limbs), to the dorsal aspect of the hoofs/in between the hooves and at the corner of the mouth in one case, to the less-furred parts in one case and spread over the entire body in the last case. No specific parasite, bacteria or fungi could be identified in any of these four cases. In one case bacteria were seen in several layers of the skin and yeasts were observed in another but neither of these cases was investigated further.

A further two cases, one older female alpaca and one older male camel, had dermatitis as one of several pathology diagnoses. They were both euthanased after a period of wasting and inappetence and were diagnosed with pleuropneumonia and liver cirrhosis, respectively. Both were under weight and had contracted dermatitis during their periods of wasting. The camel had a mycotic pustular dermatitis on the inside of the thighs with the main histological find being a chronic suppurative inflammation with parakeratosis. The fungus could not be identified. The alpaca had a chronic dermatitis with hyperkeratosis localised to the ears.

Ectoparasites

Two individuals which died of traumatic injuries had mild to moderate mange infestation (*Chorioptes* sp.) localised to the legs. No other cases of mange were documented.

Urological diseases

Four cases of urological diseases were identified. All were alpacas; one young male and three older females. All four had been euthanased. For three of the four cases, disease of the urinary tract was the main pathology diagnosis and the main cause of death. From the symptoms observed, only one alpaca was suspected to be suffering from urological disease.

Urolithiasis

The young male had anuria and showed signs of painful urinary obstruction over a 24 hour period before he was euthanased. He was found to be suffering from a 3 millimetre urolith

causing complete obstruction of the ureter. The urolith was analysed and found to be a calcium carbonate stone. The obstruction was severe and had caused dilation of the pelvis of the right kidney. Necropsy also revealed more chronic disease processes in the urinary tract; a chronic cystitis and chronic interstitial nephritis.

Nephritis

All four urological cases were found to have chronic interstitial nephritis. For the young male and for one of the females, the changes observed were of longer duration and were not responsible for the acute disease causing the death of the alpaca. However, two of the females had chronic active interstitial nephritis that eventually caused their symptoms and death. One had severe uraemia. She had been inappetent for three weeks before she was euthanased. Necropsy revealed several severe disease processes in the body including ulcerative esophagitis, ulcerative stomatitis and a perforating gastric ulcer with subsequent suppurative peritonitis and hepatitis. The chronic inflammation of the kidneys was tentatively suggested as the cause for the changes observed in the body. The other female had suffered from long-term but unspecified issues and was diagnosed antemortem with heart failure due to a heart murmur and oedema. Necropsy revealed chronic active interstitial nephritis, dilated ventricles of the heart, calcifications in the lungs and chronic lung and liver stasis. There were no signs of inflammation or degeneration of the myocardium. The observed changes were proposed as secondary processes caused by end-stage kidney disease and uraemia.

Reproductive disorders

This group includes two cases among adults classified as disorders of the genitalia, and several cases of abortions and death in conjunction with birth of varying classification. Counting death in conjunction with birth, reproductive disorders comprised 16% of all cases.

Abortions

Almost 10% (10/93) of alpaca necropsy cases were aborted foetuses and all aborted foetuses were alpacas. The majority were full term or close to full term pregnancies. The foetal membranes and/or placenta were submitted together with the foetus in all but one case. The cause of abortion was identified in only one of the cases and was found to be the result of a necrotizing placentitis only visible histologically. All the other foetuses were without any signs of trauma, infection, inflammation or malformations. One aborted foetus could be linked to the pseudotuberculosis infection of the mother since she was in bad health and also had abscesses in the gravid uterine horn.

The foetuses were tested for several infectious agents: Schmallenberg virus (3), Brucella sp. (6), Toxoplasma gondii (2), Listeria sp. (1), Sarcocystis sp. (1), Neospora sp. (1), Coxiella burnetti (3) and equine herpes virus (1). All these tests were negative. Samples were taken from two of the foetuses for general bacterial culture but no pathogenic bacteria could be identified in either of these two cases.

Death in conjunction with birth

Three crias and two baby camels were considered to be stillborn but all showed signs to a varying degree of being alive at birth. Four had partially air-filled lungs and the remaining cria had milk residues in its gut. The final diagnoses of these cases were categorized as circulatory, malformation, respiratory and unknown. The two baby camels died due to circulatory failure, one cria most likely suffocated because of foetal membranes over the nose and mouth, and one had a severe hydrocephalus interna with the cerebellum displaced further back than normal.

An infectious cause for the hydrocephalus was suspected. The main suspect was Schmallenberg virus and even though the test was negative Schmallenberg virus was not completely excluded. However, spontaneous hydrocephalus was also considered. The cria with milk residues in the gut also had a fatty liver that could indicate presence of bacterial toxins or severe hypoxia. As *Streptococcus* sp. was cultured from several organ samples, an intrauterine infection was thought to be a cause of the crias death.

Uterine torsion

A five-year-old female alpaca in late pregnancy was treated with oil orally for a presumed constipation due to signs of acute colic but died later the same night. Necropsy revealed the presence of a large foetus, uterine torsion as well as 360 degrees torsion of stomach compartment three. The pyloric region was necrotic, the heart was flabby and dilated and the lungs showed atelectasis with pressure marks from the ribs. Signs of severe stasis were evident in the front part of the body. She was in good body condition at the time of death but the liver was pale, indicating lipidosis. There is no information on any histological examination of the internal organs and the case therefore lacks any further clues to the reason behind the torsion or the existence of the presumed hepatic lipidosis. There is no record in the referral of transrectal examination or any further diagnostic procedures.

Necrotizing mastitis and endometritis

An adult female alpaca fell ill after a dystocia and retained foetal membranes. She had been treated with penicillin for almost a week when she suddenly started having seizures and died shortly thereafter. The referring veterinarian suspected listeriosis, botulism, tetanus or meningitis. Necropsy revealed an acute suppurative endometritis and an acute necrotizing mastitis with high frequency of cocci-shaped bacteria. There were no signs of disease in the central nervous system. The cause of death was reported to be septicaemia. Bacterial culture in samples from the udder did not reveal a specific pathogen.

Specific disease processes and trauma

Neoplasia

Seven cases of neoplasia were identified among the necropsy cases: four cases of malignant lymphoma in alpacas, one case of cholangiocarcinoma in an alpaca, one case of disseminated sarcoma in a camel and one case of myeloid leukemia/preleukemia in an alpaca. Neoplasia compriced 6.5% of all necropsy cases. The age span of affected alpacas was wide, ranging

from 18 months to 14 years with an average age of 5.5 years. However, the majority (3/5) were young adults under the age of three years. The age of the camel with disseminated sarcoma was not specified but in the files she was referred to as an adult. Two cases of malignant lymphoma were from the same farm and both were euthanased within a period of four months.

Malignant lymphoma

Body condition among the individuals with malignant lymphoma was poor: two were classified as emaciated, one as close to emaciated state and the last one as underweight. All the cases of lymphoma had wasting in their reported history but otherwise their anamneses were varied with for example anaemia, paresis, dyspnoea, salivation, swelling of the mandible and swollen lymph nodes positive for *C. pseudotuberculosis*. In only one case had the veterinarian suspected lymphoma.

Only one case of malignant lymphoma had palpably enlarged lymph nodes. Three of four cases had severely enlarged lymph nodes and masses of lymphoid tissue internally, both in the abdomen and in the thorax. This lymphoid tissue was granular in one case and transected by white areas in another case. In one case the kidneys were transected with small white formations. The final case was different from the others in the sense that the only macroscopical findings were a swollen liver and spleen. However, microscopically they were all alike; organised lymphoid tissue was substituted for immature unorganised neoplastic lymphoid tissue with infiltrative growth and without signs of follicular structures. In the case of malignant lymphoma among the organ samples, the neoplastic cells had even reached the hair follicles.

Cholangiocarcinoma

The cholangiocarcinoma was found in a fourteen year old female alpaca that had been ill and weak for almost a week. Her condition had progressively worsened with inappetence and cessation of rumination. She was treated for supposed stomach pain but after being recumbent for twenty four hours without rumination or appetite the decision was made to euthanase her. During necropsy a severe ascites was found composed of 12 litres of clear bright yellow fluid and the liver was transected with granolomatous patches of varying sizes. Metastases were found in the lungs and in the regional lymph nodes. A severe infestation of liver flukes in this case led the pathologist to propose a link between the infection and the tumour, but this was never confirmed.

Disseminated sarcoma

The disseminated sarcoma was found in a female adult camel in good body condition that had been treated for a deep wound above the right tarsus when she suddenly became ill and died. Apart from the wound the necropsy revealed multiple abscesses in the lungs. A few abscesses were large measuring approximately five centimeters in diameter. One of these abscesses was adhering to the thoracic wall and another one to the pericardial sac. In the abdominal cavity the liver was transected by small white hard foci and there were signs of acute infarcts in the kidneys. Histologically the lung tissue had widespread areas of massive accumulation of neoplastic cells and similar cells were found in the samples from the wound. The tumour was classified as a disseminated sarcoma. The hard white foci in the liver were histologically

confirmed as bone growth but any connection between the changes seen in the liver to the sarcoma seen in lungs and skin were not commented on in the final report.

Nutritional diseases

Wasting and emaciation

In 29% (28/97) of all necropsy cases (excluding aborted foetuses), wasting was the major symptom and 16% (16/97) of all animals were classified as emaciated. Among the animals with wasting as the major symptom the corresponding figure was 42%. Seven cases had emaciation as final pathological diagnosis. The emaciated animals originated from nine different farms. One animal came from a zoo, the rest were from private owners. Two cases of long-term wasting yearling alpacas, from two different owners, lacked information regarding body condition in their final reports. In one case however, the pathologist refers to the animal as having signs of starvation. A further twenty-four alpacas and six camels were classified as under weight and of these thirty individuals, six were described as being close to emaciation.

The emaciated animals consisted of six males and eight females. Two individuals were not identified according to their sex. These were also the only crias among the emaciated cases. The remaining alpacas were five to six months old (5), two years (2), four years (2), seven years (1), ten years (1) and adults without specified age (3). Among the pathology diagnoses recorded in these cases were emaciation (7), enteritis (5), malignant lymphoma (2), ascending gastric ulcer (1), chronic myocarditis (1), multiple internal abscesses (1), mandibular osteomyelitis (1), acute muscle degeneration (1), hepatic lipidosis (1) and cholangiohepatitis (1). In two six-month-old alpacas emaciation was the only diagnosis; there were no signs of infection or inflammation to explain the emaciation.

In five of the emaciated alpacas parasites were found in the intestines. In three cases these parasites were believed to be the direct cause of emaciation and subsequent death or euthanasia. Identified parasites in these cases were *Eimeria* spp. (*E. punoensis* och *E. alpacae*), *Ostertagia ostertagi*, *Camelostrongylus mentulatus, Trichuris* spp. and *Nematodirus* sp. Also one individual had eggs of an unspecified intestinal worm and in two cases the causative parasite could not be identified, probably due to deworming two weeks before death.

Specific nutritional deficiencies

Three cases of diseases caused by or suspected to be caused by specific deficiencies were identified; one case of cerebrocortical necrosis (CCN) or polioencephalomalacia supposedly caused by thiamine deficiency in an adult female alpaca, one case of acute muscle degeneration in a six-month-old alpaca and one case of myocardial degeneration in a 14-day-old cria, both suspected to be caused by selenium/vitamin E deficiency.

Systemic infections

Eleven cases were classified as being systemic infections; six alpacas and five camels. The majority of these cases (7/11) were neonatal animals. Seven died of natural causes and four

were euthanased. Eight were females, one male and two neonatal camels were not classified. Three alpacas and four camels in this group died due to septicaemia or most likely due to septicaemia. A further four individuals, two female and two male alpacas, died as a result of septicaemia but their major disease process was classified as digestive (2), respiratory (1) and reproductive (1). Septicaemia was concluded on the basis of findings such as acute petechial bleeding in several internal organs, reactive hepatitis and reactive splenitis with lymphatic atrophy.

The causative agent was found to be *E. coli* in four cases, *C. pseudotuberculosis* in two cases and *L. monocytogenes* in one case. Four cases only had mixed culture without any specific pathogen identified, in two cases this was thought to be due to treatment with antibiotics. In one case of polyarthritis in a neonatal camel coliform bacteria were cultured but the exact bacteria was not specified. In the remaining three cases no information regarding any bacteriological examination was documented.

Corynebacterium pseudotuberculosis and other cases of multiple internal abscesses

Three alpacas from an outbreak of pseudotuberculosis were examined in 2003; one four-year-old male, one seven-year-old female and her aborted foetus. The foetus had no signs of abscesses or infection but both the male and the female had multiple internal abscesses that were later confirmed to be caused by *C. pseudotuberculosis*. The male had abscesses localised to the lungs causing an ascending pneumonia while the female had abscesses in the uterus and the liver. Three days before these bodies were examined, an adult female from the same herd was sent in for necropsy. She was imported from Germany in early 2003 and was in bad condition on arrival. During quarantine she gave birth to a cria and was treated for vaginal prolapse. Later she was also treated for lameness with an abscess on one of her front legs. After the abscess was drained, she had become inappetent and despite treatment died a few weeks later. Necropsy revealed several internal abscesses but no specific pathogen was identified.

Trauma

Predator attack

Six individuals from the same herd; five females and one male aged between nine months and ten years, were killed in a predator attack in April 2013. All individuals had severe traumatic injuries and were found dead or dying in the pasture.

Suffocation

Two alpacas died from suffocation; one new-born cria and one seven-year-old female. The new-born cria suffocated due to foetal membranes covering the airways and was found dead in the pasture. The older female suffocated due to an acute and severe swelling of the pharynx. The reason for the acute swelling was not concluded but an insect bite or an allergic reaction was suspected.

Traumatic injuries in neonatal animals

One baby camel was found dead with injuries to the side of the body. Severe bleeding was found both internally and externally and the main cause of death was a ruptured liver. The pathologist suspected that the injuries were caused by an older camel, perhaps the mother itself. One male cria, three weeks old, died as a consequence of an infected rib fracture. The infection had caused an abscess around the fracture that pressed against the lungs. The infection as well as the pressure to the lungs had led to inappetence or possibly the inability to feed, evidenced by absence of milk or ingesta in the gastrointestinal canal. The infection and the anorexia had eventually caused the young cria's death.

Fractures of long bones and muscular rupture

One three-year-old male alpaca was euthanased because of a traumatic fracture to the right front leg. The fracture was a complete spiral fracture involving both radius and ulna about five centimeters from the elbow joint. The cause of the fracture was unknown, there was no evidence of infection or inflammation making the bone fragile, but all four hooves were overgrown. A seven-year-old female alpaca was euthanased after falling in the pasture. She was found lying in the field with severe blood loss and extensive muscle damage to the pelvic area. Necropsy showed bilateral total rupture of the gracilis muscle. Signs of chronic inflammation and initiated repair of the muscles in the pelvic area indicated similar but less severe previous accidents.

DISCUSSION

Both the camelid population, especially alpacas, and the amount of camelid necropsies have increased during the last decade. The camelid section established within the SvDHV in 2009 has certainly been a major factor contributing to the increasing number of camelid necropsies by offering free necropsies to its members. This can be seen as both increasing numbers of camelid necropsies after 2009 and an increase in the number of camelid owners handing in their dead for necropsies. Most of the camelids in this study were alpacas which correspond to the population of camelids in Sweden. No llamas were among the necropsy cases. The reason for this is unknown but a smaller population is one factor. For a large portion of the animals the owner or herd could be identified: the animals came from the north and south of Sweden as well as from both large and small herds.

Swedish camelids in comparison to previous studies in other countries

The findings in this study correspond relatively well to the necropsy findings in camelids previously reported from Canada, the UK and Germany (Shapiro et al., 2005; Defra 2009; Jones, 2003; Gunsser et al., 2006). Abortions were commonly classified as without known cause, systemic bacterial infections and malformations were common causes of death in crias during their first week of life, and digestive tract disease were the most common diagnosis in camelids over one year of age. Fatty degeneration of the liver was a recurring find in severely ill, inappetent or wasting camelids and circulatory failure was common as the cause of death. Emaciation as the cause of death was seen in 9% of camelid deaths in a report from Germany

but was not reported from Canada or the UK. Interestingly, emaciation was one among the most common diseases or clinical signs reported by camelid owners in the UK in a survey conducted 2000-2001 (D'Alterio et al., 2006). In this study emaciation as the cause of death was seen in 16% of all cases and in as many as 45% of the weaning alpacas making this a major priority for the future healthcare of Swedish camelids.

Comparison between the alpacas and the camels

No striking differences in diseases were seen between alpacas and camels. Systemic infections were the most common cause of death in neonatal animals and digestive tract disease (eg. enteritis, liver disease and gastric ulceration) was the most common case in adults among both alpacas and camels. However, alpacas displayed a greater variety in age-groups and disease processes. This could simply be a result of the much larger group of animals examined. The number of camel necropsies examined was too small for this to be further investigated.

The cause of death

Distribution between infectious and medical conditions

Considering all camelids in the study, infectious diseases were the dominant factor causing death in neonatal animals whereas medical conditions dominated among weaning animals. From one year of age the diseases caused by infectious agents or by medical processes were evenly distributed.

Apart from the large portion of gastrointestinal diseases caused by bacteria or parasites, camelids in Sweden suffer from common infectious diseases seen in other farm animals such as pneumonia, myo-/endocarditis and encephalitis. The causative agent was only identified in a fraction of cases and it is therefore difficult to assess similarities or differences between causative agents in camelids and other Swedish farm animals.

Tests for important contagious diseases (tuberculosis, paratuberculosis, brucellosis, and bluetongue) were conducted in a handful animals due to suspected disease or as part of surveillance programs (see Table 4). All of these agents are considered as risks not only to camelid health but to other production animals in Sweden. In 2007, a risk analysis regarding import of camelids from Chile as a risk for spread of disease among Swedish farm animals was conducted by SVA for these and several other important contagious diseases (Ågren et al., 2007). The risk of introduction was considered low for tuberculosis and bluetongue virus, low to intermediate for brucellosis and intermediate for paratuberculosis. The risk of spreading of the disease, once introduced to the country by imported camelids, was however considered high for tuberculosis, paratuberculosis and brucellosis. All imported camelids must be tested for tuberculosis and brucellosis when imported to Sweden (SJVFS 1996:24) but there are currently no surveillance programs running for camelids. All tested animals identified in this study were negative.

Many deaths due to natural causes

Regardless of the cause of the disease, a majority of the animals included in this study had died of natural causes. Some of these animals were under treatment at the time of death but most of them had either been wasting for a long period without treatment or had suddenly fallen acutely ill and died before treatment could be attempted. What many of these animals have in common is the presence of chronic disease. From the data collected in this study it seems to be a common situation for camelids to hide their illness up to the point where it turns acute enough to produce symptoms, at which point the animal often is beyond saving.

The stoic nature of SAC is a well-known problem for veterinarians treating camelids. This is one explanation for the large proportion of animals dying of natural causes. Owners and veterinarians unaware of the severity or the chronicity of the illness can easily regard the situation as an acute transient process that will get better given time and treatment (often antibiotics, anti-inflammatory drugs and B vitamin). Since many of the animals in this study were relatively young, with the largest group being animals between one and five years of age, euthanasia is not an easy option unless the veterinarian is certain the condition either has a bad prognosis or simply is too severe to treat from an animal welfare aspect. In very few, if any, of the cases had an attempt at diagnosis been made using, for example, blood sampling or image diagnostics. The lack of equipment for refined diagnostics in the field deprives the veterinarian of the information needed to make the right decision. In a postal survey performed in the UK in 1992-1993, a diagnosis had been made in less than half of the deceased camelids (Davis et al., 1998). In the present study the numbers was even less. The fact that the diagnoses found in the referrals were vague and based only on symptoms explains the inconsistency observed between the clinical diagnoses and the pathology diagnoses. This also displays the need for improved diagnostic procedures in the field.

The cause for abortions

Aborted foetuses represented almost 11% of all alpaca submissions. The cause for abortion could only be identified in one case. All the other foetuses and their foetal membranes were without signs of infection or inflammation according to the final report. There is great variation in the necropsy procedure for alpaca abortions in Sweden. What tests are run and how much time is put into finding the cause seem to be dependent upon the individual pathologist's experience and interest. Some pathologists treat these aborted foetuses as foals, some treat them as ruminants. A standardized procedure for camelid abortions including specific standard tests for common infectious agents known to cause abortions in camelids is needed. This is also true for the histological examination where a negative result is difficult to interpret as there is no exact documentation regarding what the pathologist have looked for in the preparations. In a previous report from the UK, an infectious cause for abortion was only found in 2 out of 60 submissions (Jones, 2003). The results in this study are therefore not different from the results in the UK but do raise the question if something other than infection has caused these abortions. Stress is one major factor contributing to abortions and SACs are known to be sensitive to stress. But hopefully, stress is not the only cause for all the late abortions. Placental villous atrophy causing placental insufficiency have been found to be more common in camelids than previously known (Schaefer, 2012). There are no comments regarding this condition in any of the abortion cases and it remains unclear whether any of the

abortions in this study was due to placental insufficiency. There were, however, some indications of this condition as one alpaca foetus had a fatty liver that had developed in utero implicating bad nutrient supply over the placenta.

Causes of death in neonatal camelids

The most common cause of death among neonatal alpacas and camels were septicaemia and nutritional deficiency. In contrast to previous reports (Sharpe et al., 2009) neonatal diarrhoea was not a common cause of death or a common part of the history among deceased neonatal camelids in this study. In a postal survey performed in the UK in 1992-1993 mortality among neonatal camelids was especially high during the first week of life (Davis et al. 1998). This was also true regarding the necropsy cases in this study where the majority of the deceased neonatal camelids had died during the first ten days of life. Almost as many neonatal camelids died during the period 1-4 months of age, mainly due to infectious diseases. This group is not mentioned in precise numbers in any of the other reports and therefore cannot be evaluated further regarding similarities between countries. However, the first six months is a sensitive period for most species and camelids in Sweden are no exception.

Failure of passive transfer (FPT) is commonly associated with sepsis and has been found to be a major determinant of mortality in crias (Garmendia et al., 1987). There were no records of any tests of total protein or immunoglobulin concentration among the cases of fading neonatal camelids in this study. However, crias with sepsis do not always present with the signs commonly observed in calves which can make diagnosis difficult (Dolente et al., 2007) and may be a cause for not suspecting sepsis and FPT. Weaver et al. (2000) showed that commercially available SST test for assessment of passive transfer of immunoglobulins can be used for camelids in a similar manner as for calves and foals. If taken into practice, this could improve field diagnostics and identify affected neonatal camelids. With a diagnosis and appropriate treatment, neonatal death due to FPT with or without septicaemia among camelids in Sweden could decrease in the future.

Gastrointestinal disease

Gastrointestinal disease is considered by several authors to be the leading cause of disease and death in camelids (Fowler, 2010; Kennel 1992; Smith, 1989). This assumption matches the findings made in this study. Acute enteritis, sometimes with subsequent septicaemia, was seen as the cause of death in several young alpacas and young adults while chronic enteritis becoming acute was more common in adult camelids. Three cases of gastrointestinal emergencies, potentially surgically correctable, were identified; one intussusception and two cases of intestinal strangulation. In 1998, Cebra et al. presented a retrospective study where surgically correctable gastrointestinal lesions, their characteristics and the outcome of surgical or medical treatment were investigated. They proposed that more cases of acute gastrointestinal diseases should be treated surgically, thus increasing survivability in this group. They suggested that the symptoms should be used as a guideline to the type of treatment to be chosen. Proximal non-strangulating lesions often presented with dehydration, abdominal distension and inappetence while gastrointestinal lesions associated with inflammation, ischemia and intestinal distension causing mesenterical stretch more often

presented as signs of abdominal pain. The clinical signs could therefore be used as an indication as to which animals to treat surgically. However, regardless of the lesions or the site of the lesions, the camelids rarely showed signs of violent colic as seen in horses with similar intestinal lesions. One should therefore not wait with surgical intervention due to mild or moderate signs of pain in these cases. Of the three cases seen in this study, one was found dead without previous symptoms, one was treated for lameness when it suddenly died due to an intestinal strangulation and one case of intussusception was treated medically for signs of colic. Only the latter could have been treated surgically and according to guidelines presented by Cebra et al. (1998), this case had the signs that should have prompted surgical intervention.

Endoparasites as the cause of clinical gastrointestinal disease

Several intestinal parasites known to cause intestinal disease in ruminants have been found to cause gastroenteritis in camelids (Defra, 2009; Jones, 2003; Rohbeck et al. 2006). Parasitic gastroenteritis is also known to be an important cause of death in camelids in the UK (Defra, 2009). In this study intestinal parasites were found in more than one out of ten alpacas handed in for necropsy but in less than half of the enteritis cases. All but one of the enteritis cases had histological signs of parasitic infection or a history of parasites in faecal samples before death but for the majority of the enteritis cases there are no records of any faecal samples being taken. The reason for not identifying the parasite behind cases of enteritis with strong eosinophilic elements or a history of wasting and positive faecal samples before death remains unclear. For a better understanding of the parasite population in camelids with enteritis further investigation is needed at necropsy.

Intestinal parasites were seen in both juvenile alpacas and adult alpacas. The intestinal parasites found in the Swedish camelid carcasses were similar to the ones found in the UK and Germany (Jones, 2003; Defra, 2009), mainly *Eimeria* spp. and common nematodes found in sheep and cattle. *Eimeria* spp. was the most commonly encountered parasite in this study and *Eimeria macusaniensis* has previously been reported to be an important gastrointestinal pathogen in camelids (Cebra et al., 2007; Fowler, 2010). *E. macusaniensis* and *E. lamae* are considered highly pathogenic (Fowler, 2010) while *E. punoensis* and *E. alpacae* are considered to be non-pathogenic or mildly pathogenic (Trout et al., 2008; Foreyt & Lagerquist, 1992). Several cases in this study with enteritis and findings of *Eimeria* spp. had co-infections with other parasites and/or bacteria. It is therefore difficult to define its connection with the observed intestinal disease. *Eimeria* spp. is also known to be difficult to detect in outbreaks of intestinal disease (Cebra et al., 2007) and it is therefore likely that some cases have passed undetected. *E. macusaniensis* and *E. lamae* can cause acute death without prior symptoms or just a few days of anorexia and diarrhoea as well as long periods of inappetence and wasting without any oocyst being identified in faecal samples until after several weeks of infection, sometimes not at all (Cebra et al., 2007; Chigerwe et al., 2007). Shedding of oocysts can also decline rapidly in acutely ill animals (Radostits, 2007). In most cases the coccidia were not specified but one case of *E. macusaniensis* and one case with *E. punoensis* and *E. alpacae* were diagnosed.

Apart from *Eimeria* spp., the most common find of intestinal parasites were common nematodes including *Trichuris* spp., *Nematodirus* spp., *Ostertagia* sp. and *Haemonchus* sp.

Camelostrongylus mentulatus was found sporadically. According to the submissions to VLA, common nematodes such as *Nematodirus* spp. were regularly recorded among alpacas and llamas in the UK (Jones, 2003; Defra, 2009). Interestingly they found disease to be associated with immature forms of parasites and remarked that a low egg count could indicate a much larger worm burden. However, all the cases of parasitic gastroenteritis in their records had been showing clinical signs as well as a high worm egg count.

Coccidia and nematodes seem to be the most important and common intestinal parasites in the Swedish alpaca population and their connection to intestinal disease should not be underestimated. However, it is important to understand the difficulties in identifying especially *Eimeria* spp. in outbreaks of intestinal disease and several follow-up tests are often needed to identify the infection. Since the intestinal parasites causing enteritis in camelids seem to be relatively similar in all studied countries, knowledge regarding treatment and preventive strategies can therefore be gained by studying other countries with similar husbandry methods.

Nutritional issues

Emaciation

More than 40% of the animals with wasting as their major symptom was considered emaciated at necropsy. These animals showed clear signs of disease and should have been treated by a veterinarian before reaching an emaciated state. Many of these animals belonged to the most interesting group identified in this study: the weaning alpacas that died from starvation despite being fed during late winter and early spring. Almost 80% of the animals in this age-group had wasting as the main symptom and half of the individuals died due to starvation. The hepatic lipidosis and liver damage observed in some of the cases was probably secondary to the emaciation but primary liver disease cannot be completely excluded.

An immunodeficiency syndrome characterized by wasting and recurrent opportunistic infections has been described for juvenile llamas but a similar syndrome has not been identified in juvenile alpacas (Hutchison et al., 1992). The lack of recurrent infections in the history of the wasting alpacas in this age group also contradicts immunodeficiency as the cause for the wasting. Protein-energy malnutrition syndrome (PEM) has been studied in ruminants and been implicated as a problem in SACs by Carmalt (2000). However, Carmalt implied that PEM is an even bigger problem among SACs because of the common belief that SACs can survive on worse quality forage than ruminants such as cattle. This might be true but becomes a problem if it is over-estimated. Furthermore, Carmalt discusses the problem with the cold climate of the north as a contributing factor to PEM in North American SACs. This corresponds well with the emaciated weaning alpacas seen in this study. The weaning alpacas which died from starvation all died during late winter or early spring. The emaciation had thus begun during a period of the year when temperatures often falls several degrees below zero for many months in a row. Weaning alpacas need extra energy to provide for their growth but during the winter they also need extra energy on top of this to provide body heat. Wasting is inevitable if both of these needs are not properly filled. Further complicating the situation is the weaning itself. It is a stressful situation for any animal and this period can

leave the animal with negative energy balance. For alpacas in Sweden, the weaning-period coincides with the cold winter months giving them a bad start at the beginning of a trying time. The only ways to establish the diagnosis of PEM are exclusion and through forage analysis. The referrals for the emaciated animals in this study does not mention forage analysis or any blood sampling or other diagnostics for excluding other causes for emaciation to have been performed before death and PEM will remain a speculation for these cases.

Hepatic lipidosis

Hepatic lipidosis was seen in a substantial number of cases with wasting as the major symptom and have been described as a cause of high mortality in camelids (Van Saun et al., 2000). The pathogenesis behind hepatic lipidosis in camelids is not entirely understood but PEM seem to be a strongly contributing factor (Tornquist et al., 2001) making any kind of disease causing inappetence a risk factor (Van Saun et al., 2000). There were no comments in the referrals regarding hepatic lipidosis and the treatment schemes used did not imply that hepatic lipidosis was a major concern among treating veterinarians. Hepatic lipidosis seem to be an underestimated disease process in camelids in Sweden. Many lives can probably be saved in the future by increasing the awareness of hepatic lipidosis in sick and wasting camelids.

There is one report of a successful treatment of hepatic lipidosis in a camelid (Van Saun et al., 2000). A pregnant and lactating female llama fell ill after a period of extremely hot weather (heat stress). The llama had to be hospitalized for a week and received parenteral solutions for several days before her appetite was restored. Treatment also included iv-infusions with added salts and minerals as well as insulin. Treatment for sick Swedish camelids is available but demands economical means and causes a lot of stress to the animal. It is therefore important to identify animals at risk before the situation worsens and hospitalization becomes the only option. A simple blood sample can be used to identify early liver damage in inappetent animals and early treatment with iv-infusion and insulin at the farm could reverse the trend for sick animals.

Cardiovascular and urological disease

Cardiomyopathy is not a common finding in SACs and only a few case reports have been published including dilated cardiomyopathy in an alpaca and sudden death due to hypertrophic cardiomyopathy also in an alpaca (Gentile & Abbott, 2010; Van Alstine & Mitsui, 2010). The majority of cardiology cases in this study were infectious diseases such as endocarditis and myocarditis and only one case of dilated cardiomyopathy was identified. Since the symptoms observed in the cases of cardiac disease were vague and similar to symptoms seen with a variety of other diseases, cardiac disease and particularly myocarditis and endocarditis should be a differential diagnosis for all camelids with wasting, inappetence and respiratory distress.

Four cases of interstitial nephritis were identified but the cause of the disease could not be found in any of the cases. According to Fowler (2010), interstitial nephritis in camelids is mostly a result of infectious agents. Further research into the cause of interstitial nephritis and its causative agents is needed. Most of all, kidney disease should be a differential diagnosis in

any camelid with long term issues including inappetence and bad general condition. Just as with liver damage, a simple blood sample can give valuable information in these cases.

Prevalence and characteristics of neoplasia

The prevalence of neoplasia among the camelids in this study (excluding abortions) was 7.2% which corresponds well with a previous report regarding prevalence of neoplasia in camelids in Oregon, USA, where the prevalence among 551 camelid submissions (excluding abortions) was 6.9% (Valentine & Martin (2007). For alpacas and camels the numbers were 7.2% and 7.1%, respectively. Most of the alpacas with neoplasia were under the age of three years which also correspond well to the report from Oregon where alpacas with neoplasia were found to be relatively young. Malignant lymphoma was the most common neoplasia among the alpacas in this study. Several cases of malignant lymphoma i SAC have been reported and is considered to be a relatively common form of neoplasia in alpacas and llamas (Cebra et al. 1995; Sartin et al, 2004; Valentine & Martin, 2007).

One alpaca had a cholangiocarcinoma. Only one case of cholangiocarcinoma in SACs, in this case a llama, has previously been reported. The alpaca had signs of previous severe liver fluke infestation with proliferation of the bile ducts which made the pathologist speculate on a connection between the infection and the neoplasm. In Asia, mainly Thailand, a carcinogenic fish-borne liver fluke (*Opisthorchis viverrini*) has been linked to cholangiocarcinoma in infected humans (Haswell-Elkins et al., 1994). The mechanism behind this is unknown and there is no evidence in the literature of liver flukes causing similar neoplastic changes in infected animals.

According to the findings in this study malignant lymphoma seem to be the most common neoplasia in SACs in Sweden and should be considered as a differential diagnosis in sick SACs with signs of lymph node enlargement, inappetence and general bad health. Blood samples should be taken and biopsies from enlarged lymph nodes should analysed to rule out treatable general lymphadenitis before euthanasia.

Stress-related deaths and diseases

South American camelids are known to be sensitive to stress such as occurs during handling and shearing but also stressful situations such as social isolation (Pollard & Littlejohn, 1995). Among the cases examined in this study, one case of dermatitis and one case of acute circulatory failure could be traced to such stressful situations, one causing acute death of an otherwise healthy alpaca. It is difficult to avoid all stressful events, especially for sick animals that might require restraint for examination and blood sampling etc. But care should be taken to make sure these individuals always have herd mates close by during all handling (Pollard & Littlejohn, 1995). Isolation of sick animals which is common procedure for many suspected infectious diseases, or alternatively keeping animals in special sick pens, is not good advice for South American camelids since this can severely endanger their health.

A disease process commonly connected to stress in other animals such as horses and dairy cows is gastric ulcers. Gastric ulcers were found in a small number of alpacas in this study. Some were severe with large perforated lesions that had led to extensive peritonitis whereas others were merely erosions on the surface of the gastric mucosa. It is difficult to identify animals with gastric ulcers unless they are very severe causing inappetence and other signs of disease. It is also difficult to treat in camelids since oral omeprazole, commonly used in farm animals, have been found to be insufficient in camelids (Poulsen et al., 2005). To effectively increase pH in the third compartment of camelids, antiulcer agents such as omeprazole or pantoprazole need to be injected intravenously (Smith et al., 2010; Christensen et al., 2001). Nevertheless, a camelid with signs of wasting and inappetence with a history of recent increase in the amount of grain fed, transportation, handling or other stressful events should be considered at risk and treated with anti-ulcer agents and be served good quality forage to avoid further deterioration.

Skin conditions

Parasitic dermatitis, especially parasitic mange, has been reported as fairly common from other countries and skin diseases has also been found to be a major concern for Swedish camelid owners as well as owners in other countries (Andersson, 2003; Davis et al., 1998; Defra, 2009; Bornstein & de Verdier, 2010). In this study only two individuals had parasitic mange. Both were incidental findings in two traumatic deaths and both animals were in good health at the time of death. The specific parasite was identified as *Chorioptes* sp.. Both *Chorioptes* sp. and *Sarcoptes scabei* have previously been diagnosed in Swedish alpacas (Eriksson et al., 2012). The non-parasitic skin conditions encountered in this study were severe chronic dermatitis that had led to euthanasia. These cases represent the worst case scenario and cannot be considered as representatives of the population as a whole. They all had different clinical signs and there was no overall pattern that linked these animals to each other. Some were idiopathic while others had eosinophilic dermatitis without any infectious agents being found. Among the emaciated and weak animals seen in this study, remarkably few had skin disorders. If the ectoparasitic burden in Swedish camelid farms were heavy, these animals should be the first to be affected.

Apart from parasitic dermatitis, idiopathic hyperkeratosis or zinc-responsive dermatitis is a well-known issue for British veterinarians attending camelids (D'Alterio et al, 2006). Clauss et al (2004) described skin conditions observed in animals with low zinc and copper status but low zinc levels were not always related to skin disorder indicating that some other factors were involved. Low zinc levels have been reported from a Swedish herd of alpacas (Wasberg, 2012) and mineral deficiency could therefore be one factor behind the cases of idiopathic dermatitis seen in this study.

The findings in this study indicate that skin disorders are sporadic, often idiopathic and characterized by a few severely affected individuals, as opposed to an overall high prevalence of parasitic dermatitis. The cause for the high percentage of concerned owners could be due to the visibility of skin disorders and the difficulties encountered when trying to treat them. However, there can also be a large proportion of animals that are affected by skin conditions

but these animals are less likely to end up at a necropsy and are therefore not visible in a study of this kind.

Animal welfare aspects

Several animals had died due to illnesses that cannot be cured by means of general treatment schemes such as antibiotics and anti-inflammatory drugs. These animals must be identified by the field practitioner and euthanased if surgery or intensive care at an animal hospital is not an option. Since many of the camelids sent in to necropsy had died suddenly after only a few days illness it is important that the veterinary practitioner remembers the stoic nature of these animals, and acts quickly. A camelid with signs of illness should not be left waiting. However, acting quickly is not effective if a diagnosis is lacking and the animal receives the wrong treatment. Improved diagnostic procedures in the field will therefore play a major part in the effort to improve animal welfare for sick camelids. There are animals in this study with long periods of wasting (sometimes leading to emaciation and death), inappetence or even such severe symptoms as hind limb paresis that had not been examined by a veterinarian. Information to camelid owners regarding the need for quick intervention is thus also important to improve animal welfare.

CONCLUSIONS

In all surveys, studies and reports available on camelid health, neonatal deaths, intestinal diseases, parasitism, nutritional disorders and skin diseases are considered to be the major concerns on camelid farms around the world. This study has shown that the Swedish camelid population in general suffers from similar conditions as camelids held in other European countries and in North America, with some exceptions. Neonatal alpacas and camels mainly suffer from infectious diseases caused by common bacteria. Weaning crias have been found to be in danger of emaciation due to PEM during late winter and early spring. Adult alpacas and camels suffer from infectious diseases such as gastroenteritis (bacterial and parasitic), pneumonia, myo-/endocarditis, hepatitis and dermatitis as well as medical issues including chronic kidney disease, neoplasia and heart disease. Nutritional conditions among Swedish camelids of all ages are mainly hepatic lipidosis and/or PEM. Sadly, too many animals die on their own due to limitations in knowledge among veterinarians and owners as well as limitations in diagnostic procedures leaving veterinarians to treat animals based on vague symptoms. A simple blood sample could in many cases have given valuable information and guided treatment and prognosis. Treatment of ill camelids needs to be updated and targeted for better results. Liver disease, mainly hepatic lipidosis, seems to be overlooked in Swedish camelids. Its role in the progress of diseases where inappetence is a factor as well as for the death of sick camelids should not be underestimated.

Applications

Veterinary:

- Improve diagnostic procedures in neonatal intensive care – quick tests for failure of passive transfer used for calves have been found to work for camelids as well.
- Improve field diagnostics to detect chronic illness and severe acute conditions to prevent animals from dying on their own.
- Inform practicing veterinarians of camelids stoic nature and alert them to act quickly in the case of a camelid with symptoms of disease or pain.
- Make practicing veterinarians aware of the problem with hepatic lipidosis in diseased and inappetent camelids of all age-groups and inform them of how to detect and treat hepatic lipidosis.

Pathology:

- The diagnostic procedures for aborted camelid foetuses need to be standardized for better consistency and a better outcome.
- Clarify cause of death in the final necropsy reports, even when a cause of death could not be identified – this will make sure that owners keep on sending in their dead camelids to necropsy.

At the farm:

- Do not wait to contact your veterinarian in the case of a wasting camelid or a camelid with signs of disease and/or pain.
- Make sure all new-borns get their colostrum during the first hours of life to prevent FPT and septicaemia.
- Prevent emaciation in weaning alpacas by
    - feeding them high quality forage
    - complete their diet with concentrate for cold climate, growth and stress
    - use regular body scoring to control weight
    - use individually adapted weaning: do not wean a cria which is unfit nutritionally or mentally and avoid weaning during extreme cold periods

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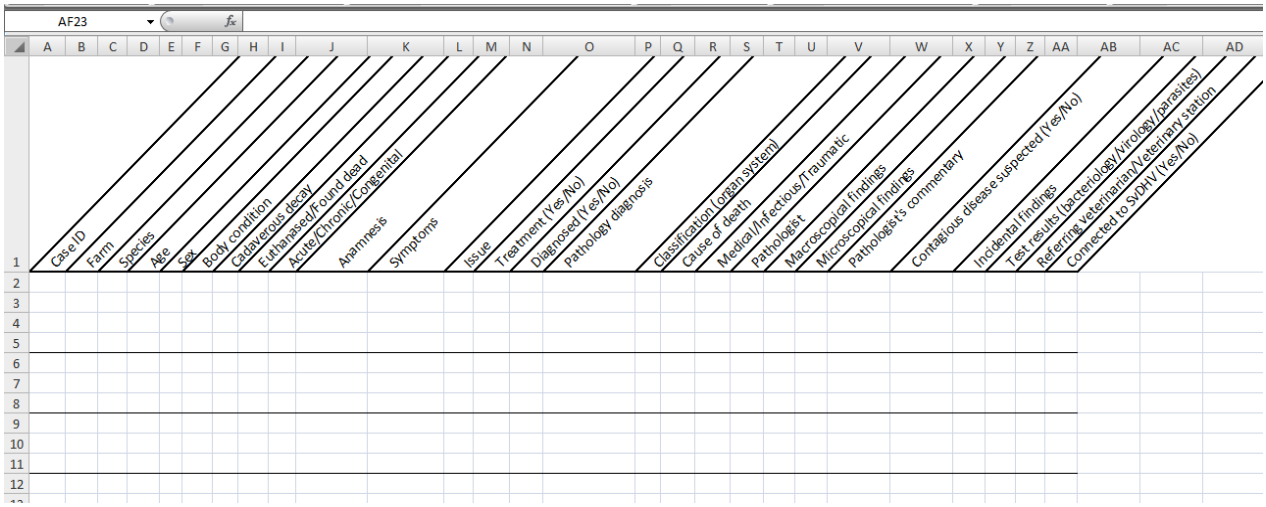
APPENDIX I: BASIC STRUCTURE FOR CASE COMPILATION IN EXCEL



Collected information:

- Case ID (including information on where the necropsy was performed)
- Farmorigin
- Species
- Age
- Sex
- Body condition (1-5, 1=emaciated and 5=obese)
- Cadaverous decay (1-5, 1=fresh and 5=very severe decay)
- Euthanased/Found dead
- Acute/Chronic/Congenital
- Anamnesis
- Symptoms
- Issue (in referral)
- Treatment (Yes/No)
- Diagnosed antemortem (Yes/No)
- Pathology diagnosis
- Classification (organ system)
- Medical/Infectious/Traumatic
- Pathologist
- Macroscopical findings
- Microscopical findings
- Pathologist's commentary
- Contagious disease suspected (Yes/No)
- Incidental findings
- Test results (bacteriology/virology/parasites)
- Referring veterinarian/Veterinary station
- Connected to SvDHV (Yes/No)

APPENDIX II: DETAILED INFORMATION ON NECROPSY CASES IN DIFFERENT AGE GROUPS

Alpacas

Prenatal deaths

Almost 10% (10/93) of alpaca necropsy cases were aborted foetuses and all aborted foetuses among the necropsy files gathered were alpacas. All but one foetus were brought to the necropsy together with the foetal membranes and/or placenta. The majority were full term or close to full term pregnancies. The cause of abortion was identified in one of the cases (10%) and this abortion was found to be the result of a necrotizing placentitis only visible histologically. All the other foetuses were without any signs of trauma, infection, inflammation or malformations.

One of the aborted foetuses had a severely ill mother that died of sepsis as a result of multiple abscesses caused by *Corynebacterium pseudotuberculosis*. During the necropsy of the mother, several abscesses were found in the pregnant horn of the uterus and the conclusion was that the abortion was due to the mother's illness and resulting poor health. There was no growth of *C pseudotuberculosis* in samples from the foetus and no signs of the infection affecting the foetus directly, but multifocal petechial bleeding in both the placenta and internal organs of the foetus indicated acute circulatory failure prior to death and abortion. In the case of the necrotizing placentitis, tests were conducted for herpes virus, toxoplasmosis, sarcocystosis and neosporosis. All tests were negative except for a weakly positive result for *Neospora* sp. and neosporosis was therefore considered as a probable but less likely cause for the abortion.

The foetuses were tested for several infectious agents: Schmallenberg virus (3), Brucella sp. (6), Toxoplasma gondii (2), Listeria sp. (1), Sarcocystis sp. (1), Neospora sp. (1), Coxiella burnetti (3) and equine herpes virus (1). Samples were taken from two of the foetuses for general bacterial culture but no pathogenic bacteria could be identified in either of these two cases.

Neonatal deaths

Cria deaths during first week of life

This group included eight alpaca crias from six different owners between the years 2008 and 2013. For one cria the owner was not identified. Six crias were female, the remaining two were males.

Three of these crias were considered by the owner to be stillborn. However, two showed clear signs of being alive at birth; this was seen as partially air-filled lungs. The final diagnoses of these cases were categorized as malformation (1), respiratory (1) and unknown (1). One was considered to be traumatic while the remaining two could not be defined due to uncertainty in the necropsy finds.

One cria was found dead in the pasture with foetal membranes tightly around the head. The lungs showed obvious signs of the cria breathing after birth and even though the exact cause of death could not be identified, the pathologist considered suffocation as a probable cause. The other had partially air-filled lungs and a hydrocephalus interna with the cerebellum displaced further back than normal. An infectious cause for the hydrocephalus was suspected. The main suspect was the Schmallenberg virus and even though the test was negative Schmallenberg virus was not completely excluded. However, spontaneous hydrocephalus was also considered. The third cria had confusing macroscopic findings: only approximately 1 % of the lung parenchyma was air-filled but milk residues in the gut indicated feeding had taken place before death. This cria also had a fatty liver that could indicate presence of bacterial toxins or severe hypoxia. As *Streptococcus* sp. was cultured from several organ samples, an intrauterine infection was thought to be a cause of the crias death.

Two crias had been euthanased due to malformations. One, a female cria, was euthanased immediately post-partum because of multiple malformations including brachygnathia inferior and superior, protruding and asymmetrical eyes, bilateral polydactyli as well as flexor tendon contracture of both front legs. The pregnancy was full term and the cria was in good body condition. None of the internal organs was affected and histologically there were no signs of inflammation or infection. PCR was used to search for Schmallenberg virus in samples of brain tissue, lymph node and spleen but were negative. No further testing was made and the cause of the malformations was not concluded in this case. The other euthanased neonate was a one day-old male cria with severe dyspnea and blindness. The referring veterinarian suspected malformation in the nasal cavity and the necropsy revealed malformation of the chonchae and cataract of both lenses. No other malformations were found and no signs of infection were seen in the internal organs.

The remaining three neonatal crias died of natural causes. The first cria was in good body condition but weak from birth and did not nurse. The owner had brought the cria in to the house for warmth and care but it died shortly after. No significant finds were made during necropsy and the only test performed, a test for *Brucella* sp. as part of a surveillance program, was negative. One cria had died two days after birth, coughing shortly before death. The veterinarian suspected aspiration pneumonia because the owners had bottle-fed the cria with goat's milk but no signs of pneumonia or aspiration were found. Instead hepatic and nephrogen lipidosis was set as final diagnosis and the cria was thought to have died from malnutrition. The last cria showed emaciation, losing two kilos during its first four days of life. It fell ill with diarrhoea and quickly deteriorated. The umbilicus and joints were normal at examination the day before the cria died and the veterinarian suspected diarrhea and wasting as the cause of death. However, the necropsy revealed a suppurative peritonitis, pleuritis, pericarditis and polyarthritis that could be traced back to an umbilical infection and the cause of death was septicaemia. No bacterial cultivation was made and the bacteria causing the infection remain unknown.

Crias between two and twelve weeks of age

Nine necropsy cases fit into this age category, all individuals died of natural causes. The majority were males (5), two were females and two lacked documented sex. The most commonly affected organ system was the digestive tract (4) followed by circulatory (2),

systemic (2) and locomotor (1). Enteritis was the most common diagnosis (4/8) with the infectious agents involved being identified as *E. coli* (3/4), *Clostridium perfringens* (2/4), coccidia (1/4) and one unidentified bacteria (1/4). In one case of *E. coli* enteritis 200 EPG of *Nematodirus* spp. was also found in the intestine but its impact on the development of disease is not commented on in the report.

The enteritis cases were widespread in the age group with the age of affected crias ranging from three weeks to twelve weeks. Their body condition was considered good in two cases and emaciated in the remaining two cases. Three of four enteritis cases were peracute or acute with the crias not showing any signs of illness prior to death, or at most, displaying weakness during the last 24 hours. Despite this, one case of enteritis was classified as necrotizing, one as haemorrhagic and another one was caused by a massive overgrowth of hemolytic *E. coli*. The only enteritis case with signs of illness was a six week-old severely emaciated cria that had been weak from birth. Failure of passive transfer of maternal antibodies was suspected as the cause and as the cria deteriorated, treatment with B vitamin and antibiotics was initiated but the cria eventually died. At post mortem, suppurative enteritis with villous atrophy was found as well as acute widespread suppurative pneumonia. Milk residues and straw was found to be obstructing the pharynx and it was unclear if the cria died from suffocation due to bottle feeding or due to the actual bacterial infection and its emaciated state.

For two cases the cause of death was found in the heart. One cria died from suppurative myocarditis while the other died from myocardial degeneration. In the case of the myocarditis the six week old male cria was found dead without prior symptoms. The necropsy report describes hydrothorax, hydropericardium and a swelling in the myocardium of the apex measuring 2 cm in diameter. Histologically this swelling was found to consist of focal accumulations of inflammatory cells, mainly neutrophils, both degenerative and regenerative processes and granulation tissue. Hepatic lipidosis and an acute lung stasis were also found indicating the chronicity of the disease and the acute situation prior to death, respectively. The other cria had signs of ill health during the week before it died, mainly poor growth, but during the last 24 hours staggering and dyspnoea were observed. The referring veterinarian suspected pneumonia but the necropsy showed that the dyspnoea was due to a severe circulatory failure with acute lung oedema prior to death. Signs of on-going circulatory failure were also seen in the liver and the meninges. The cause was a massive myocardial degeneration. Histologically this degeneration was typical for the one seen with E vitamin and selenium deficiency.

One cria died as a result of malnutrition following inappetence because of a trauma causing an infected rib fracture. A one month old female, began showing neurological signs, mainly staggering, two days prior to death. Vitamin E/selenium deficiency or intestinal issues were suspected. At necropsy, an abscess in the brain was found to be the source of the neurological signs as well as the septicaemia eventually causing the crias death. The abscess had infiltrated the brain tissue causing atrophy and also a secondary hydrocephalus interna, by obstructing the outflow of fluids. Complicating the crias situation was also aspiration pneumonia.

The last cria, a three month old male, fell acutely ill with fever and coughing and died before the veterinarian could attend. Necropsy revealed reactive hepatitis, myocarditis and an

interstitial pneumonia with the typical appearance seen in acute respiratory distress (ARDS) caused by septicaemia. Bacterial culture from lung and spleen showed extensive growth of *E. coli*.

Weaning animals (five to twelve months)

Nine crias died around weaning with the female:male ratio being 4:5. All but one died of natural causes. Two cases were from 2003, the other cases were from the years 2010-2013. The main symptom in a majority of cases was wasting (7/11). In five of these cases the body condition was documented as emaciated at necropsy and in four cases emaciation was also the final diagnosis. A further three cases in this age group were considered to be too thin; two of these were commented on as being close to emaciated state. In seven cases from five different farms the main symptom was wasting (78%). All the wasting alpacas of this age group died during the winter/early spring.

Only two cases of emaciation were linked to a specific disease process. The first was found to be due to several deep ascending ulcers of the first compartment of the stomach. There were several patches of necrosis and one ulcer deep enough to have caused a focal peritonitis. Both chronic and acute processes were identified and histologically the area of ulceration contained a massive colonization of bacteria. Gram positive and Gram negative cocci as well as clostridium-like rods were identified microscopically but the specific bacteria were not confirmed through culture. The stomach was filled with badly chewed straw material but the teeth were considered healthy and normal. The other case of emaciation linked to a disease process was due to endoparasites. The ingesta of the intestine were loose and dried faeces were found around the anus. Several parasites were found in the stomach and the intestine: *Ostertagia* spp. in large amounts, *Camelostrongylus mentulatus*, *Eimeria* spp. (*E. punoensis och E. alpacae*) and *Capillaria* spp. in moderate amounts.

Two weaning crias died from intestinal emergencies: one because of a 15 cm invaginated small intestinal segment causing necrosis and focal peritonitis and the other because of a small intestinal strangulation. A cause for these emergencies (eg. foreign body, inflammation, infection) was not found in any of the cases.

The only weaning cria that was euthanased was a nine month old male in good body condition. The cria had not been able to urinate for an entire day and the procedure to catheterize was considered impossible on such a young animal and it was therefore put to sleep. At necropsy a three millimetre large calcium urolith was found approximately 15 centimeters from the opening, completely obstructing the urinary outflow. The bladder had thickened walls and was severely dilated. The pelvises of both kidneys were hyperaemic and slightly dilated containing turbid and mucoid urine. Histologically both the bladder and the kidneys displayed chronic inflammatory processes and the final diagnoses were therefore obstructing urolith, chronic interstitial nephritis and chronic cystitis.

One weaning cria died in a predator attack. The two remaining crias died during spring 2010 as the result of severe liver damage. Both had been wasting for some time and both had signs of liver damage before death; one had severe icterus, the other had hydroabdomen with the ascitic fluid indicating liver damage. According to the history a bowel punctate was

performed on the cria with hydroabdomen and the fluid had characteristics of liver damage. Both were diagnosed with hepatic lipidosis and one also had lipidosis of the kidneys. The true cause of disease could not be determined in any of the two cases but starvation was considered a probable cause.

One to five years

This was the largest age group with 30 individuals. The female:male ratio was 2:1. The majority of animals was in the age range of two to four years (24/30) and 67% (20/30) had died from natural causes or were found dead. The body condition was considered good or over ideal weight in 50% of the cases, 30% were considered to be under ideal weight and 13% were emaciated. Of the four emaciated animals two had been euthanased, one died of acute enteritis and one died as a result of the emaciation. The final diagnoses were classified as infectious in 33% of cases, medical in 50% and traumatic in 13%. One case was without final diagnosis. Among the traumatic cases were three predator kills.

Pathology diagnoses were widespread in this age group. The most common organ system to be affected was the digestive tract (8/30). Other organ systems involved in the main diagnosis were circulatory (5), haematology/lymphatics (4), skin (3), neurological (2), locomotor (1), respiratory (1), systemic (1) and genitalia/reproductive system (1). As mentioned above, one case was without significant finds and three individuals were killed in a predator attack. Among the pathology diagnosis in this age group were cases of enteritis (4), malignant lymphoma (3), chronic dermatitis (3), hepatic lipidosis (3), gastric ulcers (2), hepatitis (2), myocarditis (2), acute circulatory shock (2), encephalitis (1), pneumonia (1), endocarditis (1), polioencephalomalacia (1), fractures (1), multiple bleeding (1), uterine torsion (1), torsion of C3 (1), intestinal torsion (1), atrial septal defect (1) and myeloid leukemia/preleukemia (1).

One out of three was considered to be acute; four were medical cases, one was infectious, one was traumatic and one unknown because of non-significant findings. More than 65% (20/30) were chronic conditions and of these 30% (6/20) were chronic acute seen as peracute or acute with either no symptoms prior to death or symptoms only visible for a few days or a week before death.

Six to nine years

Thirteen cases belonged to the age group six to nine years of age. The female:male ratio was just above 3:1. The majority had died of natural causes (8/13) and of these eight five were in the acute category and died peracutely without previous symptoms (5) or only symptoms for less than one hour prior to death (2). Most of the chronic cases were euthanased (4/7) and of the two chronic cases that were found dead one only showed signs of disease during the last days in life. The body condition was fairly good in this age group: the majority was in good body condition (7/13), four were under ideal weight, one case had no body condition documented and only one was classified as emaciated.

The most commonly affected organ system was the digestive tract (4) followed by circulatory (2), respiratory (2) and systemic (2). One case each was classified as neurologic, dermatologic

and locomotor. The most common cause of disease was infectious (6) followed by medical (4) and traumatic (2). The case of chronic dermatitis could not be classified as either infectious or medical since the aetiology could not be determined.

One of the cases classified as medical was a stress-induced circulatory shock with acute myocardial injury. This was an eight year old fully healthy female that died during shearing. The other three medical cases were a strangulating intestinal hernia in a pregnant female, a case of dilated cardiomyopathy with left-sided heart failure in a pregnant female with wasting and respiratory distress, and a case of hepatic lipidosis.

Among the infectious diseases were osteomyelitis of the mandible caused by a tooth root abscess (1), *E. coli*-enteritis (1), suppurative bronchopneumonia (1), encephalitis of presumed viral background (1), multiple abscesses caused by *C. pseudotuberculosis* (1) and unspecified septicaemia (1).

The two traumatic cases were suffocation due to acute swelling of the pharynx and one extensive muscle rupture from a slipping accident.

Ten years or older

This age group consisted of eight individuals from seven different owners. Their bodies were sent in for necropsy between the years 2006-2013 and six of these necropsies were conducted during 2013. The female:male ratio was 7:1. Only one case was classified as emaciated, three were found be under ideal weight and four were in good body condition.

The most common organ systems to be affected were the digestive tract (3) and urinary tract (3). One case each was classified as respiratory and hematology/lymphatics. Two were predator kills and they were the only ones who had not been euthanased in this group. The reason for euthanasia were wasting (3), inappetence (3), respiratory distress (1), signs of circulatory shock (1) and swollen lymph nodes positive for *C. pseudotuberculosis* (1).

Two individuals were the victims of the same predator attack and categorized as traumatic deaths. Three were found to be suffering from internal infections; two from chronic active interstitial nephritis, one from ascending pneumonia and one from chronic active enteritis. The remaining two individuals were found to be suffering the consequences of neoplasias; one from a cholangiocarcinoma and one from a multicentric malignant lymphoma and these two were classified as medical conditions. However, in the case of the cholangiocarcinoma an infectious agent was suspected to be the origin of the neoplastic transformation of the tissue. This animal had signs of severe liver fluke infestation and the pathology report discusses the possibility of a link between the infection and the neoplasia.

One of the females suffering from chronic active interstitial nephritis was in good body condition but had been inappetent for three weeks and only been hand-fed with liquid food during these weeks. Apart from the nephritis, a severe ulcerative gastritis, esophagitis and stomatitis was found as well as a perforating gastric ulcer near the transition from esophagus to stomach. The ulceration had led to a focal fibrinous suppurative peritonitis and suppurative hepatitis causing the liver to attach to the stomach. The pathologist discussed the possibility

of uremia being the cause of the ulcerations in the digestive tract, linking the finds in the kidneys to the ones in the digestive organs. This was also based on the fact that the alpaca smelled of urine and had severe ascites. However, there was no information regarding the composition of the ascitic fluid in the report. Also the spleen was enlarged in this female and a big calcified thrombus, measuring 5 centimeters x 1,5 centimeters, was found in a blood vessel adjacent to the spleen. The other female with chronic active nephritis also had ascites but this was caused by circulatory shock as the female had chronic stasis in the lungs and the liver as well as dilation of both ventricles of the heart.

Adults without specified age

Among the necropsy cases were four females documented as adults but without specified age. Two females were from the same herd and died during April 2010. They had been treated for endoparasites three weeks before death after *Eimeria* spp. and *Trichuris* had been identified in a faeces sample from one of the females. This female died on her own after being ill for a week, lying down but eating and drinking all the time. The other female was euthanased after only two days of acute disease. The issue for both was nutritional deficiency or parasitic infestation. During necropsy both were classified as emaciated and the main findings were located to the digestive tract. In the euthanased female the final diagnosis was chronic enteritis with possible association to previous parasite infestation. For the other female the final diagnosis was abomasitis and enteritis. Histologically this female was found to also have a chronic cholangiohepatitis. There were no findings of liver flukes during necropsy but multiple calcifications in the liver parenchyma could indicate previous infestations.

The third female fell ill after a difficult delivery and retained foetal membranes. Necropsy revealed an acute suppurative endometritis and an acute necrotizing mastitis. The fourth female was an imported animal from Germany. She had a history of wasting and inappetence and was classified as emaciated. A month before death she had been treated for lameness with fever and swelling of the carpal joints. She had been treated with several antibiotics; oxytetracycline, benzylpenicillin and clindamycin as well as cortisone and non-steroidal anti-inflammatory drugs. Her inappetence had started after the veterinarian drained an abscess over the carpal joint. Chronic bruising with alopecia and hyperkeratosis was found on the skin in the area of the carpal joints at post mortem and inside the body cavities were large abscesses; one by the liver/diaphragm and two by the lungs. The main cause for her inappetence and emaciation was believed to be the infection spread from the wounds of her front legs causing large internal abscesses. Bacterial culture from the abscesses showed slight growth of *Proteus* sp.in mixed culture but no pathogenic bacteria were identified.

Camels

In all, 14 cases of camel necropsies were included in the study. Four were documented as Bactrian camels, one as Dromedary and the remaining nine camels were not specified. The age of the individuals ranged from newborn to twelve years with 50% being under the age of two weeks. The majority were females (10/14), two were males and two were not identified.

The final diagnoses were classified as systemic (5), circulatory (3), digestive (3), respiratory (1), dermatologic (1) and unknown (2).

Neonatal deaths

This group consisted of seven neonatal camels from birth to ten days old. All with documented sex were females (5/7), the others are of unknown sex. Only two cases had documented body condition and these two cases were classified as under ideal weight. Three of the seven neonates had been euthanased. Euthanasia was due to severe signs of septicaemia in two cases and neurological symptoms in one case.

Two females were handed in as presumed stillbirths. Both had been alive at birth but died shortly after. They both had signs of severe circulatory failure. In one case the circulatory failure were believed to be existing before birth due to the severity of the identified changes in lung and liver tissue. In the other case, the circulatory failure was believed to have evolved during the birth process.

Of the remaining five cases, all but one were considered to be caused by an infectious disease; three were found to have septicaemia and one to have polyarthritis. The last neonate died as a result of trauma with severe blood loss. In the cases of septicaemia, the causative agent was identified in one case as *Listeria monocytogenes*. The others had only small amounts of bacteria in mixed culture and no documentation on any bacterial culture, respectively. All three had signs of acute septicaemia in liver and spleen seen as neutrophilia and hyperemia but the main findings were in the brain and meninges. In two cases suppurative meningitis was identified histologically. In the third case a brain abscess was found during necropsy explaining the neurological symptoms seen prior to death. In the history for this neonate was colostrum provided from a cow and not from the mother. The other two septicaemia cases were thought to have suckled their mothers. Culture from joint fluids showed the polyarthritis case to be caused by *E. coli.* This neonate had been weak from birth and only lived for two days. It is unclear whether this neonate ever received any colostrum: at necropsy the gut and the intestines were practically empty.

One to nine years

Five camels, one male and four females, fit into this category; two were two years old, one was three years old and two were nine years. The most common symptom of disease was wasting (3) but no camel in this age group was considered to be emaciated at necropsy. Other symptoms were respiratory signs (2), inappetence (1) and hind limb paresis (1). One camel in this group had no signs of disease but was euthanased due to a positive test for tuberculosis. This camel, however, had no signs of disease at necropsy either and despite microscopic evidence of acid-stable rods the bacterial growth was negative for mycobacteria twice. In the cases where wasting and/or inappetence were the main symptoms the final diagnoses were hepatic lipidosis (1), chronic interstitial pneumonia (1) and chronic parasitic enteritis (1). It remains unclear whether the hepatic lipidosis was primary or secondary but no other primary cause for the wasting and inappetence was found. This camel had been inappetent for five

weeks before it eventually died. The causative agent of the pneumonia was not identified but an airborne agent was suspected because of the localisation of the disease process to the anterior lobes. In the case of parasitic enteritis, no parasite was identified and there is no record of any parasitology tests performed to find the causative agent. In the final part of the small intestine were multiple small pustular abscesses. However, this camel had been treated for roundworms and tapeworms about one month before it was euthanased but a faeces sample taken after treatment did show large numbers of unspecified *Trichostrongylidae* and a blood sample had indicated an ongoing infection.

Ten years or older

Only one camel, a male, was over the age of ten years. It had been euthanased after a period of inappetence and wasting. The male had been losing weight for several months and its body condition was under ideal weight. During necropsy, a trichobezoar of 700 grams were found in the pyloric region, mainly consisting of hard packed fodder and pieces of plastic. Tissue necrosis and hyperaemia was evident in the area where the trichobezoar was found. This was thought to be an incidental finding as the final diagnosis was liver cirrhosis which was the supposed main cause for the inappetence. Several etiologies for the liver cirrhosis were mentioned in the final report; among these were infection, toxins, nutritional deficiency and immune-mediated diseases but the aetiology for this camel's cirrhosis was not concluded. This camel had also been suffering from a skin condition the last month before death. Histologically this skin condition was classified as a chronic fungal pustular dermatitis.

Adults without specified age

One female belonged to this category. She was in good body condition with a foal at her side at the time of death but was under treatment for a deep wound on her right hind leg when she suddenly got worse and died. The wound had a necrotic center, measured 10 x 20 centimeters and reach almost all the way down to the bone. When opened the thorax revealed an ongoing abscessation within the lungs consisting of multiple abscesses with necrotic centers. The lung tissue as well as in tissue samples from the wound area revealed the presence of a sarcoma. Signs of infection were seen in both the wound samples as well as in the lung tissue, and lung samples showed growth of *E. coli*. The infection was believed to be secondary to the tumor and the cause of death most likely septicaemia after systemic spread of the infection from the wound site.