Trends in the premature death of pet rabbits

Research Project Veterinary Medicine Utrecht University
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Prefactory note

Within the training of Veterinary Medicine at the Utrecht University, all students have to fulfill a three months research project. This paper is the final report of the research project carried out by Drs. L.S. Banga at the department of Pathobiology of the University of Utrecht.

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Abstract

Among rabbits kept as pets, there is a high level of mortality at a young age. To gain insight into the causes of premature death of pet rabbits and the factors that play a role and might be welfare related, in this study the aim is to determine an overview of the causes of death in early deceased rabbits.

Therefore, using the data from VPDC Utrecht of necropsies on pet rabbits (age 6 to 36 months) from the period '93-'09 and the data of necropsies on pet rabbits in the period '09-'10, the causes of death of respectively 143 and 10 pet rabbits were identified.

A notable trend is that the largest share (61,1%) of causes of premature death is caused by infectious agents. Non-infectious disorders and diseases of unknown etiology amount respectively 18,2% and 14,7%. Further analysis of the causes of death shows that Viral heamorrhagic disease (VHD), Pasteurella multocida and bacterial sepsis, unspecified on the latter, are the three most common causes of death at a young age, resp. 35,5%; 14, 0% and 7,0%.

With respect to the overall population of pet rabbits and the causes of premature death, the image is probably distorted by a selective population of animals within this study, whereby a large number of animals is characterized by sudden death. Other factors such as euthanasia don't seem to have any direct effect.

Introduction

Health and welfare problems in small pets can be attributed to several factors. The main factors are husbandry and care, whereby size, density, temperature, nutrition, hygiene and medical care fall short. Also improper handling of animals could underlie health and welfare problems. [Veer, 1999] Depending on the nature and intensity, health and welfare problems can result in mortality. Therefore mortality is often indirect due to a lack of adequate housing and care. [Veer, 1999]

When it comes to the premature death of small animals in the Netherlands, rabbits prove to be in the group with the highest percentage of premature mortality. At 84% of the owners pet rabbits die early. The average age at death is significantly lower than the life expectancy of 8-12 years. [Caneel et al., 2000]. Research of Caneel [2000] shows, that only a very small number of owners meets the species-specific requirements of their animals. Many owners have no idea by what their pet dies and can not indicate whether their pet dies prematurely. [Caneel et al., 2000]

Rabbits and other small pets are increasingly kept as a pet. The high mortality at a young age within this group of animals [Caneel et al., 2000] is partially caused by factors, including the way animals are housed, that are not optimal.[Veer, 1999] To better understand the extent to which the cause of death, for small pets as rabbits, who died at relatively young age, is related to health and welfare there must be obtained more insight into the cause of death of these animals. Therefore by October 2009, the Veterinary Pathology Diagnostic Centre (VPDC) started, as part of a welfare study commissioned by the Ministry of Agriculture, to conduct necropsies on small pets that were performed free of charge.

An inventory for many common diseases and causes of death in rabbits in the laboratory Pasteurella multocida seemed very important, though mortality was higher due to gastrointestinal problems, especially in young rabbits.[Seamer and Chesterman, 1967] Recently it's said that in past years in the pet rabbit Pasteurella is less common. Pasteurella establish itself as upper respiratory tract disease, but also when spread hematogenously, as otitis, abcesses, pneumonia, pleuritis, pericarditis and sudden death due to bacteremia. [Quesenberry and Carpenter, 1997]

With respect to gastrointestinal problems, Quesenberry and Harrenstien [Quesenberry and Carpenter, 1997; Harrenstien, 1999] indicate that gastrointestinal problems by name the enteritis complex, are the most common diseases of rabbits in clinical practice. Signs ranging from soft stool and diarrhea to enterotoxaemia, sepsis and death. Pathogenic bacteria and the factors that allow them to proliferate are the usual causes. These factors include diet (high levels of protein and low levels of fiber), antibiotics, stress and genetic predisposition to gut dysfunction, many of which can be managed with basic veterinary procedures and appropriate diet. [Quesenberry and Carpenter, 1997; Harrenstien, 1999]

Identification of common diseases in small pets in Germany by Langenecker [2009], shows that in rabbits dental problems (14%) and suspected of Encephalitozoon cuniculi (11%) seem to occur the most, followed by trauma and abscesses (8%). The suspicion of E.cuniculi is based on clinical symptoms and / or positive antibody titer. Though it is impossible to differentiate between rabbits with an active infection, a latent infection or rabbits that had mounted an antibody response but were no longer infected [Harcourt-Brown and Holloway, 2003], rabbits with antibodies to E. cuniculi but without signs, have been exposed and probably carry the parasite often as a latent infection. [Quesenberry and Carpenter, 1997]. Rabbits suffering from encephalitozoonosis show a range of clinical signs from asymptomatic to sudden death. The disease may be acute or chronic, and the clinical signs are caused by lesions within the central nervous system, kidney or eye [Harcourt-Brown and Holloway, 2003].

With respect to dental disease, also said to be the most common condition found in pet rabbits by Mullan [2006], the majority of the owners were unaware of their rabbit's problem. The vast majority of dental problems express themselves in anorexia and is thereby also the most common cause of anorexia [Langenecker et al., 2009; Harcourt-Brown, 2002]. Also weight loss and disruption of the gastrointestinal tract is expected. The reduced food intake and the hypomotility of the gastrointestinal tract, leads to an energy deficit and cuts down the supply of fluid and nutrients to the caecal microflora. A fall in blood glucose stimulates lipolysis and mobilization of free fatty acids from adipose tissue. Excess free fatty acids cause fatty infiltration of the liver and oxidation of free fatty acids causes ketoacidosis. Rabbits are particularly susceptible to acidosis. Once ketoacidosis occurs, rabbits become increasingly depressed and anorexic. Hepatic lipidosis develops rapidly and death occurs within a week of the onset of anorexia. [Harcourt-Brown, 2002]

Several diseases are frequent within species, but these are not necessarily associated with high mortality and thus have not always the largest share of premature death in small animals. Data on the most common causes of death are still limited available. Also, the prevalence and type of disease in small animals in practice is different than in laboratory animals[Langenecker et al., 2009], therefore literature is in those cases difficult to extrapolate. It is therefore difficult to predict which diseases are the most common causes of death.

To understand the causes of death of the premature deaths of pet rabbits and the factors that play a role and perhaps being welfare related, this study aims to establish an overview of the causes of premature death (age 6 t to 36 months) of pet rabbits. Therefore, in this study we shall determine the most common causes of premature death and which/ if factors are related.

As previously mentioned, the identification of literature, as regards to the most common problems and causes of death in rabbits, give no clear picture. Though based on the above findings in the literature it is possible to expect in this study Fatty liver and enteritis as the two most common causes of death, at an early age, in pet rabbits.

Materials and methods

This research is designed in two parts:
1. a Survey on data from the archive of VPDC, Utrecht 1993-2009
2. Necropsies on pet rabbits at VPDC, Utrecht 2009-2010

Survey on data from the archive 1993-2009

Data from the archives of the VPDC, Utrecht present necropsy reports on rabbits from 1993 until 2009 which were submitted for a necropsy concerning a further diagnosis, which included 1841 rabbits. Only necropsy reports of rabbits that were known to have died at the age between 6 and 36 months were used. Reports of rabbits, which were held as laboratory animals, were excluded. This resulted in a total of 143 necropsy reports.

Each report consisted of a brief clinical history, macroscopic findings following a standard protocol used by the VPDC, Utrecht (appendix 1), cytology of liver, spleen, lungs and gut contents and any abnormalities that were found during macroscopy. Microscopic and microbiological data were only available if macroscopic findings had given reason to conduct microscopy or microbiology. Each report contained a conclusion, indicating the cause of death.

Necropsies on pet rabbits in 2009-2010, Welfare project

The rabbits which were submitted for a necropsy concerning a further diagnosis and / or for the welfare research, started by October 2009 at the VPDC, until February 2010 were used. These rabbits had died at an age between 6 and 36 months. Immediately after death the rabbits were cooled and within 24 hours after death offered for necropsy. This resulted in a total of 10 necropsies.

The necropsies were performed using a comprehensive protocol, consisting of the standard macroscopy of the VPDC, Utrecht (appendix 1), cytology of liver, spleen, lungs, gut contents and any abnormalities that were found during macroscopy and microscopy according to the protocol on behave of the welfare project (appendix 2). Also samples of several organs were frozen according to the welfare protocol (appendix 2) so that later microbiological examination could be met, if the findings of the macroscopy, cytology and microscopy gave reason to. The necropsy reports were also accompanied by a comprehensive medical history filled out by the owner of the deceased rabbit (appendix 3).

Data analysis

All data were entered into the database created by Baijens (2008). This database made it possible, after exporting to excel, to analyze the data from all necropsy reports. Based on the conclusion of the necropsy reports, followed by a determination whether any cause of death was infectious, non-infectious or the etiology was unclear, the data from both parts were divided into three main groups, followed by a further breakdown:

- Infectious; distributed to infectious agents as cause of death.
- Non-infectious; distributed to disease as cause of death.
- Etiology unknown; distributed to organ, named as most important abnormality in the necropsy report.

Several other factors have also been examined:

- The proportion of euthanasia in the three main groups in comparison to the animals not euthanized.
- The amount of Fatty liver and enteritis

After determination of the three most common causes of death, several attributing factors were examined:

- Sudden death
- Body condition score (well or very excessive, good or normal and moderate to poor)

The chi-square test was used to assess the significance of differences between the shares of sudden death. The Fisher's exact test was used to assess the significance between the shares of causes of death in the population of euthanized en non-euthanized animals.

Also a comparison was made between the proportions of causes of death in the group of '93-'09 and the group of '09-'10. To asses the significance, the Fisher's exact test was used.

Results

Survey on data from the archive 1993-2009

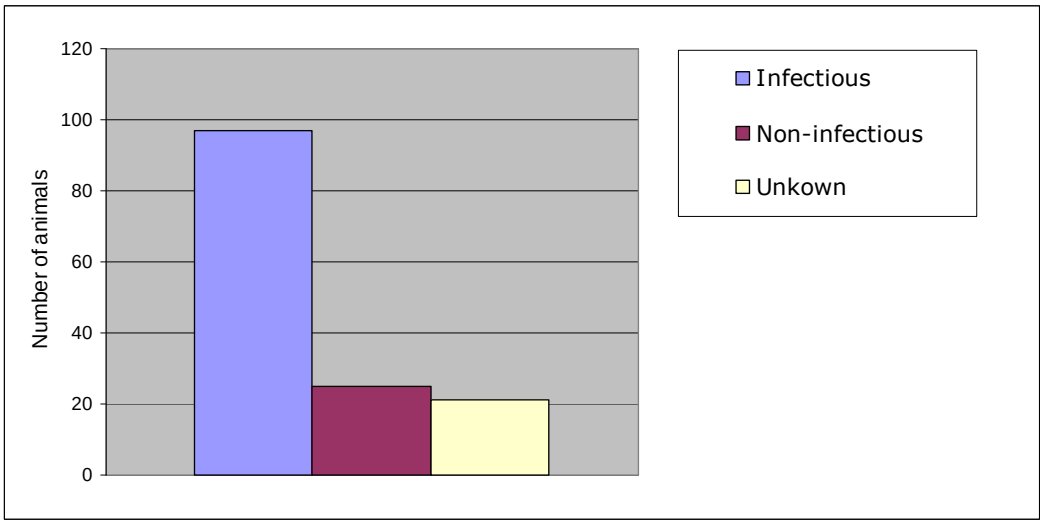
1. Causes of death

In the group of rabbits, that died prematurely in the period from 1993 to 2009, were a total of 143 rabbits. Based on the conclusion from the necropsy reports, followed by a determination whether any one cause of death was infectious, non- infectious or if the cause of death was caused was unclear, the division into three main groups resulted in the following numbers:

- Infectious: 61,1% (n = 97)
- Non-infectious: 18,2% (n = 25)
- Unknown etiology: 14,7% (n = 21)

Figure 1 shows the distribution of the causes of death in a diagram. A full account of the origin of the different causes of death can be found in the Tables 1, 2, 3 and 4 (Appendix 4)

Figure 1. Distribution of death causes



The further breakdown of the origin of the causes of death show that within the group of non-infectious causes of death, the percentages of the different causes of death vary between 0,7 and 2,8%. Whithin the group of infectious causes of death, there are also a number of different causes of death, but within this study in this group, three infectious agents account for the largest percentages:

1. VHD: 35,5% (n=45)
2. Pasteurella multocida: 14,0% (n=20)
3. Bacterial sepsis (agent non-specified): 7,0% (n=10)

Together, these 3 largest groups are responsible for 52,5% of the deaths. In the group of rabbits died of Pasteurella were 14 of 20 (70%) that died of a clear indication of sepsis or acute pasteurellosis.

2. Enteritis

In the necropsy reports in 6,3% (n=9) of the cases enteritis was concluded. Enteritis has in this study been split up and hasn't always been seen as main reason of death and therefore falls, within the division into the three main groups, among various causes.
Precise subdivision of enteritis is reflected in Table 5 (Appendix 4).

3. Fatty liver

The total number of cases of Fatty liver, and associated metabolic disturbances, that a play a causal role in the death of rabbits, accounted for a total of 2,8%. When you look at cytology or microscopic evidence of fatty liver the number is resp. 13,3% and 6,3%, but fatty liver is in most cases not the main reason of death. In cases where cytology and microscopic showed evidence of fatty liver, respectively 15,8% and 22,2% lead to death. Numbers can be found in Table 6 (Appendix 4)

4. Euthanized

Euthanasia had in 7% (n=10) of the cases taken place. When looking at reasons for disease of these animals, thus the indirect cause of death, then the following distribution was obtained:

- Infectious 3,5% (n=5)
- Non-infectious 0,7% (n=1)
- Unkown etiology 2,8% (n=4)

In Figure 2 and Figure 3 is shown respectively the distribution of causes of death within de euthanized population and the distribution of causes of death within the population of animals which were not euthanized. Numbers can be found in Table 7 (Appendix 4). In the comparison of the two groups, by using the Fisher's exact test, we obtained a P-value of 0,072.

Figure 2. Distribution of indirect causes of death in euthanized animals of '93-'09

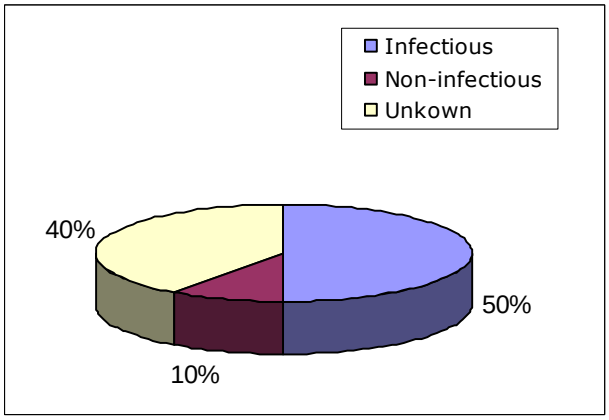
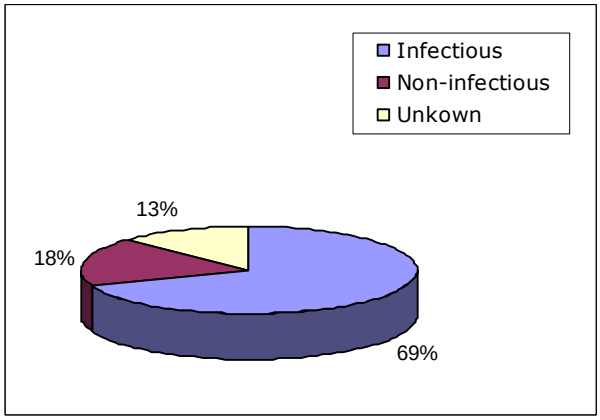


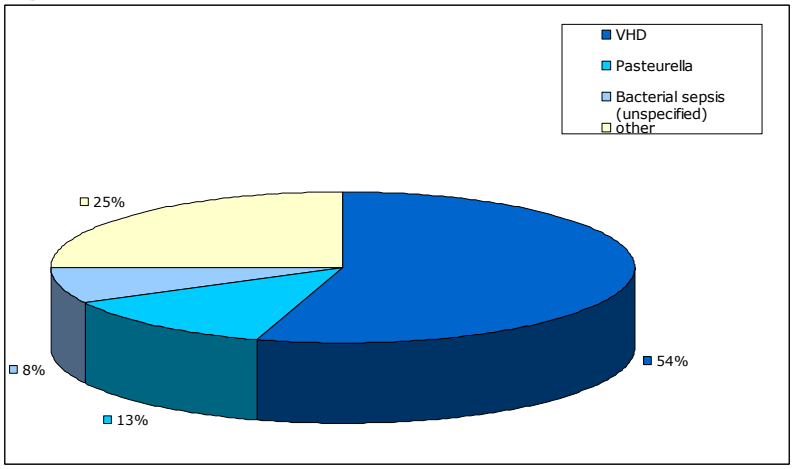
Figure 3. Distribution of causes of death in the population of '93-'09 minus euthanized animals



5. Sudden death

Using the data from the anamnesis, it was possible to make a comparative overview of percentages of sudden death. Within the whole population of rabbits in this part of study 44,8% (n=64) seems to have deceased suddenly. Of these animals 75,0% can be accounted to the three causes of death which occur most (VHD, Pasteurella, bacterial sepsis) as seen in Figure 4. An expanded view is shown in Table 8 and 9 (Appendix 4).

Figure 4. Distribution of causes of sudden death within overall sudden death mortality '93-'09

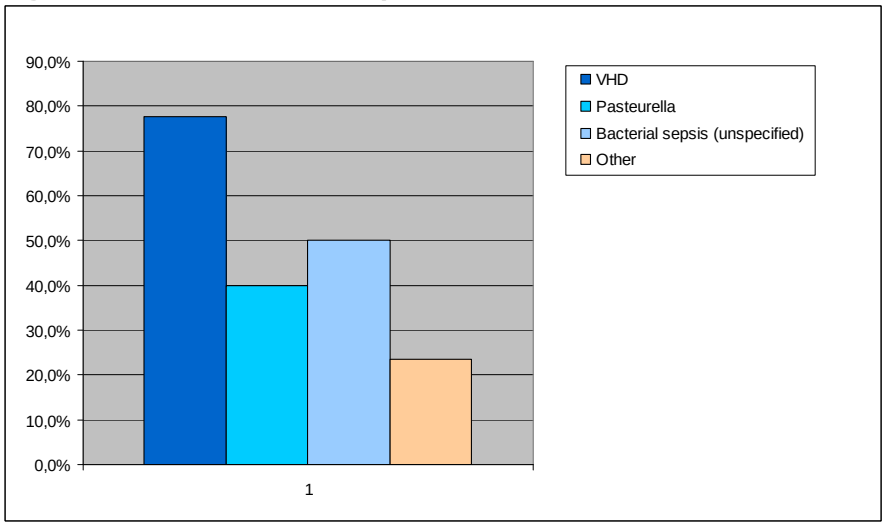


Within the three causes of death which occur most, the distribution of sudden death is as follows:

- VHD 77,8%
- Bacterial sepsis 50,0 %
- Pasteurella 40,0%

An overview of these proportions of sudden death whitin the three groups of most common causes of death and the amount of sudden death within the population died of other causes, is shown in Figure 5. Using the Chi-squared test we determined, there was a significant difference in of the amount of sudden death within these groups; the P-value was smaller then 0,001.

Figure 5. Sudden death mortality within the different causes of death



6. Body condition score

Within the whole population of rabbits 39,2% had a normal/good body condition score. In 25,2% of the rabbits there is a very well or excessive and in 11,9% there is a moderate to poor body condition score.

The distribution of the body condition scores within the different groups according to the cause of death are shown in Figure 6. In this study VHD causes mortality in rabbits with a normal body condition in 55,6% and no mortality among rabbits in moderate to poor nutritional status (0%). This division is also reflected in Table 10 and 11 (Appendix 4)

There is also an overview made regarding the distribution of the three most common causes of death and other causes of death within the different scores of body condition. In Figure 7 is the distribution of causes of death within the different body condition scores plotted.

The share of deaths caused by Pasteurella seems proportional distributed throughout the different body condition scores. This is not the case with deaths caused by VHD, whereas VHD seems to accounts for the biggest share of mortality (44,6%) in the group of good/normal body condition score, this share is bigger than the proportion of VHD within the whole population (31,5%).

In the group of moderate to poor body condition score mortality due to other causes of death seems to have a relatively high proportion (82,4%), which seems also higher than the proportion of deaths due to other causes within the whole population (47.5%). This distribution is also reflected in Table 12 (Appendix4).

No statistical tests were used.

Figure 6. Distribution of body condition score within the different causes of death.

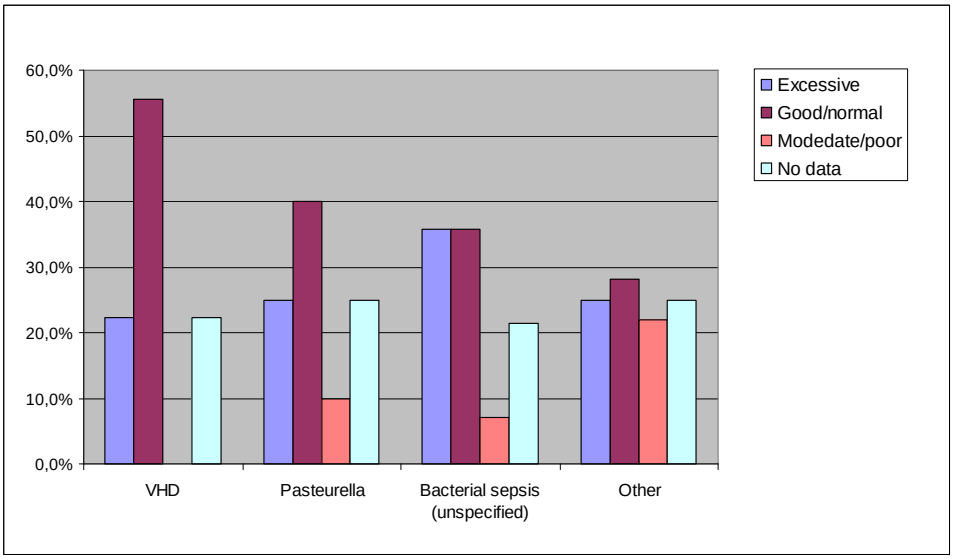
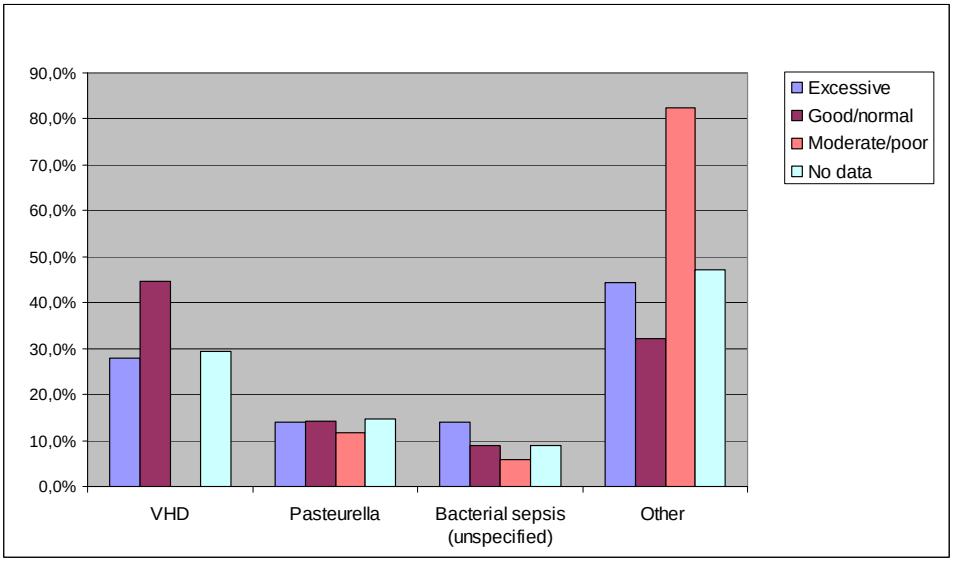


Figure 7. Distribution of the causes of death whitin the different body condition scores



Necropsies on pet rabbits in 2009-2010, Welfare project

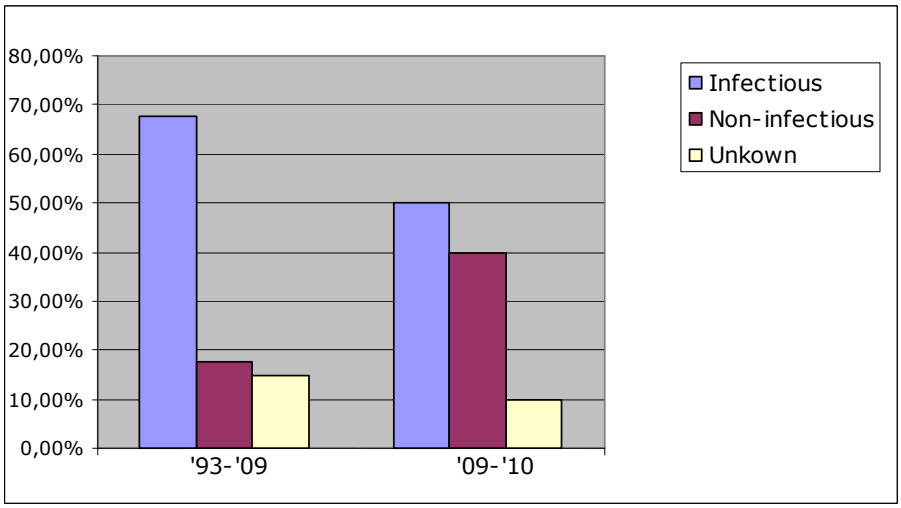
1. Causes of death

In the group of rabbits that died prematurely in the period from October 2009 until February 2010, were a total of 10 rabbits. Based on the conclusion from the necropsy reports, followed by a determination whether the cause of death was infectious, non- infectious or if the cause of death was unclear, the division into three main groups resulted in the following numbers:

- Infectious: 50% (n = 5)
- Non-infectious: 40% (n = 4)
- Unknown etiology: 10% (n = 1)

Figure 8 shows the distribution of the causes of death in a diagram, the distribution of causes of death of the population of rabbits from the period 1993 until 2009 has also been plotted. The Fisher's exact test has been used, the P-value is 0,185 which means there is no significant difference.

Figure 8. Comparison of distribution of causes of death in the groups '93-'09 and '09-'10.



E. Cuniculi is seen two times (20%). Pneumonia has occurred three times (30%), but these have in this study been split up and haven't always been seen as the main reason of death and therefore fall, within the division into the three main groups, among various causes. VHD has been concluded once (10%), this also applies to bacterial sepsis (unspecified). Pasteurella hasn't been mentioned as a cause of death. A full account of the distribution of causes of death is reflected in the Tables 13, 14, 15 and 16 (Appendix4).

2. Sudden death

The number of animals that died suddenly in this group is 20%. These were caused by VHD (n=1) and E. Cuniculi (n=1).

Discussion

Limitations of this study

This study made use of necropsy reports of pet rabbits offered over a period of 16 years. The aim was to obtain an overview regarding the causes of death of pet rabbits prematurely deceased. However, it's difficult to say how the population of rabbits used in this study, reflect the whole population premature deceased pet rabbits.

Remarkable here is the low percentage of necropsy reports in which preliminary clinical diagnosis is to be found. Only 4,9% spoke of a clinical diagnosis or suspicion. It is therefore likely that above all, animals in which a clinical diagnosis was unknown were offered for necropsy. The motivation of the owner could be that if a clinical diagnosis already has been made, the precious necropsy of the corresponding rabbit is less important, whereas in rabbits with no clinical diagnosis, necropsy could indeed add a significant additional value for the owner. Although people are of good will and do indeed like their pets and think of them as important, animals shouldn't consume too much work, time and money [Veer, 1999]. It is therefore unlikely that every owner is motivated enough to offer their deceased rabbit for a necropsy. Consequently it's plausible that a unwanted selection has taken place, so that a vast majority of the animals are rabbits in which a clinical diagnosis was not or difficult to diagnose. Therefore diseases which are difficult to diagnose in the living animal, will result in a relatively large proportion of the necropsies. This problem can be overcome by lowering the threshold for necropsies so that people are more inclined to offer animals in which a clinical diagnosis is already made.

The absence of a clinical diagnosis reflects not only the problem of a possible selection to the population of rabbits in this study, but also the problem that many of the necropsy reports hardly contain a medical history with the corresponding data regarding the anamnesis. The intention to see if there are factors linked to the most common causes of death, were made difficult.

Since this study intended to make a finding on the causes of death in pet rabbits, it is important to note that it was not always possible to distinguish between pet rabbits and rabbits from rabbitries. The factors in which rabbits at rabbitries are kept differ from those with pet rabbits. Therefore the distribution of causes of death in rabbitries could differ from those of pet and thereby could affect the display of causes of death in this study.

The age criteria that have been related to premature death (6 to 36 months) do not include all animals that die prematurely, as the group of animals of zero to six months and the group older than 36 months do not show, whereas the average life expectancy is set to 8-12 years [Caneel et al., 2000]. Diseases at an older age, still causing premature mortality, such as uterine adenocarcinoma [Baba and von Haam, 1972; Cutler, 1998] will result in this study as a relatively low share (in this study uterine adenocarcinoma has been

found just once, the rabbit died of pasteurellosis). The share of death caused by neoplasia is in this study is zero.

Hypothesis

The expectation made beforehand pronounced enteritis as one of the two most common causes of death. This seems not the case, since other causes gained higher rates. (VHD, Pasteurella, Bacterial sepsis). Although 6,3% seems to come close to the rate of death by bacterial sepsis, it is important to realize that enteritis is not always seen as the cause of death. In the results, enteritis has been placed among different causes than enteritis. Therefore, the actual rate at which enteritis plays a causal role in mortality is contributed less. However there is also to debate if infectious causes as dysbacteriosis, Clostridium, Tyzzer's disease, coccidiosis and E. coli should been seen as enteritis. In that case, the mortality rate due to enteritis is higher and might meet expectations. (Table 5 appendix 4)

The expectation made beforehand pronounced Fatty liver, due to a high expectation of anorexia and dysfunction of the gastrointestinal tract [Langenecker et al., 2009; Mullan and Main, 2006; Harcourt-Brown, 2002], as one of the two most common causes of death. This seems not the case, since other causes gained higher rates. (VHD, Pasteurella, bacterial sepsis). Evidence for Fatty liver in cytology and microscopy are high, however, are often not listed as such in the conclusion. Fatty liver perhaps is common, though it seems actually less responsible for mortality.

Trends in the causes of early death

A notable trend in the results seems to be the large proportion of infectious causes compared to non-infectious causes and the group whose etiology is unknown. The fact that the infectious causes seems to play such a large role in the premature death of rabbits may have important consequences for the factors related to welfare. Where as a highly virulent agent could cause disease in a healthy animal without being compromised by welfare factors, in contrast factors such as environmental conditions which elicit physiological coping responses in animals, thus involving poor welfare, alter animals' susceptibility to infectious agents [Broom, 2006].

In a further breakdown of the causes of early death, it is striking that three diseases seems to amount for the largest proportion of early mortality. These are VHD, Pasteurella multocida and bacterial sepsis. In the latter, no specific cause was appointed and further investigation in this study is therefore difficult.

Sudden death

Within the population of '93-'09, an overview of 'sudden death' mortality has been made. It should be noted that sudden deaths play a major role in the introduced animals (44,8%). Within the group of animals that died suddenly the majority was caused by disorders of the top 3 (VHD, Pasteurella, bacterial sepsis) and this was in comparison with the distribution of sudden death by other causes than VHD, Pasteurella and bacterial sepsis significantly different.

This relation could be caused by a possible adverse selection on the animals. Animals dying of diseases that have a rapid disease course and cause sudden death, such as VHD and Pasteurella multocida [Quesenberry and Carpenter, 1997; Donnelly, 1995] could be therefore more difficult to diagnose in the living animal, in which cases the owner could be motivated for the animal to offer for necropsy. Animals with the disease course slower and in which a diagnosis has been made during life, may be offered less for the costly necropsy. This potentially unwanted selection, could give raise to a bias with respect to high numbers of animals died prematurely from VHD, Pasteurella and bacterial sepsis.

VHD

In this study VHD seems to have the biggest role in causing premature death in rabbits. VHD is caused by a calicivirus that only occurs in the European rabbit (Oryctolagus cuniculus) [Lavazza and Capucci, 2006] and is known for a high morbidity and a high mortality, ranging 80-100% [Lavazza and Capucci, 2006; Chasey, 1997; Xu and Chen, 1989]. The acute disease is characterized by few signs and sudden death [Goodly, 2001]. This is also reflected in the results of this study, whereby in 77,8% of the deaths caused by VHD, there is mention of sudden death in the anamnesis. But how sudden death is associated with the corresponding difficulties to make a clinical diagnosis and therefore has become an unwanted selection criterion, is not to say. Perhaps therefore the proportion prematurely dying of pet rabbits by VHD in the population is much lower than this study suggests.

VHD is spread through contact with infected rabbits, mostly by fecal-oral contact. As VHD is currently endemic in Europe [Lavazza and Capucci, 2006; Goodly, 2001], it can be said that with respect to husbandry, rabbits held outside are at risk of becoming infected. In Australia it has been shown that flies also can play a role in the transmission [Asgari et al., 1998]and even transmission through aerosol spread is possible [Chasey, 1997].The virus is very stable and transmission can also occur indirectly through people and materials [Lavazza and Capucci, 2006; Chasey, 1997]. Therefore, animals held inside could also get infected.

Because of the high resistance of the virus, it can stay infectious in the environment for several weeks, it's therefore important that hygiene measures are taken to minimize transmission[Donnelly, 1995; Lavazza and Capucci, 2006; Chasey, 1997]. It's possible to vaccinate against VHD .Vaccination gives a 6 month protection and is therefore needed two times a year[Donnelly, 1995].

VHD occurs mainly in adult rabbits older than 2 months. These are healthy rabbits in a good body condition [Chasey, 1997], which also seems to be reflected in the distribution of body condition scores in this study (though not proven by statistic tests), and because of the wide range of vectors, directly and indirectly, and the high resistance of the virus it will be difficult to prevent transmission [Lavazza and Capucci, 2006; Chasey, 1997]. Therefore in general, but also with respect to welfare issues, the best way to prevent death of pet rabbits by VHD is vaccination.

Pasteurella

Pasteurellosis seems to be in this study the second most common cause of premature death in rabbits. Pasteurellosis, caused by Pasteurella multocida, is a known widespread infection in lab rabbits [Cary et al., 1984], but is also in pet rabbits in the form of "snuffles" one of the most common problems [Langan et al., 2000].

It has several forms of manifestations, the most evident of which is the respiratory form. The respiratory form is first localized in the upper respiratory tract, known as above-mentioned “snuffles”, and the ultimate outcome is pneumonia and pleuropneumonia leading to death. There are also forms that form abscesses, otitis and encephalitis or septicemia. In the septicemic form, most often no respiratory signs are observed and rabbits can die without any apparent symptoms. The latter is in laboratory rabbits said to be seldom diagnosed [Coudert et al., 2006].

In this study, in cases involving Pasteurella, pneumonia is named 6 times and hepatitis once as a major factor in the cause of death, but in 14 out of 20 rabbits, sepsis / acute pasteurellosis is specifically emphasized. Therefore the septicemic form in this study seems to be a major cause of death in the early death of rabbits. In cases of Pasteurella, particularly in the septicemic form, there is a high risk of sudden death [Coudert et al., 2006]. As sudden death is in this study possibly an adverse selection criterion it may have been, as with VHD, that the share of mortality by Pasteurella is biased high.

Pasteurella multocida comprises five capsular serogroups and 16 somatic serotypes [Dabo et al., 1999]. Together they form a wide range of different strains. These strains are different in their virulence, so strains that cause respiratory problems are different from those causing septicemia [Dabo et al., 1999; Lu et al., 1983; Carter and Chengappa, 1980; Okerman et al., 1979]. Therefore, although “snuffles” is a common problem, literature suggest that this may be seen as separate from high mortality rate due to Pasteurella sepsis.

Conjunctival, oral, transcutaneous and vaginal routes have been described, but the nasal route is the major route of penetration [Coudert et al., 2006]. The rabbit upper respiratory tract constitutes a very effective mean of defense. However, the mucous membrane is very fragile, thus rapid air velocity or a to low relative humidity will end in drying-up the mucous membrane and of a increased sensitivity of the epithelium to infection. An ammonia level above 5 ppm is enough to paralyze the epithelial cilia in rabbits and promote rhinitis. Pelleted feeds containing too many “ fines” (poorly agglomerated particles) will have the same effect [Coudert et al., 2006]. So with respect to husbandry, poor hygiene of the rabbit’s immediate environment, inadequate ventilation as well as overcrowding are promoting factors [Coudert et al., 2006].

Pasteurellae do not survive a long time outside the organism. Airborne transmission, in the strict sense of speaking, plays a minor role except when the air is loaded with dust. They are facultative anaerobic, highly susceptible to physiochemical treatments and can only survive a few days in 4°C but for weeks in slurries and corpses [Coudert et al., 2006]. Therefore sanitary

regiments and disinfection can play an important role, but promoting causes of ventilation and NH3 level and dust should be reduced [Coudert et al., 2006].

It's also shown that rabbits with high levels of cortisone have a higher prevalence and more severe lesions [Lu et al., 1983] and therefore stressful events, such as sudden changes in environments, or chronic stress should be avoided.

Comparison of the survey's of necropsies '93-'09 and '09-'10
The necropsies on the animals of the period October 2009 until February 2010 were performed free of charge and together with the additional advertising to reach a wider audience to offer their animals for necropsies, the aim was to reduce the influence of the motivation of the owner and therefore the selection on the population of rabbits used in this study. Although E. cuniculi occurs twice, because of the small numbers of animals there is no ruling which causes of death occur most.

As seen in figure 8, the distribution of causes of death in the groups infectious, non-infectious and etiology unknown, it seems that the distribution in the period '09-'10 is not fully comparable with the distribution for the period '93-'09, but the difference is not significant.

Also in the period '09-'10 there is pneumonia seen three times and in this study those are to be found among different denominators. When those could be found among Pasteurella, there would be a totally different division that much more appears to match the distribution of the period 1993-2009. This alternative comparison is depicted in Figure 9 (Appendix 5). The supply of animals was in this time span still too low for a good comparison and to make statements about differences and similarities between the two populations of rabbits in this study.

Other factors

Euthanasia
When we compare the euthanized rabbits and reasons for euthanasia, and therefore the indirect causes of death (infectious, non-infectious, etiology unknown), with the population of animals of '93-'09 in this study that were not euthanized, there seems to be more death because of diseases of unknown etiology, although the difference is not significant since we obtained a P-value of 0,072. Therefore we conclude that in this study euthanasia doesn't really seem to influence the distribution of causes of death.

Body condition
Concerning the body condition, determined in the period '93-'09, it is striking that the group of animals died of VHD were all in a good to excessive body condition and non were in a moderate to poor body condition, though this is agreement with literature[Chasey, 1997]. This distribution is different with respect to the entire population. The distribution of body condition of animals died of Pasteurella corresponds to its distribution throughout the population. Looking at the groups, divided according to body condition, the mortality in moderate to poor body condition seems mainly due to causes other than the top three (82,4%). Regarding these findings, it is important to

realize that determining and documenting the body condition score was in this study not defined by a protocol and executed by different individuals. The use of statistics would create an apparent certainty, therefore no statistics were used and conclusions of the body condition can't be made.

Future research

In this study, we faced a number of constraints which could be overcome in future research. To conduct necropsies which are free of costs for the owner, there probably will be a population of rabbits in the study available that is more comparable to the total population prematurely died pet rabbits, as is started in the second part of this study. However this research should be conducted over a longer time span, so there could be higher number of animals available and therefore more accurate conclusions in the trends of premature death could be made.

When the necropsies will be accompanied by a comprehensive report of medical history with the corresponding data regarding the anamnesis, more informed conclusions about zootechnical and / or welfare factors can be made.

Where similar research is done without the criteria of age, there can be obtained a clearer view of the distribution of causes of death in relation to the total range of age.

It also deserves attention for doing similar research in other species, because also within other pets, such as guinea pigs and rats, there is relatively high premature mortality [Caneel et al., 2000]. By doing similar research within these species and look at trends in premature mortality and any related welfare and zootechnical factors, a comparison of those related factors to between several species could be made. This comparison could allow us to make statements about the care of pets and structural mistakes made by owners.

Concluding remarks

Within this research it is notable that particularly the infectious diseases contribute to the premature death of pet rabbits. The three most common causes of premature death in rabbits seems to be VHD, Pasteurella multocida and bacterial sepsis, the latter unspecified. The image is probably distorted by a selective population of animals within this study, of which a large number of animals was characterized by sudden death. Factors related to zootechnics and welfare, based on literature, seems to concern particularly pasteurellosis in which good ventilation and hygiene and the prevention of stress are important. With VHD biannual vaccination seems to be the best prevention. More research with a wider range of animals that died, accompanied of extensive data regarding the anamnesis and medical history, are needed to be able to make more substantiated statements on the zootechnical and welfare-related factors of premature death in pet rabbits and other species.

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Attachments

Appendix 1. Protocol Necropsy VPDC

Pathologienummer: Diersoort:

KLADBLOK
Gebeld met inzender (d.d., door wie, welke mededeling):

Cassette 1:
Cassette 2:
Cassette 3:
Cassette 4:

Los in formaline:
Ingevroren:

CYTOLOGIE
HC lever:
HC milt:
HC long:
HC darm:
Natief darm:

IFT: ja/nee

MACROSCOPIE
Sectiedatum: Path./ sio: Student:

Chip/Oormerk:
Vacht:
Bespiering/ voedingstoestand:
Gewicht:

Kop en hals
Neus:
Oren/Ogen:
Mondholte/gebit:
Tong (incl. speekselklier):
Hersenen:
(Bij)schildklier:

Thorax/ respiratie & circulatie
Ligging organen / vrij vocht:
Trachea:
Pleura/diafragma:
Longen:
Hart en grote vaten:

Abdomen/ overige interne organen
Ligging organen/ vrij vocht:
Maag:
Duodenum/ pancreas:
Jejunum/ ileum:
Colon:
Caecum:
Lever:
Milt:
Lnn:
Nieren:
Bijnieren:
Blaas:
Geslachtsapparaat: m/v t

Skelet/ extremiteiten
Mineralisatie:
Gewrichten:
Voetzolen:

Voorlopige conclusie na macroscopie:

Appendix 2. Protocol Necropsy Welfare project small mammals VPDC

Macroscopy	Microscopy: put in cassettes	Freeze
identification chip/ tatoo		
body weight		
skin, nails	skin left flank	
bone (right femur)	right femoral head, **decalcify**	
skeletal muscle	dorsal back muscles, left	
eyes	OS and OD	
external ears		
nose, larynx	conchae	
mouth, teeth		
pharynx and oesophagus	oesophagus	
(para) thyroid	(para) thyroid	
trachea	trachea	
lung	lung	lung
hart	hart, full circle at 1/3 height	hart
large vessels		
		fat
intestinal tract	stomach, duodenum, jejunum, caecum, colon	colon
pancreas	pancreas	pancreas
liver and gall bladder	liver and gall bladder	liver
kidney end urinary tract	kidney, bladder	kidneys
spleen, lymph nodes	spleen, Lnn. Mesenteriales	spleen
bone marrow (right femur)	bone marrow R. femur, distal and middiafyse	
adrenal gland	adrenal gland	adrenal gland
brain	brain	brain
pituitary gland	pituitary gland	
redproduction organs	ovaries, uterus, testicles	
other pathologically changed areas	other pathologically changed areas	

Appendix 3. Questionnaire Anamnesis

Anamneseformulier welzijnsonderzoek
konijn, cavia, fret en rat

VPDC, Postbus 80158, 3508TD UTRECHT **Tel. 030- 253 3195** Fax: 030-2534774

Praktijk: …… Relatienummer:……
Dierenarts: …… E-mail:……
Tel. Nr.: ……

Eigenaar …… Konijn/ cavia/ fret/ rat (omcirkelen wat van toepassing is)
Straat: …… Naam/ nr…….. .....
Postcode: …… Leeftijd/ Geb. datum:……
Woonplaats: …… Geslacht: M/ ex-M/ V/ ex-V
Tel. Nr.: ……
Code eigenaar: ……..

Crematie □ nee/ □ ja, naar……
□ **Euthanasie/** □ **Gestorven** □ dd:……

Individu ziek sinds:.....
Aantal dieren in groep: .....
Aantal dieren in eenheid ziek:.....
Reeds behandeld met: ……
Tijdsduur behandeling: ……

Verschijnselen
□ Diarrhee □ Ademhalingsproblemen □ Huidproblemen
□ Kreupelheid □ Slechte groei □ Plotseling dood
□ Slecht eten □ Slecht drinken

Huisvesting:
Lokatie: □ Binnen □ Buiten
Afmetingen: L: ..... B: ..... H: .....
Materialen: □ Hout □ Metaal □ Plastic/Fiberglas
□ Glas □ Anders.....
Bodembedekking:.....
Extra ventilatie: □ Nee □ Ja
Frequentie schoonmaken huisvesting:.....
Gebruikte schoonmaakmiddelen/desinfectia:.....

Voederfrequentie:.....
Voersamenstelling:
0 Pellets: Merk..... Hoeveelheid:.....
0 Hooi Merk..... Hoeveelheid:.....
0 Groente Soort..... Hoeveelheid:.....
0 Fruit Soort..... Hoeveelheid:.....
0 Snoepjes Merk..... Hoeveelheid:.....
0 Anders Beschrijving.....
Wat wordt hiervan gegeten?.....
Voedingssupplementen (incl. vitamine C): □ Nee □ Ja
Watervoorziening: □ kraanwater □ water uit een fles □ regenwater □ anders
Type: □ Schaaltje/kom □ Drinknippel
Frequentie verversen van water:.....

Anamnese: .....
.....
.....

Klinische diagnose: .....
……
……

Appendix 4. Results

Table 1. Causes of death '93-'09

Cause of death	Number	%
Infectious	97	67,8%
Non-infectious	25	17,5%
Unknown	21	14,7%
Total	**143**	**100,0%**

Table 2. Infectious causes of death '93-'09

Causative agent of death	Number	%
VHD	45	31,5%
Pasteurella	20	14,0%
Baterial sepsis (unspecified)	10	7,0%
Dysbacteriosis	5	3,5%
E. cuniculi	4	3,5%
E. coli	3	2,1%
Graphidium strigosum	2	1,4%
Clostridium	2	0,7%
Myxamatosis	1	0,7%
Coccidiosis	1	0,7%
Yersinia pseudotuberculosis	1	0,7%
Tyzzer's disease	1	0,7%
Shope firbroma	1	0,7%
Other	1	0,7%
Total	**97**	**67,8%**

Table 3. Non-infectious causes of death '93-'09

Cause of death	Number	%
Trauma	4	2,8%
Heart failure (anesthesia)	4	2,8%
Heart failure (cause unclear)	2	1,4%
Teeth	2	1,4%
Ileus	2	1,4%
Liver lobe torsi	2	1,4%
Metabolic (ketoacidosis/ Fatty liver)	2	1,4%
Hyperthermia	1	0,7%
Hypocalcemia	1	0,7%
Stomach rupture	1	0,7%
Anorexia	1	0,7%
Kidney problem	1	0,7%
Aspiration pneumonia	1	0,7%
Dysfunction of caecum	1	0,7%
Total	**25**	**17,5%**

Table 4. Unknown causes of death '93-'09

Assumed organ	Number	%
liver	5	3,5%
gastrointestinal tract	4	2,8%
lungs	3	2,1%
heart	1	0,7%
pleura	1	0,7%
other	7	4,9%
Total	**21**	**14,7%**

Table 5. Cases with enteritis

Differentiation of causes of death	Enteritis found under:	Number	%
Infectious			
	Dysbacteriosis	1	
	E. Coli	1	
	Bacterial sepsis	1	
	Other: Diptheroid (unspecified)	1	
	VHD	1	
	Clostridium	1	
	Tyzzer's disease	1	
	Y. pseudotuberculosis	1	
Non-infectious			
	Aspirationpneumonia	1	
Total		**9**	**6,3%**

Table 6. Cases with Fatty Liver

Named in	Number	% within whole population	also in conclusion	%
Cytology	19	13,3%	3	15,8%
Microscopic	9	6,3%	3	22,2%
Conclusion	**4**	**2,8%**	x	x

Table 7. Euthanized animals

Cause of illnes	Number	%
Infectious	5	50,0%
Non-infectious	1	10, 0%
Unkown	4	40,0%
Total	**10**	**100,0%**

Table 8. Sudden death by 'top 3 within population 'died suddenly'

Cause of death	Number	%
VHD	35	54,7%
Pasteurella	8	12,5%
Bacterial sepsis (unspecified)	5	7,8%
Total	**48**	**75,0%**

Table 9. Sudden death mortality in perspective to overall mortality within 'top 3'causes of death

Cause of death	Number of animals died	Numbers of animals died suddenly	% of animals died suddenly
VHD	45	35	77,8%
Pasteurella	20	8	40,0%
Bacterial sepsis (unspecified)	10	5	50,0%
Other	68	16	23,5%

Table 10. Numbers of body condition scores within different causes of death

Score	VHD	Pasteurella	Bacterial sepsis (unspecified)	Other
Excessive	10	5	5	16
Good/normal	25	8	5	18
Moderate-poor	0	2	1	14
No data	10	5	3	16
Total	**45**	**20**	**14**	**64**

Table 11. Distribution of body condition score within populations based on cause of death

Score	VHD	Pasteurella	Bacterial sepsis (unspecified)	Other
Excessive	22,2%	25,0%	35,7%	25,0%
Good/normal	55,6%	40,0%	35,7%	28,1%
Moderate/Poor	0,0%	10,0%	7,1%	21,9%
No data	22,2%	25,0%	21,4%	25,0%
Total	**100,0%**	**100,0%**	**100,0%**	**100,0%**

Table 5. Distribution of causes of death within populations based on body condition scores

Score	VHD	Pasteurella	Bacterial sepsis (unspecified)	Other	Total
Excessive	27,8%	13,9%	13,9%	44,4%	100,0%
Good/normal	44,6%	14,3%	8,9%	32,1%	100,0%
Moderate/Poor	0,0%	11,8%	5,9%	82,4%	100,0%
No data	29,4%	14,7%	8,8%	47,1%	100,0%
Whole poplation	*31,5%*	*14,0%*	*7,0%*	*47,5%*	*100,0%*

Table 13. Causes of death '09-'10

Cause of death	Number	%
Infectious	5	50,0%
Non-infectious	4	40,0%
Unknown	1	10,0%
Total	**10**	**100,0%**

Table 6. Infectious causes of death '09-'10

Infectious agent causative of death	Number	%
Bacterial bronchopneumonia (unspecified)	1	10,0%
E. Cuniculi	2	20,0%
Bacterial sepsis (unspecified)	1	10,0%
VHD	1	10,0%
Total	**5**	**50,0%**

Table 15. Non-infectious causes of death '09-'10

Cause of death	Number	%
Teeth	1	10,0%
Pneumoniae	2	20,0%
Necrosis of fat	1	10,0%
Total	**4**	**40,0%**

Table 16. Unknown causes of death '09-'10

Assumed organ	Number	%
Kidneys	1	10,0%
Total	**1**	**10,0%**

Appendix 5. Diagram Alternative comparison of distribution of death causes

Figure 9. Alternative comparison of the distribution of death causes of '93-'09 and '09-'10