

# CHAPTER 3

## STATISTICS, BY BODY SYSTEM, RELATING TO RED SQUIRRELS PRESENTED FOR POST MORTEM EXAMINATION

### Introduction

**Natural causes of morbidity and mortality are many and varied, which makes this area of red squirrel conservation particularly interesting, and a number of published papers, including new discoveries such as leprosy, have resulted from this work. Given the time taken to put this publication together, cases have been added after some chapters are already finished, therefore the figures are not always consistent.**

Chapter 3 looks at the statistics relating to body systems and touches on the wide variety of pathogens and injuries found in 813 red squirrels on the Isle of Wight between 1993 and 2001. Chapter 4 goes into greater depth and discusses specific diseases. As part 3 is about reporting data and not teaching, readers will require a basic understanding of the body systems and pathogens.

Some body systems have more data entries than others, so there is no set pattern to how the results of each system are written up. Pathology may show in one organ or multiple organs, therefore the same case will appear in more than one table.

Euthanasia (1.5% of cases) is included in cause of death tables as barbiturates do burn the internal organs they touch, usually the heart, lungs and liver but occasionally the kidneys and adrenals. All squirrels euthanised by the vet had extreme pathology and no chance of recovery and return to the wild, therefore euthanasia was the kindest outcome as the animal was suffering.

Misadventure (1.5% of cases) covers mishaps such as falling onto a large pyracantha thorn, electrocution or drowning in a water butt. Rat poison (1.5% of cases) affects all the organs, although as the varying figures for the body

systems show, the effects are not always apparent by eye in every organ. The wild predator entries (0.5% of cases) relate mainly to red squirrels killed by birds, generally buzzards, or in one instance, a fox.

Undetermined entries (4% of cases) speak for themselves. Even with testing, it is not always possible to positively identify the cause of death. Sending samples for testing was relatively easy in the beginning, until labs began to close. Although samples are kept for a while, if nobody wants them, they are discarded. This, sadly, leaves many questions unanswered.

Over half of the animals brought in for post mortem examination are adults but as road kills account for 67% of adult deaths overall, this is unsurprising. Sub-adults (squirrels up to a year old) often do not survive their first year and although some are killed crossing roads, many more are brought in sick or deceased due to various diseases or poor condition. Sub-adults and juveniles (squirrels not yet weaned) are more often found dead in gardens.

Cause of death	Number	%
Cat kill	64	7.9
Dog kill	6	0.7
Euthanised	14	1.7
Misadventure	13	1.6
Natural causes	244	30
Rat poison	14	1.7
Road kill	425	52.3
Undetermined	29	3.6
Wild predator	4	0.5
<b>Total</b>	<b>813</b>	

Table showing the breakdown of cause of death for all 813 cases recorded up to mid 2022

### Respiratory system

The age breakdown relating to the respiratory system is no surprise as there are more adults presented for post mortem examination. Also, as mentioned previously, the highest percentage of road kills are adults. Significant diseases such as toxoplasmosis are discussed in detail in the next chapter.

The lungs are often damaged due to impact with a vehicle, although trauma to the head is generally the cause of death. Naturally, a road kill squirrel may also show pathology in the lungs – and other organs – even if it is not the cause of death.

A cat or dog kill does generally show trauma to the lungs due to asphyxiation, or by a dog holding the squirrel in its teeth, hence the high number in the table.

One case of a pulmonary carcinoma caused the death of a sub-adult female squirrel found dead in a garden. She was in poor condition and had a heavy flea burden. An extensive invasive mass in one lung was discovered after histological examination. The mass was composed of innumerable islands of pleomorphic epithelial cells<sup>1</sup> separated by a fibrovascular stroma<sup>2</sup>. Enclosed within the mass were numerous alveoli, bronchial glands and foci<sup>3</sup> of necrosis and inflammatory cells (V. Simpson *et al.* 2013).

<sup>1</sup> Pleomorphic epithelial cells: potentially cancerous cells

<sup>2</sup> Fibrovascular stroma: fibrous connective tissue associated with growths

<sup>3</sup> Foci: cells in an organ that are different from surrounding cells

Age	Number	%
Adult	277	66%
Sub-adult	95	22%
Juvenile	52	12%
<b>Total</b>	<b>424</b>	

### Age breakdown

Details	Number	%
Barbiturate damage	12	2.8%
<i>Bordetella</i>	3	0.7%
Congenital defects	3	0.7%
Damage to trachea	2	0.5%
Displaced or macerated lungs	44	10.4%
Hepatozoon	4	0.9%
Impact lesions	219	51.6%
Puncture wounds	17	4%
<i>Toxoplasma</i>	5	1.2%
No pathology	108	25.5%
Other pathology	7	1.7%
<b>Total</b>	<b>424</b>	

Table giving pathology found in squirrels mentioned in the respiratory system column of the database.

Comparing this table to the table above shows that cause of death is not always due to disease

Cause of death	Number	%
Cat/dog kill	49	11.6%
Euthanised	12	2.8%
Misadventure	6	1.4%
Natural causes	118	27.8%
Rat poison	3	0.7%
Road kills	225	53.1%
Wild predator	2	0.5%
Undetermined	9	2.1%
<b>Total</b>	<b>424</b>	

Table showing cause of death where the respiratory system is mentioned

Ten of the 12 squirrels euthanised had lung damage due to barbiturate damage. The barbiturate missed the lungs in two animals. Reasons the squirrels were euthanised are varied and given in the table below.

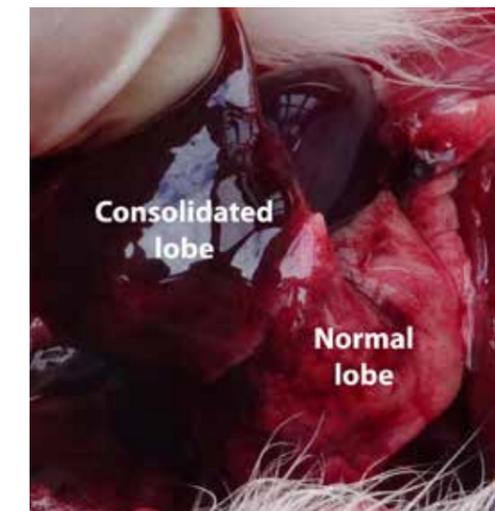
### Consolidation and congestion

A variety of causes of death show either consolidation or congestion of the lungs. Congestion and consolidation may be partial, that is they may affect part of a lobe or a percentage of the whole lung. Congestion is seen as a result of an infection or irritant. If untreated, consolidation and death follow. In these cases the heart struggles and becomes enlarged.

The majority of casualties (225) are road kills and unless the lungs are tested for pathology, the likelihood is that in the majority of cases congestion is recorded as being caused by the animal being hit by a vehicle rather than pathology. Displaced or macerated lungs and damage to the trachea also relate to road kills. Puncture wounds are generally inflicted by a cat or dog, except in the case of an unfortunate squirrel that fell onto a large pyracantha thorn. *Bordetella*, *Hepatozoon*, *Toxoplasma*, congenital defects and other diseases are discussed in future chapters.



An example of congested lungs



An example of a consolidated lobe

Location	Sex	Age	Details
Alverstone	F	SA	Caught in trap and lost limbs
Appuldurcombe	F	J	Blind in left eye. Euthanised due to congenital abnormalities
Blackwater	M	SA	Abscess
Brading	M	J	Euthanised due to skin loss
Firestone	M	A	Caught by dog
Freshwater	F	A	Broken bones in foot
Havenstreet	F	A	Osteomyelitis
Lake	M	SA	Poor condition. Displaced scapula
Ningwood	F	A	Caught in trap and lost limbs
Ryde	F	SA	Congenital defect
Shanklin	F	SA	Abscess
Wootton	M	A	Fractured cervical vertebrae

Table showing condition of the 12 red squirrels that were euthanised

### Key to all tables

F	Female	M	Male
A	Adult	SA	Sub-adult
J	Juvenile		

Sex	Age	Details	Final Diagnosis
M	A	Brown spots 3mm diameter on rt. lung. Numerous <i>Hepatozoon</i> schizonts. Heavy neutrophil infiltration of bronchioles & parenchyma	Pneumonia cause unknown
M	SA	2mm white irregular foreign body embedded behind right lung	Pneumonia cause unknown
M	SA	Badly congested lungs and small nodules on lobes	Poor condition
M	J	Collapsed, including cellularity, prominent alveolar macrophages, few <i>Hepatozoon</i> schizonts. Bronchioles contain degenerated cells plus coccal bacteria	Bacterial bronchitis suspected
M	SA	Congested, suspect protozoal schizonts	Pulmonary & cardiac failure due to unidentified protozoan
M	A	Diffuse foci of neutrophils, oedema	Suspect due to bacterial hepatitis/cholangitis leading to septicaemia
F	A	Displaced lobe (medial lobe displaced anteriorly). Discolouration indicates ante mortem	Gastritis
F	A	Enlarged & congested lungs. Focal necrosis. <i>Toxoplasma</i> schizonts	<i>Toxoplasma</i>
M	A	Lung congestion over whole lungs but not consolidated	Generally debilitated and possible toxoplasmosis
F	A	Lungs congested	<i>Bordetella</i>
F	SA	Lungs 100% congested	<i>Toxoplasma</i>
F	A	Lungs consolidated. Occasional schizonts	<i>Toxoplasma</i>
F	A	Lungs enlarged & congested. Irregular surface	<i>Bordetella</i>
F	A	Many macrophages full of yellow/brown pigment. No <i>Hepatozoon</i> or other protozoa	<i>Toxoplasmosis</i>
M	J	Numerous streptococcal colonies in lung	Streptococcal
M	A	Scattered haemorrhagic foci both lungs	Unidentified infection
F	SA	Several thrombosed vessels	Exudative dermatitis
M	A	Yellowing lungs. Jaundice through blood virus	Haemolytic icterus
F	A	Congested non-purulent fluid in bronchi, recent thrombus in one artery	Road kill (had cancer)
M	A	Left lung consolidated and right heavily congested. <i>Hepatozoon</i> 3+	Road kill

A sample of cases mentioning lung pathology

#### Key to all tables

F Female  
M Male  
A Adult  
SA Sub-adult  
J Juvenile

## Liver

The majority of lesions seen in the liver are caused by impact trauma seen in road kills. Notable pathology involving the liver is a cluster of hepatitis cases, *Toxoplasma*, *Bordetella* and one case of suspected *Yersinia pseudotuberculosis* as assessed by professional pathologist Dr Ian Keymer.

The liver may appear enlarged and pale with necrotic foci and *Toxoplasma* schizonts present if the squirrel has contracted toxoplasmosis. This description does appear in the database numerous times but unless the samples are sent to a laboratory for testing, all but a few cases are unconfirmed.

As a soft organ, the liver is often damaged in road kills. Damage ranges from lesions to maceration. On occasion, the organs, including the liver, are displaced within the body cavity. The gall bladder may also burst, spreading yellow bile onto adjacent organs.

A liver may appear spongy in texture, discoloured and dull if the squirrel has an illness. Spots on the surface of the liver, as in the case of suspected *Yersinia pseudotuberculosis*, are also seen occasionally. Without laboratory testing, the cause of these lesions cannot be confirmed.

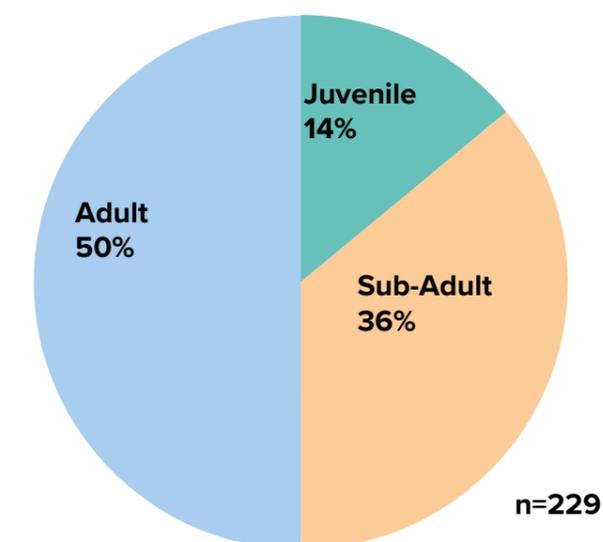


Liver with atypical appearance

Cause of death	Number	%
Cat/dog kill	0	4%
Euthanised	6	2.5%
Misadventure	2	1%
Natural causes	73	32%
Rat poison	4	2%
Road kill	130	56.5%
Undetermined	4	2%
<b>Total</b>	<b>229</b>	

Table showing cause of death where the liver is mentioned

### Liver pathology. Age breakdown



Location	Sex	Age	Liver pathology	Cause of death
Firestone	F	A	Enlarged liver disintegrated when squeezed	Unidentified infection
St Lawrence	M	A	Multiple granulomas with <i>Capillaria</i> eggs & adult worms	Road kill
Alverstone	F	A	Multiple foci of necrosis with possible <i>Toxoplasma</i> schizonts in hepatocytes <sup>1</sup> in margins	<i>Toxoplasma</i>
Wootton	F	A	Enlarged & pale. Necrotic foci, numerous <i>Toxoplasma</i> schizonts present	<i>Toxoplasma</i>
Wootton	F	A	Multifocal hepatic necrosis & clusters of tachyzoites <sup>2</sup> in margins	<i>Toxoplasma</i>
Wootton	M	SA	<i>E. coli</i> and unidentified bacterium	Ectoparasites
Ningwood	F	A	Necrotic yellow area approx. 5mm diam. Remaining liver pale	Septicaemia
Ryde	M	J	Gall bladder black & hard. Bile leaked	Gastritis
Northwood	F	A	Solidified & enlarged liver	Hepatitis
Nettlestone	M	A	Yellowing liver. Bile duct unblocked. Jaundice through blood virus	Haemolytic icterus
Parkhurst	M	J	Possible peribronchial fibrosis plus mineralised foci in arterial wall	Inconclusive
Northwood	F	A	Surface mottled. Inside spongy	<i>Bordetella</i>
Northwood	F	A	Dark patches on liver	<i>Bordetella</i>
Gurnard	F	A	Focal necrosis throughout liver. <i>Toxoplasma</i> +ve	<i>Toxoplasma</i>
Northwood	M	A	Lymphocytic infiltration around bile ducts. Suspect due to bacterial hepatitis/cholangitis leading to	Septicaemia

A sample of cases mentioning liver pathology

<sup>1</sup> Hepatocytes: Cells making up the majority of the liver

<sup>2</sup> Tachyzoites: Rapidly multiplying cells in certain infections such as *Toxoplasma gondii*

## Skin

Once again, road kills and adults account for the highest numbers of animals where skin lesions are recorded in the database. Rat poison cases may seem unlikely to have skin lesions but, as the table shows, they do, even though they are unrelated to the cause of death. The comments in the table below are taken from the 'skin lesions' column of the post mortem database.

Fatal exudative dermatitis and *Staphylococcus aureus* present with skin lesions and are discussed in detail in the following chapter. Fleas are a problem for red squirrels and ectoparasites are also discussed in the following chapters. It is vital to keep the flea burden down as they are a significant cause of anaemia. It is rare to find mites and very rare to see a tick.

### Skin lesions mentioned in cases relating to rat poisoning

3mm x 15mm missing fur upper left groin

Coat wet. Nick on lower lip.

25mm x 3mm abrasion near side

Old abrasions on left foot

Scaly patches in armpits 4mm x 5mm

42mm x 22.5mm patch of fur regrowth on back

Puncture wound penetrated right ribcage due to bird scavenging fresh carcass

Lesions on tongue, lower lip and palette

Tail stripped of fur & some missing from rump

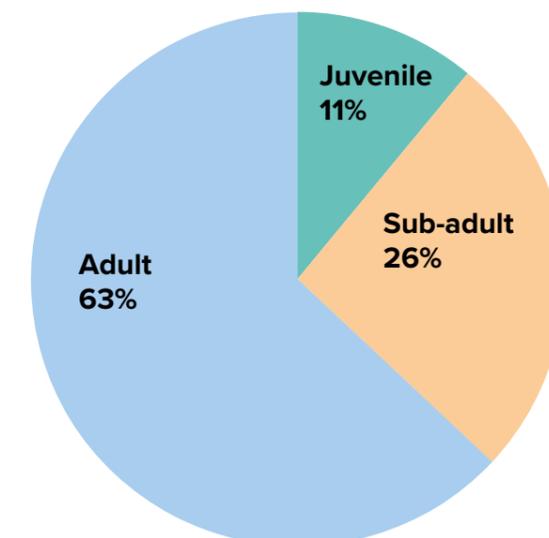
Cause of death	Number	%
Cat/dog kill	17	10.6%
Euthanised	9	5.6%
Misadventure	3	1.9%
Natural causes	74	46.3%
Rat poison	8	5%
Road kill	37	23%
Undetermined	10	6.3%
Wild predator	2	1.3%
<b>Total</b>	<b>160</b>	

Table showing cause of death where skin pathology is mentioned



Flea droppings on a squirrel with a high number of the parasites

### Skin pathology. Age breakdown



n=160

### Musculo-skeletal system

Pathology relating to the musculo-skeletal system is predominantly trauma injuries sustained in road traffic accidents. Minor concussion is rare and generally the squirrel recovers and is released. As usual, the high percentage of adults relates to road kills. Eighty-seven percent of road kill injuries are to the head, suggesting that the squirrel hit the car, as opposed to the car running over the squirrel.

If a squirrel is inactive due to illness, then muscle tone is poor. Unsurprisingly, all animals with severe anaemia had poor muscle tone. Teeth are occasionally missing due to trauma or, in some cases, there is a congenital defect. All seven congenital defects relating to the musculo-skeletal system were found in young animals. More on this subject in the following chapters.

The three squirrels ingesting rat poison were also in poor condition, with one animal missing five digits. This squirrel was caught by a cat and, as the injuries did not appear fresh, presumably were not bitten off by the cat. Twenty squirrels overall had missing digits, which were not attributed to road kills. In the case of Fenn trap injuries, whole limbs were missing.

In common with other species, bones and teeth show wear in old age. An emaciated male that had been feeding in the same garden for years presumably died of old age as no pathology was found. He had arthritis and very poor muscle tone. His bones, particularly noticeable in the ribcage, were yellowed and hardened.

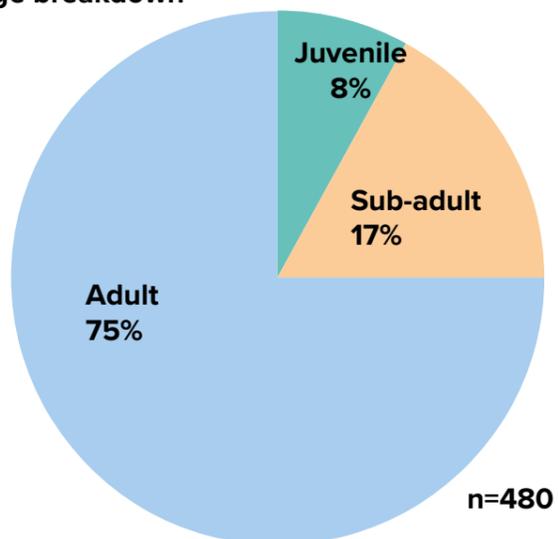
Cause of death	Number	%
Anaemia	14	3%
Cat/dog kills	11	2.3%
Euthanised	12	2.5%
Misadventure	3	0.5%
Natural causes	56	12%
Old age	1	0.2%
Rat poison	3	0.5%
Road kills	371	77.2%
Undetermined	9	1.8%
<b>Total</b>	<b>480</b>	

Table showing cause of death where the musculo-skeletal system is mentioned

Congenital defects	Number	%
Fractured skull	55	11.5%
Missing digits	20	4.2%
Multiple skull fractures	136	28.3%
Other injuries	91	19%
Poor muscle tone	45	9.4%
Skull mascerated	126	26.2%
<b>Total</b>	<b>480</b>	

Breakdown of musculo-skeletal injuries

### Musculo-skeletal system pathology. Age breakdown



Arthritic femurs compared to a young healthy femur

A juvenile female squirrel was found to have congenital hip dysplasia. That is, the head of the femur was unformed and too small to stay in the socket. She displayed normal behaviour in all respects and did adapt up to a point, but her back legs soon became sore, so she was euthanised.

An adult post-lactating female with a grossly enlarged forearm was brought in by a member of the general public. She was in good condition with a full stomach and no signs of disease. She was taken to a vet, who diagnosed osteomyelitis, so she was euthanised.

Osteomyelitis is a bone infection, causing swelling of the bone marrow. In turn, the soft tissue proliferates as the bone itself deteriorates. Peeling away the layers of excess flesh revealed that the left fore limb bones were crumbling and the fleshy mass extended into the shoulder. This is the only case found on the Isle of Wight to date.



Young squirrel with hip dysplasia



Grossly enlarged forepaw



Peeling away the tissue



Excess tissue extended into the thorax

## Cardiovascular system

The majority of cases involving the cardiovascular system relate to damage or displacement of the heart due to impact trauma, severe anaemia or thinning of the blood due to ingesting rat poison. In 103 cases the heart was compromised by the cause of death but heart pathology itself was not the direct cause.

One juvenile had an obvious congenital heart defect. His mother had pushed him out of the nest and he was found alive but died shortly afterwards.

Anaemia, predominantly in young animals, contributed to 21 deaths. These were all sub-adults with a very heavy flea infestation. Adults with a slow debilitating illness also had a heavy flea burden and some degree of anaemia but not to the extent of the sub-adults; indeed, the sub-adults had no bleeding upon cutting with a scalpel or any discernible blood in the body cavity.



*Congenital heart defect in juvenile male*

Details	Number	%
Anaemia	21	6%
Barbiturate damage	12	3%
Congenital defect	5	1.5%
Enlarged heart	29	8%
Impact lesions/organ displacement	160	44%
Mesentery blood vessel abnormality	5	1.5%
Thinned blood pooled in body cavity	14	4%
Various infections/conditions	115	32%
<b>Total</b>	<b>361</b>	

*Table showing pathology in the cardiovascular system*

Cause of death	Number	%
Cat/dog kill	22	6%
Euthanised	12	3%
Misadventure	7	2%
Natural causes	103	28.5%
Rat poison	14	4%
Road kill	194	54%
Undetermined	7	2%
Wild predator	2	0.5%
<b>Total</b>	<b>361</b>	

*Table showing cause of death where the cardiovascular system is mentioned*

Sex	Age	Details	Final Diagnosis
M	SA	Blood in pericardium. Blood-stained fluid in chest	Internal parasites
F	A	Congestive heart failure	Hepatitis
M	SA	Multiple foci of myocyte necrosis – heart	Pulmonary & cardiac failure due to unidentified protozoan
F	A	Few mononuclear foci. Internal haemorrhage	Road kill
M	J	Scattered mineralised foci	Possible peribronchial fibrosis plus mineralised foci in arterial wall
M	A	Fat accumulating around aorta	Road kill
M	SA	Few foci of necrosis in heart	Road kill
F	A	Haemorrhage into abdominal cavity. Blood thin. Mesentery vessels engorged with blood	Rat poison
M	A	Granuloma in one artery	Suspect due to bacterial hepatitis/ cholangitis leading to septicaemia
F	SA	Single focus of myocyte necrosis	Exudative dermatitis
M	A	Arteries from the heart appeared black and thicker than normal	Testicular cancer
F	A	Degenerative/necrotic myocytes, most right ventricle. Few Toxoplasma tachyzoites	Toxoplasmosis
M	SA	Foreign body attached to heart. White oval 2mm x 7mm	Unidentified endoparasite

*A sample of cases mentioning cardiovascular pathology*

## Digestive system

The digestive system has the most entries in the database, not due to any pathological reason but rather that stomach contents are generally, but not always, noted. Only 9.3% had pathology relating to the digestive system. Stomach size varied from below average size (by eye), with a tough leathery texture as opposed to the normal elastic structure, to very large. Rarely, a full stomach was stretched the length of the body cavity. Pathology found in the digestive system of red squirrels is remarkably similar to that of humans, that is, due to parasites, cancer, ulcers and infections. More details are given in the next chapter.

In road kill victims, the stomach and intestines are often displaced, with the large intestines sometimes pushed between the femur and muscle and the stomach burst. Stomach contents were not analysed. Typically they consisted of an off-white paste as shown in the photograph. The assumption is that the paste is predominantly nuts. Occasionally, pollen or leaf material is found. This is in spring and early summer, of course. There is no obvious correlation between stomach contents and cause of death. A healthy squirrel with a full stomach is just as likely to become a road kill victim as an under-nourished or sick squirrel.



Typical stomach contents

Abnormal stomach in an adult male that was grossly underweight. Cause of death was a dog kill

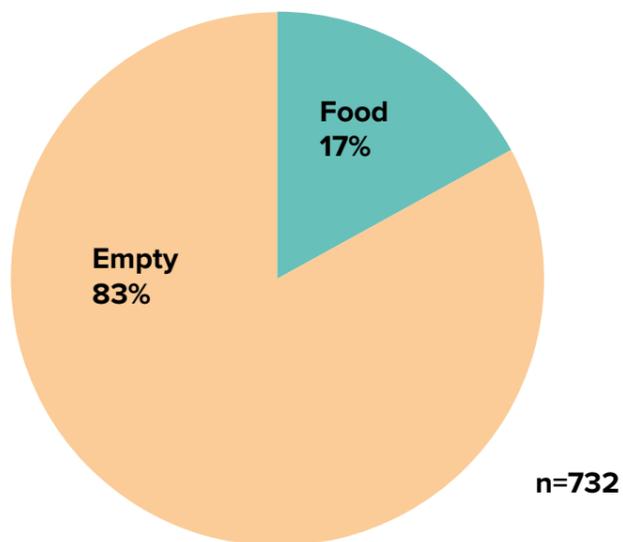
Cause of death	Number	%
Cat/dog kill	60	8
Euthanised	13	2
Misadventure	13	2
Natural causes	230	31.5
Rat poison	14	2
Road kill	371	50.5
Undetermined	26	3.5
Wild predator	5	0.5
<b>Total</b>	<b>732</b>	

Table showing cause of death where the digestive system is mentioned

Sex	Age	Details	Final Diagnosis
F	A	Exudate in abdomen. Necrosed rectum. Few contents in colon. Abscess between rectum & uterus	Septicaemia
M	SA	Yellow ingesta. Large int. semi-solid consistency. Large number of coccidial oocysts in intestinal contents	Endoparasites
F	A	Full stomach. Coccidae multiples in small intestine	Road kill
F	A	Stomach bloated with runny content and throughout gut. No infection but abnormal digestive function Possibly paralytic ileus – shock	
M	A	Some food in stomach. Hard faeces throughout gut. Twisted gut adj. caecum. Stomach lining inflamed	Twisted gut
M	J	Gastritis. Perforated stomach ulcer, discoloured intestines. Unformed faeces in gut & signs of diarrhoea	Gastritis
F	A	Hardened food in stomach. Loss of liver function caused bile in intestine	Hepatitis
F	A	Extensive tumour mass involving smooth muscle, mostly spindle types. Spindle-cell-type tumour involving lymph nodes: structure obliterated by tumour cells invading stomach and associated lymph nodes	Road kill
F	SA	Intussusception lower intestine approx. 35mm long. Necrosis of gut. Stomach empty except for pinkish mucoid fluid.	
		Enlarged lymph adjacent to intussusception	Endoparasites
F	A	Full stomach normal. Small quantity of yellow pus in duodenum & gut. Faeces normal	<i>Bordetella</i>
F	A	Full stomach. Unusual striations on colon. Watery fluid in gut. Two swollen mesentery glands	Endoparasites
M	A	Empty stomach. Hard faeces lower int. Inflamed stomach & mesentery tissue	Bacterial pneumonia
F	A	Full stomach. Gritty substance in intestines. Growth on mesentery	<i>Toxoplasma</i>
M	J	Large worms in abdomen. Yellow substance in lower bowel. Mass of faeces adhering to anus	Bacterial bronchitis suspected
F	A	Intussusception protruding through anus. Black/red smelly semi-fluid in small intestine in least-affected section. Rest disintegrating and 'gloopy'. Small amount of digested food in stomach	Unidentified infection
F	J	Empty stomach. Hard small faeces small int. Large int. black/green almost fluid substance leaking. Peritonitis	Gut infection
F	J	Stomach & intestines filled with gas. Yellow foreign bodies attached to outside of large intestine 15mm long	Endoparasites
M	SA	Stomach burst and adhered to spleen, liver, heart & pancreas. Very sticky, couldn't examine organs Sweet sickly smell. Diarrhoea around anus	Fungal infection
M	A	Large stomach full of grey granular material. Stomach lining bloody	Road kill

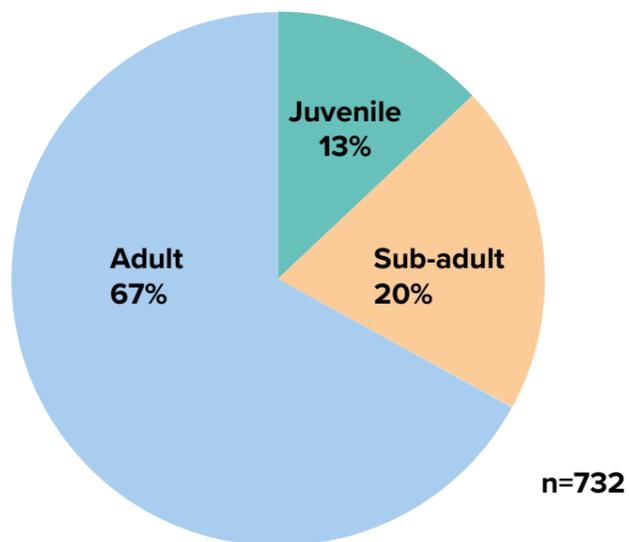
A sample of cases mentioning pathology of the digestive system

**Stomach contents**



*Pie chart showing percentage of squirrels that had food in their stomach. Of those with food in their stomach, 28% were described as having a full stomach*

**Digestive system. Age breakdown**



*The pie chart relates to comments on the database, only 9.3% actually showed pathology*

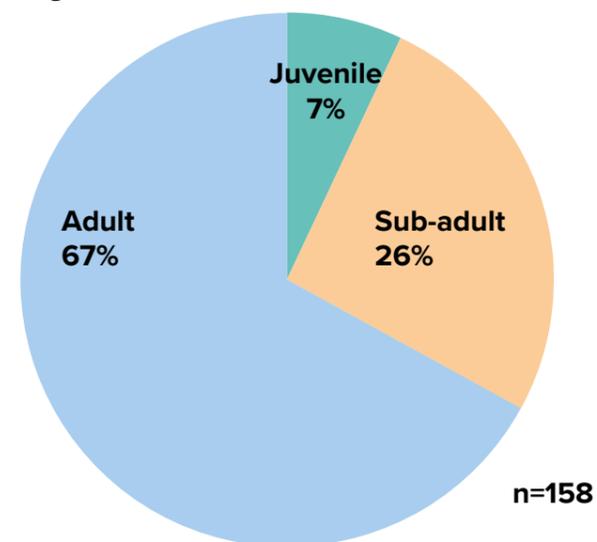


*An example of intussusception where the bowel 'telescopes' in on itself. The likely cause in this case was internal parasites*

**Lymphoreticular system**

The lymphoreticular system consists of the spleen, lymph nodes, lymphatic vessels, bone marrow and thymus. The bone marrow was not examined during post mortem examinations. A notable sign of infection is an enlarged spleen, although the nature of any infection is found only with laboratory testing. Spleen size does vary but a grossly enlarged spleen is not easily missed.

**Lymphoreticular system pathology. Age breakdown**



Cause of death	Number	%
Cat/dog kill	8	5%
Euthanised	3	2%
Misadventure	1	0.5%
Natural causes	89	56.5%
Rat poison	3	2%
Road kill	48	30.5%
Undetermined	5	3%
Wild predator	1	0.5%
<b>Total</b>	<b>58</b>	



*Grossly enlarged spleen from a squirrel with a lung infection*

Sex	Age	Details	Final Diagnosis
F	A	Spots on spleen. <10 small yellow/white lesions <1mm. Suspected yersinia pseudotuberculosis	Road kill
F	A	Enlarged spleen	Hepatitis
M	A	Enlarged spleen	Unidentified infection
M	A	Yellowing spleen and lymph nodes	Jaundice through blood virus. Haemolytic icterus
M	SA	Enlarged & solidified mesentery lymph gland	Pulmonary & cardiac failure due to unidentified protozoan
M	A	Abnormally small. Inflamed stomach & mesentery tissue	Bacterial pneumonia
F	SA	Spleen twice normal size. Inflamed pancreas	<i>Toxoplasma</i>
F	A	Widespread cellular necrosis & tachyzoites	<i>Toxoplasma</i>
F	A	Enlarged spleen. Pus in lower abdominal cavity and organs stuck to each other	Abscess in left groin
F	A	Enlarged spleen	Kidney infection
M	A	Lymphocytic infiltration around bile ducts. Suspect due to bacterial hepatitis/cholangitis leading to	Septicaemia
M	A	Multiple granulomas with <i>Capillaria</i> eggs & adult worms	Road kill
F	A	Multiple foci of necrosis with possible <i>Toxoplasma</i> schizonts in hepatocytes in margins	<i>Toxoplasma</i>
F	A	Enlarged & pale spleen. Necrotic foci, numerous <i>Toxoplasma</i> schizonts present	<i>Toxoplasma</i>

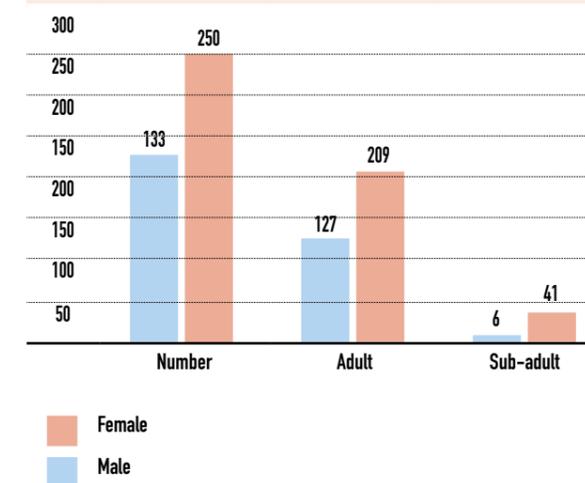
## Reproductive system

Pathology relating to the reproductive system is predominantly found in adults. Comments in the database generally apply to reproductive status but occasionally there is interesting pathology. Adult female road kills sometimes include pregnant animals with foetuses in various stages of development. Finding dead lactating females is particularly upsetting as, presumably, live kittens are left to starve. A total of 34 females presented for post mortem examination were pregnant, whilst 17 were lactating. Not all were road kills.

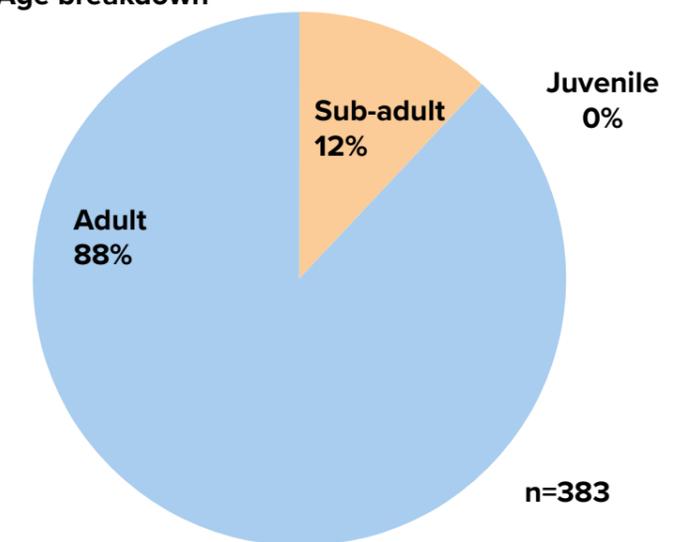
One adult female had extensive adhesions involving the abdominal organs and an unidentified mass in the peritoneal cavity. Histological examination showed the mass to be the necrotic remains of what was judged to be a foetus, which was possibly the result of an ectopic pregnancy.

Another squirrel had an enlarged, inflamed uterus containing the remains of a part-mummified foetus with trabecular bone evident. As autolysis had set in, the body was not suitable for further investigation. Both of these squirrels were examined by Vic Simpson (Simpson et al. 2013).

Breakdown of age and sex  
n=383



Reproductive system pathology.  
Age breakdown



Four foetuses, nearly full term – three female, one male. The mother was attacked by a buzzard

Cause of death	Number	%
Cat/dog kill	21	5.5
Euthanised	6	1.6
Misadventure	5	1.3
Natural causes	82	21.4
Rat poison	9	2.4
Road kills	245	64
Undetermined	12	3
Wild predator	3	0.8
<b>Total</b>	<b>383</b>	

Table showing cause of death where the reproductive system is mentioned

A number of foetuses were preserved in formalin and later photographed to show development within the womb. It is interesting to note that they have different positions and expressions, even in the womb. The foetus on the far right was presumably full term as its sibling had been born shortly before the mother died. She had got into a water trough with steep sides and could not get out.



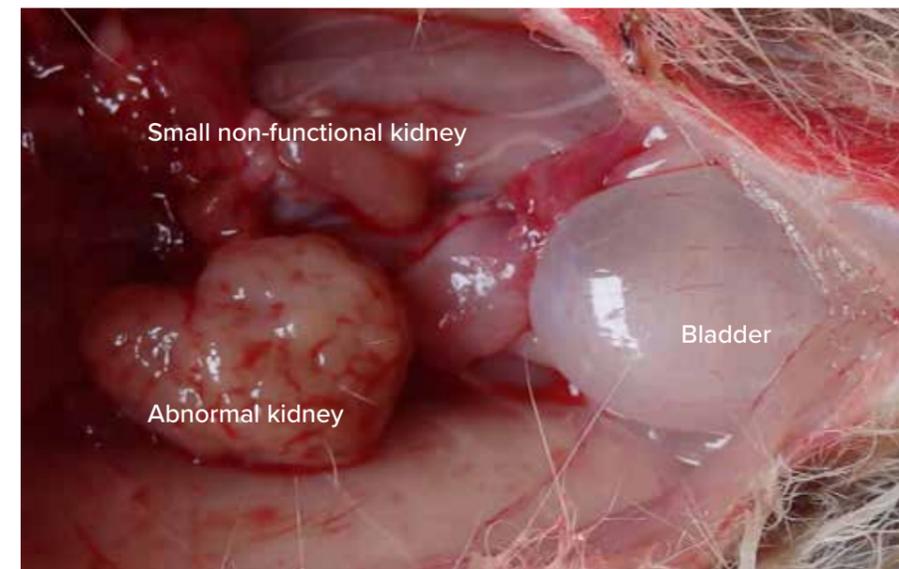
Foetuses in different stages of development. The discolouration is due to the preservation process

Sex	Age	Details	Final Diagnosis
M	A	Testes dropped. Blood on prepuce. Growth on testes. Vas deferens pale blue	Testicular cancer
F	A	Lactating. Found in netting around pond – strangled	Misadventure
F	A	Pregnant. Full-term foetus. One kitten born in water. Vulva distended. Died in water butt	Misadventure
F	A	Post lactating – or did milk dry up early? Kitten found in same place	Lung infection, possibly toxoplasmosis
F	A	Pregnant. Three embryos, approx. two weeks	Hepatitis
F	A	Uterus turgid. Greatly enlarged blood supply to reproductive system especially ovaries and distal to end uterine horns	extensively pronounced oestrus or early pregnancy
M	A	Breeding condition. Vas deferens and sheath swollen and hardened	Undetermined
M	A	Inflamed prepuce	Severe ulcerative dermatitis associated with staphylococcal infection
M	A	Inflamed tip to penis/prepuce	Unidentified infection
M	A	Testes dropped. Blood on prepuce. Growth on testes. Vas deferens pale blue	Testicular cancer
M	A	Ulcerated scrotal lesion	Unidentified infection
M	SA	Warts on scrotum	Unidentified infection
F	A	Pregnant, almost full term with one abnormal foetus that fell apart	Cat killed squirrel with unidentified infection

### Urinary system

The urinary system is mentioned in 229 cases, predominantly adults. Barbiturate damage after euthanasia and trauma due to impact with a vehicle are included in the figures. Abnormalities of the kidney include congenital defects and carcinoma.

Of the six animals euthanised, five sustained skeletal injuries, such as losing limbs in Fenn traps, and one squirrel had an abscess. Five cases where the kidney is mentioned in the pathology report are due to barbiturate damage. Also, one squirrel had scattered, small infarcts indicative of an earlier bacterial infection.

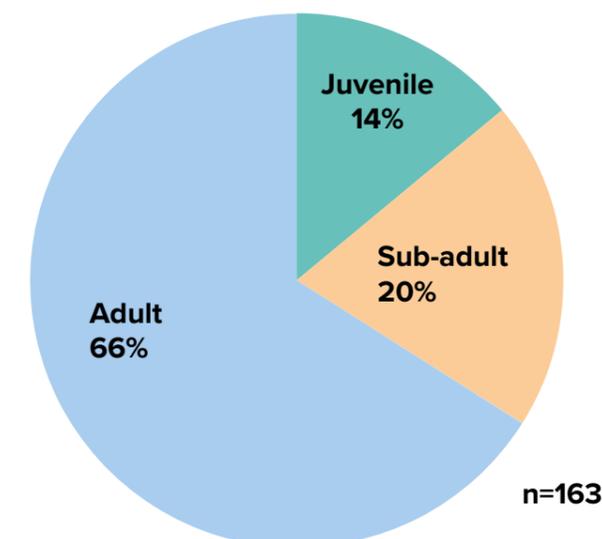


Abnormal kidneys in a juvenile

Cause of death	Number	%
Cat/dog kill	11	6.5%
Euthanised	4	2%
Misadventure	3	2%
Natural causes	83	51%
Rat poison	6	4%
Road kill	45	28%
Undetermined	11	6.5%
<b>Total</b>	<b>163</b>	

Table showing cause of death where the urinary system is mentioned

### Urinary system pathology. Age breakdown



Sex	Age	Details	Final Diagnosis
F	A	30g fat around kidneys. Euthanised due to injury	Road accident injury
F	A	Abnormal growth on kidney. Pregnant. Poor condition	Cat kill
F	SA	Abnormal left kidney. Multiple abnormalities to organs	Natural causes
F	A	Abnormally small kidneys covered in fat. Poor condition	Cat kill
M	A	Bladder hard one end & thickened throughout. Growth & blood where it joins urethra	Cancer
F	A	Bladder thickened & empty. Enlarged kidneys	Unidentified infection
F	A	Excess fat around kidneys	Unknown cause
F	A	Fat covering kidneys. Inside of kidney appeared abnormal	Cat kill
M	SA	Foreign body attached to kidney. White, oval 1mm x 4mm	Unidentified endoparasite
F	A	Kidneys abnormal	Natural causes
F	A	Kidneys abnormally small	Gut infection or parasites
F	A	Kidneys approx. 50% larger than normal	Natural causes
F	A	Kidneys soft & spongy	Septicaemia
M	A	One pole of left kidney pale with mottled appearance. Enlarged spleen	Unidentified infection
F	J	Only one kidney and that was abnormal	Anaemia and kidney failure
F	A	Pustules on kidneys	Toxoplasma
M	A	Connective tissue around kidneys inflamed	Bacterial pneumonia

A sample of cases mentioning pathology of the urinary system



Excess fat (30g) accumulated in the lower abdomen of the road accident injury victim mentioned in the table

### Endocrine system

The endocrine system is regulatory and comprises the hypothalamus, pituitary gland, thyroid glands, thymus, parathyroid, pancreas, adrenals and gonads. The hypothalamus and pituitary glands were not examined during basic post mortem examinations and the head was generally too badly damaged in road kill victims in any case. The gonads are discussed in the reproductive system section.

Enlarged adrenals are generally seen in stressed squirrels, often in animals picked up by humans, cat kills, rat poisoning, bird attacks and sometimes road kills. Not all squirrels are killed outright when in collision with a car.

'Abnormal' in the table relates to inflammation or discolouration. In one case of euthanasia, the barbiturates used had damaged the adrenals and the pancreas.

In one squirrel, fat deposits surrounded the adrenal glands. On the rare occasion fat deposits were found, they were generally around the kidneys or in the lower abdomen.

Details	Number	%
Enlarged adrenals	89	78.8%
Enlarged pancreas	12	10.6%
Abnormal adrenals	3	2.6%
Abnormal pancreas	9	8%
<b>Total</b>	<b>113</b>	

Table giving statistics relating to the adrenals and pancreas

Cause of death	Number	%
Cat/dog kill	14	12
Euthanised	4	3.5
Misadventure	2	2
Natural causes	65	57.5
Rat poison	4	3.5
Road kill	21	18.5
Undetermined	2	2
Wild predator	1	1
<b>Total</b>	<b>113</b>	

Table showing cause of death where the endocrine system is mentioned

### Endocrine system pathology. Age breakdown



Fat accumulated around kidney

