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Rabbits

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Introduction

Over the centuries, the rabbit has been used for food, sport and clothing, as a scientific model, and as a hobby (the rabbit 'fancy'). In the UK, the keeping of rabbits as pets developed in Victorian times, since when their popularity has grown enormously: rabbits are now the UK's third most popular mammalian pet. Many are kept as house pets and true companion animals. They are relatively long-lived in captivity (up to 10 years) and this should be borne in mind when acquiring a young animal.

All domestic rabbits are the same species as the wild European rabbit (*Oryctolagus cuniculus*). There are many other species of rabbit and these, along with cottontails, pikas and hares, make up the order Lagomorpha. There are many recognized rabbit breeds and varieties (Figure 8.1) and more are constantly evolving by selective breeding and mutation. Many pet rabbits are cross-breeds.

Advantages of rabbits as pets include:

- Generally docile and responsive
- Good house pets
- Can be house-trained to use litter-tray.

Disadvantages include:

- Can become aggressive, or nervous and difficult to handle
- Can be destructive in the house, and unneutered animals can exhibit territorial marking
- Can be easily damaged by incorrect handling
- Larger breeds are difficult for young children to handle.

Biology

Rabbits are highly social, burrowing herbivores that are natural prey for a large number of carnivores. In the wild they live in warrens of 70 or more individuals, broken down into small groups of two to eight. They spend a lot of time engaged in mutual grooming and lying together but their displays of greeting behaviour, pain and fear are poor. Scent is much more important than sight and each animal has an individual scent profile. They can distinguish between familiar and unfamiliar humans, and between human genders. Thumping with the hindleg is an alarm call. Fear elicits either complete immobility or a flight response, often with frantic attempts to escape and screaming. As a prey species they have evolved to be constantly vigilant, lightweight and fast-moving, with a highly efficient digestive system that enables them to spend the minimum time possible above ground and in danger of capture. Biological data for the rabbit are summarized in Figure 8.2.

Digestive tract anatomy

Rabbits are hindgut fermenters, adapted to digest a low quality, high-fibre diet consisting mainly of grass. Gut transit time is rapid and fibre is eliminated from the digestive tract as soon as possible. This permits body size and weight to remain low, which is advantageous in a prey species. In the wild, feeding takes place mainly in the early morning and evening and at night. Indigestible fibre (lignocellulose) stimulates gastrointestinal motility and has a protective effect against enteritis.

The stomach is thin-walled and poorly distensible. Vomiting is not possible. Food, hair and caecal pellets are always present in the stomach. Bacterial fermentation takes place in the caecum, which is very large,

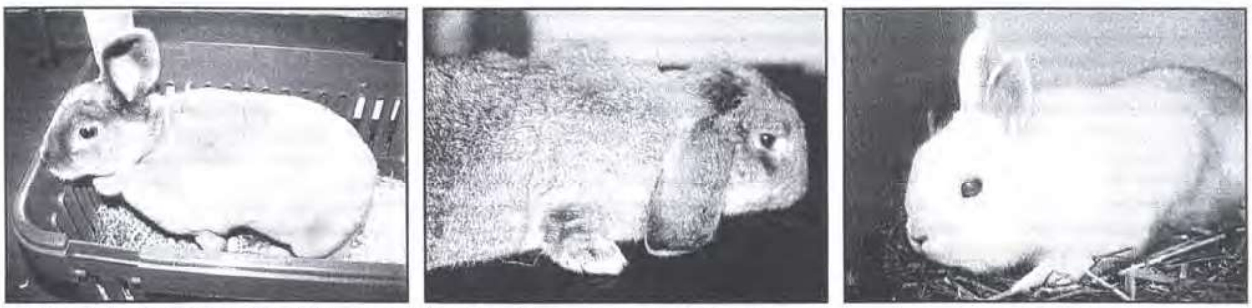


Figure 8.1 Examples of rabbit breeds: Rex, Dwarf Lop, Netherland Dwarf.

Lifespan	5–10 years
Weight	1–10 kg (breed dependent)
Dentition	I 2/1 C 0/0 P 3/2 M 3/3
Respiratory rate	30–60 breaths per minute
Heart rate	180–300 beats per minute
Blood volume	60 ml/kg
Rectal temperature	38.5–40°C
Water intake (daily)	50–150 ml/kg
Food intake (daily)	50 g/kg
Urine production (daily)	10–35 ml/kg
Sexual maturity	4–8 months (does earlier than bucks)
Oestrous cycle	Reflex ovulation; oestrus Jan–Oct
Length of gestation	28–32 days
Litter size	4–12
Birthweight	30–80 g
Weaning age	6 weeks

Figure 8.2 Biological data for the rabbit.

thin-walled and coiled and has many sacculations (or haustrae). It terminates in the vermiform appendix, which is rich in lymphatic tissue. The caecum lies on the right side of the abdomen. Caecal contents are normally semi-fluid. The colon is sacculated and banded. Colonic contractions separate fibrous from non-fibrous particles, and fibre moves rapidly through for excretion as hard faecal pellets. Antiperistaltic waves move fluid and non-fibrous particles back into the caecum. Three to eight hours after eating, mainly at night, soft, mucus-covered caecal pellets are expelled and eaten directly from the anus (a process known as caecotrophy, coprophagy, refection or pseudorumination). Arrival of the caecotrophs at the anus triggers a reflex licking of the anus and ingestion of the caecotrophs, which are swallowed whole and not chewed. A muscular band of richly innervated tissue with a thickened mucosa, the fusis coli, lies at the end of the transverse colon and acts to regulate colonic contractions and controls production of the two types of pellet.

The mucous covering protects the caecal pellet bacteria from the low pH of the stomach. Caecotrophs remain in the stomach for up to 6 hours, with continued bacterial synthesis, and eventually the mucous layer dissolves and the bacteria are killed. This process of caecotrophy allows absorption of nutrients and bacterial fermentation products (amino acids, volatile fatty acids and vitamins B and K) and the redigestion of previously undigested food.

Dentition

Rabbits have six unpigmented incisor teeth: one in each mandible and two each side of the premaxilla. The second upper incisor is much smaller than the rest (it is commonly referred to as a 'peg tooth') and is palatal to the first incisor. There is a long diastema between the incisor and premolar teeth. The premolar teeth are similar in form to the molar teeth and are frequently described together as the 'cheek teeth'.

All the teeth grow continuously and never form anatomical roots. The part of the tooth embedded in the alveolus should therefore be described as 'reserve crown', though it is more commonly referred to as the 'root'. The visible part of the tooth is correctly described as the 'exposed crown'.

The first incisor teeth are normally kept very short, with the occlusal surfaces taking on a chisel-like shape (Figure 8.3) the lingual profile of which is flush with the gingiva. Incisor wear, growth and eruption are generally balanced over time, at a rate of about 3 mm per week.

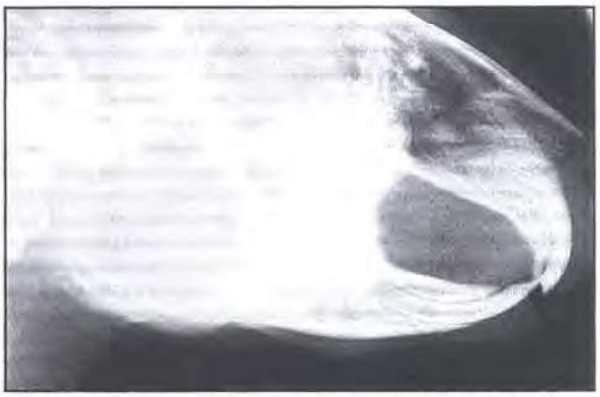


Figure 8.3 Lateral radiograph showing the features of healthy rabbit dentition: chisel-shaped first incisor wear pattern, approximately 45 degrees upper, 30 degrees lower; smooth incisor tooth surface, longitudinally grooved in maxillary first incisor teeth; tips of the mandibular incisors rest between the maxillary first and second incisors; transversely ridged cheek tooth occlusal surfaces angled at about 10 degrees to horizontal; tooth wear patterns bilaterally symmetrical; short teeth with very short exposed crown; distinct radiographic dental and periodontal outlines with large apical radiolucencies and no distortion of adjacent bone; oral cavity profile narrowing rostrally; and smooth ventrolateral border to the mandible.

The mandible is narrower than the maxilla, with the temporomandibular articulation positioned dorsal to the occlusal line. Functionally the incisor teeth are used with a largely vertical scissor-like slicing action. Cut vegetation is then moved to the back of the mouth by the tongue and ground between the cheek teeth. When grinding fibrous natural foods, the mandible has a wide lateral chewing action, concentrating on one side at a time. This wears the whole cheek tooth occlusal surface. Grass is highly abrasive, as it has a high content of silicate phytoliths, so there is rapid wear of the teeth (around 3 mm per month) with equally rapid tooth growth and eruption to compensate for this. Mandibular teeth, incisors and cheek teeth, grow and erupt faster than their maxillary counterparts.

Sexing

The anogenital distance is greater in the male (buck), which has a round preputial opening. The female (doe) has an elliptical vulval opening (Figure 8.4). Within a breed, does tend to be slightly larger than bucks, but bucks have broader heads.

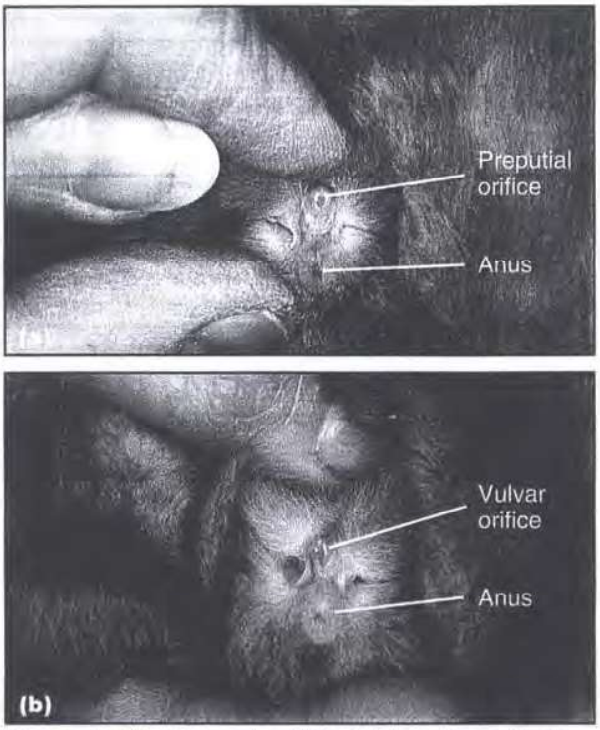


Figure 8.4 Sexing may be difficult in immature animals (before testicular descent in the male). (a) The preputial orifice is always circular. (b) The vulvar orifice is elliptical. The anogenital distance is longer in males than in females. Courtesy of D. Malley.

Husbandry

Housing

Rabbits are social animals and should be provided with a companion wherever possible.

- Litter mates can be kept together but should be neutered if of different sexes
- Unrelated females will usually tolerate each other if sufficient space is provided, but they can fight
- Intact bucks will fight and inflict severe injuries
- All introductions should be supervised
- Neutering minimizes the risk of conflicts
- The most stable pairing is a neutered buck and neutered doe.

It is not recommended that rabbits are kept with guinea pigs, as bullying by both species can occur – especially by the rabbit. Rabbits can also harbour *Bordetella bronchiseptica*, which is pathogenic to guinea pigs.

Outdoor housing

- Rabbits are generally hardy but need protection from extremes of weather
- Avoid direct sunlight, as heat stress and heat stroke occur easily
- The hutch should be raised off the ground
- A waterproof roof and louvred panel to cover the mesh-fronted area in bad weather should be provided
- The hutch should at least be big enough for the rabbit to stretch out fully, stand upright on its hindlegs and, if confined to the hutch for long periods, be able to perform at least three 'hops' from one end to the other
- A solid-fronted nesting area and a mesh-fronted living area should be provided, bedded with wood shavings and hay or straw
- Good ventilation is essential, to prevent respiratory disease
- Rabbits need daily exercise and need to graze: the hutch should be placed within an enclosure, or a separate ark or run should be provided (Figure 8.5); alternatively, a shed or garage can be used to provide a floor-pen. Raised shelves or platforms are readily used
- Rabbits will burrow, so precautions should be taken to prevent escape
- Rabbits can jump well and covering the run or pen with a mesh top will prevent escape, as well as providing protection from predators
- Rabbits should always be provided with appropriate 'bolt-holes', such as empty cardboard boxes or drain-pipes, to use if alarmed
- Contact with wild rabbits should be prevented, to minimize the risk of disease transmission by direct contact (e.g. viral haemorrhagic disease) or by vectors such as the rabbit flea (myxomatosis)
- Fly and mosquito control should be considered in summer months.

Figure 8.5 Outdoor run for a rabbit.

House rabbits

- House rabbits should have a secure cage area where they can be restrained when the owner is not present. Wire cages with plastic bases are suitable
- Exercise around the house and garden should be encouraged
- Rabbits will readily learn to use cat-flaps to gain indoor/outdoor access
- Rabbits are easily trained to use a litter tray, by repeatedly placing them in it (it may be necessary initially to place some droppings in the tray). Wood or paper-based litter should be used, as Fuller's earth products can be harmful if ingested

- Electrical cables must be protected from chewing, and poisonous house plants such as *Dieffenbachia* (dumb cane) avoided
- Chewable toys are enjoyed, such as cardboard boxes, telephone directories, or commercial bird toys.

Diet

The best diet for a rabbit is grass and good quality grass hay (e.g. Timothy) with a small amount of a high-fibre (18–24%) commercial diet with protein levels around 15%. Wild plants can be given if available (e.g. bramble, groundsel, chickweed, dandelion). Alfalfa hay can be given, especially to growing animals, but care should be taken as alfalfa is high in calcium and large amounts could predispose to urolithiasis. Hay should always be available and can be fed from racks or nets to increase time spent feeding. Fresh vegetables such as kale, cabbage, watercress, root vegetables and their leaves, should also be provided; carrots or other root vegetables can be suspended from the cage roof to act as edible toys and increase time spent eating.

Grass is approximately 20–25% crude fibre, 15% crude protein and 2–3% fat. Commercial rabbit diets are often too low in fibre and too high in protein, fat and carbohydrate. These cause caecocolic hypomotility, prolonged retention of digesta, increased volatile fatty acid production and adverse alterations in caecal pH and microflora, leading to diarrhoea, ileus and death, especially around the time of weaning.

The energy requirements of a rabbit can be met rapidly on a concentrate diet, but this can lead to dental disease due to lack of wear (Crossley, 1995), obesity, and boredom-associated problems such as stereotypic behaviour and aggression. Many rabbits are selective eaters and leave the pellet and biscuit component of a commercial mix, favouring grains and pulses, which are low in calcium. It is thought that this can lead to osteoporosis and dental disease (Harcourt-Brown, 1995). Commercial mixes, consisting of pulses, grains, grass pellets and biscuits, should not be fed *ad libitum*, as this can encourage selective feeding and obesity.

Sudden changes in diet, frosted or mouldy food, and lawnmower clippings should be avoided. Rabbits enjoy sweet foods but sugar-rich treats should not be fed, though they may be of use if tempting an anorexic animal to feed.

Water intake is approximately 10% of bodyweight daily. Drinking bottles are easier to keep clean than water bowls and they avoid wetting the dewlap, which can lead to a moist dermatitis.

Breeding

Onset of puberty depends on breed, but is at approximately 4–5 months in the female and 5–8 months in the male. Smaller breeds mature earlier than larger ones.

Rabbits are reflex ovulators. There is no definitive oestrous cycle: receptive periods usually occur for 12–14 days, followed by 2–4 days of non-receptivity, but this can vary, and some does become receptive every 4–6 days during the breeding season (January to October in the UK).

A receptive doe is very active, rubbing her chin on objects and exhibiting lordosis. The vulva becomes congested and reddish-purple. Does may mount each other and this, or an infertile mating, can induce ovulation, leading to a pseudopregnancy of approximately 18 days.

Does tend to be more territorial than bucks and the doe should be taken to the buck or to neutral territory for breeding, to avoid aggression. Sexually mature bucks will mate at any time.

Nest-building behaviour involves burrowing and pulling of fur from the dewlap, flanks and belly to line the nest and expose the nipples. Pregnancy can be detected by palpation at 14 days; gestation is 30–32 days. Parturition usually occurs in the early morning. The kits are altricial (hairless, with ears and eyes closed). Passive immunity is acquired by placental transfer before birth. Rabbit milk is exceptionally nutritious and nursing is for a few minutes once (occasionally twice) a day.

Kits emerge from the nest at about 2–3 weeks of age, when they start to show interest in solid food. Coprophagy starts at about 3 weeks and weaning can take place at 4–6 weeks.

Hand-rearing can be achieved using cat milk substitute 3–5 times a day, to which probiotics can be added. Hay should be introduced at 2–3 weeks. Concentrates should only be introduced once the young are established on hay.

Handling

Rabbits should be held by the scruff and with the weight of the body supported (Figure 8.6). Twisting and kicking out by the powerful hindlegs must be deterred, as serious back injury can result.

Turning the rabbit on to its back results in a trance-like state ('hypnotization' or tonic immobility). This behaviour is a defence mechanism, i.e. 'playing dead' if caught by a predator. This useful technique can be employed single-handed with the rabbit cradled in one arm, but it should be remembered that it is stressful for the rabbit and should be used for the minimum time possible. Under no circumstances should painful procedures be carried out using this technique as restraint.

Rabbits should *never* be picked up by the ears!

Diagnostic approach

Physical examination

Most of the clinical techniques employed in dogs and cats can be applied to the rabbit. As with any animal, a systematic clinical examination, carried out in a consistent fashion, is important.

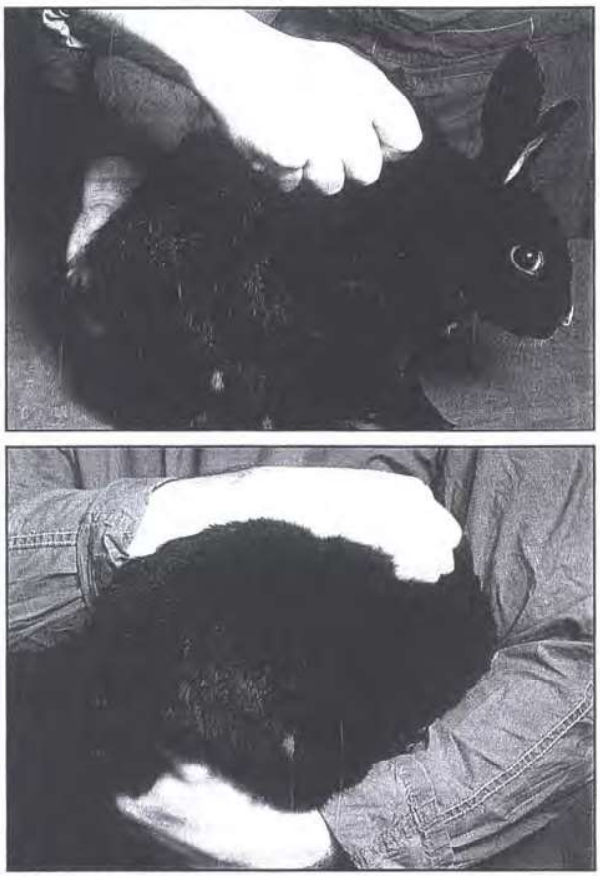


Figure 8.6 Handling techniques.

A non-slip surface should be used when carrying out a physical examination, and an assistant should hold the rabbit to prevent it jumping off the table. Placing one hand over the eyes and the other on the rump provides good restraint. The incisor teeth, ventrum, feet and nails are best examined with the rabbit held on its back. Special attention should be paid to the plantar metatarsal surface (plantar pododermatitis), and perineum (accumulation of caecotrophs, myiasis). The rectal temperature can also be taken in this position.

A rabbit in pain is immobile, with a hunched posture, and may grind its teeth and show increased aggression.

Oral examination

Sedation or anaesthesia is required to examine the mouth properly. An otoscope can be used for a cursory inspection but lesions such as tooth spurs can easily be overlooked.

Ocular examination

Purulent discharge from the nasolacrimal duct punctum is often present (see Dacryocystitis). Pressure over the medial canthus often causes expulsion of pus from the lacrimal sac. The optic nerve is above the horizontal midline of the eye, and retinal vessels spread outwards from the optic disc. Rabbits have no tapetum lucidum.

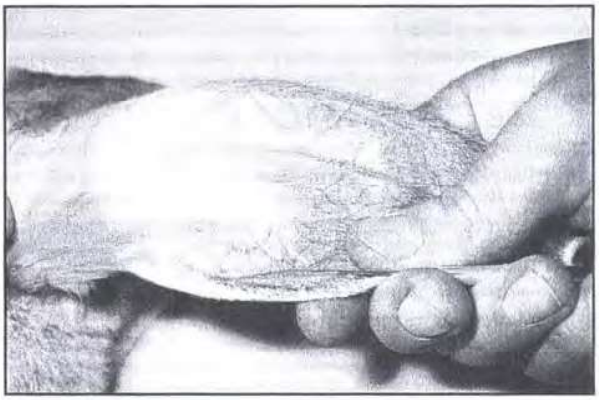
Abdominal examination

Palpation of the thin-walled abdomen is easily achieved. Vertical restraint, with the back of the rabbit held against the handler's chest, is useful for auscultation and ballotment of the abdomen. The caecum lies on the right side.

Diagnostic tests and techniques

Blood sampling

Blood collection sites are the marginal ear vein, jugular vein (Figure 8.7), cephalic vein or saphenous vein. The use of local anaesthetic cream is recommended. Blood volume is approximately 65 ml/kg and it is safe to remove 10% in a normal animal, or up to 1% of bodyweight (i.e. 6.5–10 ml/kg). Normal haematological and biochemical values are summarized in Figure 8.8.



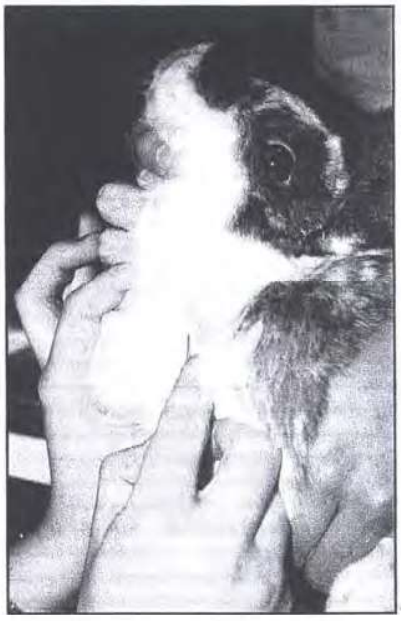


Figure 8.7 Blood collection from the marginal ear vein and jugular vein.

Cystocentesis

Cystocentesis can be achieved in a conscious rabbit, using a method similar to that for the cat. Rabbit urine is alkaline (Figure 8.9), contains albumin, calcium carbonate and ammonium magnesium phosphate crystals, and is often pigmented.

Parameter	Average	Range
Total WBC (x 10^9/l)	8.55 6	5–12 5.0–8.0
Neutrophils (x 10^9/l)		3–20 1.5–4.0
Neutrophils (%)	48	34–60 40–70
Band neutrophils (x 10^9/l)	0.2	0–0.2
Lymphocytes (x 10^9/l)	5.4	2–20
Lymphocytes (%)	53 47	43–62 20–80
Monocytes (x 10^9/l)	0.41	0–1.8
Monocytes (%)	3	0–4 0–7.0
Eosinophils (x 10^9/l)	0.26	0–0.8
Eosinophils (%)	1	0–2 0–5
Basophils (x 10^9/l)		0–0.84
Basophils (%)	2.5	0–1 0–7
Haemoglobin (mg/dl)	12	10–17.5 12–15
PCV (%)	40 39	34–50 33–47
RBC (x 10^6/mm^3)	6	5–8 5.1–7.9
MCV (fl)	69	50–75 59–79
MCH (pg)	21	18–24 16–23
MCHC (%)	33	27–34 28–36
Reticulocytes (%)		0–3
Platelets (x 10^3/mm^3)	290	240–600
In vivo coagulation time (minutes)	4	2–8
Protein (g/l)	61	49–71 50–71
Albumin (g/l)	31	27–36 33–50

Parameter	Average	Range
Globulin (g/l)	28	24–33 15–27
A/G ratio	1.09	0.7–1.89
Glucose (mmol/l)	7.5	6–8.9 4.2–8.3
Urea (mmol/l)	17	9.1–22.7 9.3–25.5
Creatinine (mmol/l)	88	53–124 70–150
Total bilirubin (mmol/l)		4.3–12.8
Triglycerides (mmol/l)		1.4–1.76
Bile acids (µmol/l)	11.6	3–20
Cholesterol (mmol/l)	1.1	0.62–1.68 0.1–2.0
Sodium (mmol/l)		134–150 130–155
Chloride (mmol/l)		92–120
Bicarbonate (mmol/l)		16–32
Potassium (mmol/l)		3.3–5.7 3.5–5.6
Phosphate (mmol/l)		1.0–2.2
Calcium (mmol/l)	3.55	2.17–4.59 5.5–7.8
Magnesium (mmol/l)		0.8–1.2
Iron (mmol/l)		33–40
Aspartate aminotransferase (IU/l)	57 < 50	33–99 5–50
Alanine aminotransferase (IU/l)	124 < 50	55–260 5–50
Alkaline phosphatase (IU/l)	51	12–96 100–400
Lactate dehydrogenase (IU/l)	187	132–252 50–500
Creatine phosphokinase (IU/l)	263	140–372 50–250
Gamma GT (IU/l)		0–5
Cortisol (resting) (µg/dl)		1.0–2.04
Cortisol (30 mins after stimulation with ACTH 6µg/kg i.m.) (µg/dl)		12.0–27.8

Figure 8.8 Haematology and biochemical values for the 'normal average rabbit'. This table gives an overview of the data published and should be treated as a guide rather than a definitive source of reference values. Reproduced from the *BSAVA Manual of Rabbit Medicine and Surgery*.

Parameter	Normal findings
Urine specific gravity	1.003 – 1.036
Urine average pH	8.2
Urine crystals normally present	Ammonium magnesium phosphate, calcium carbonate
Casts, epithelial cells, bacteria	Absent to rare
Leucocytes, erythrocytes	Occasional
Albumin	Occasional (young rabbits)

Figure 8.9 Normal composition of rabbit urine.

Catheterization

Bladder catheterization is possible in bucks but extremely difficult in does. Sedation is usually required.

Collection of cerebrospinal fluid

CSF can be collected under anaesthesia in lateral recumbency by flexing the head and inserting a needle in the midline halfway between the cranial edges of the wings of the atlas and the occipital protruberance.

Common conditions

Diseases of the rabbit are summarized in Figure 8.10. Differential diagnoses based on clinical signs are summarized in Figure 8.11. A drug formulary for the rabbit is presented at the end of this chapter (see Figure 8.18).

Disease	Aetiology	Clinical signs	Diagnosis	Treatment
Aberrant conjunctival overgrowth. Unique to rabbit	Unknown	Fold of non-adherent conjunctival tissue arising from limbus and covering variable area of cornea	Clinical signs	Surgical removal results in recurrence. Suturing fold to sclera allows vision
Abscess	*Pasteurella multocida, Staphylococcus aureus, Pseudomonas, Proteus, Streptococcus, Corynebacterium, Bacteroides* and other anaerobes. Local entry (wound) or haematogenous spread	Subcutaneous or facial swelling, draining tracts. May be dull, anorexic, pyrexic if bacteraemic. Also dyspnoea (pulmonary abscess). Neurological signs (cerebral/spinal abscess)	Aspirate. Bacterial culture. CBC and biochemistry. Radiography. Ultrasonography	Surgical removal – treatment of choice. Lance, drain and flush. Systemic antibiosis. Injection of gentamicin into capsule (0.5–1ml per rabbit empirically). Antibiotic-impregnated methylmethacrylate beads
Accumulation of caecotrophs	Excess caecotroph production (low fibre/high protein and carbohydrate diet) or reduced caecotrophy (overfeeding, physical problems, obesity, pain)	Caking of caecotrophs around perineum. Secondary myiasis. Often mistaken for diarrhoea, but faecal pellets normal	Clinical signs	Address underlying cause. Dietary reform to high fibre, low or no concentrate diet. May take several months on hay alone to resolve
Allergic/irritant rhinitis/bronchitis	Environmental allergens or irritants	Sneezing, dyspnoea, nasal discharge	Exclusion of other causes. Response to: elimination of suspected allergen; antihistamines/corticosteroids	Avoidance of allergen. Antihistamines. Corticosteroids (do not use if concurrent *Pasteurella* or other bacterial infection)
Antibiotic toxicity/enterotoxaemia (clostridial overgrowth)	Reported with all antibiotics except fluoroquinolones and potentiated sulphonamides. Especially ampicillin, amoxycillin, clindamycin, lincomycin, cephalosporins, erythromycin. Will occur only if clostridia already present in gut	Diarrhoea (brown, watery, foetid, bloody). Depression. Dehydration. Hypothermia. Abdominal distension. Collapse. Death	History of antibiotic usage. Faecal culture and toxin isolation (rarely performed)	Fluid therapy. Cholestyramine. Metoclopramide. Cisapride. Metronidazole. High fibre diet (assisted feeding). Probiotics
Bacterial dermatitis (*see also* pododermatitis). Primary bacterial dermatitis rare	Usually *Staphylococcus aureus* but also other bacteria	Alopecia. Erythema. Ulceration. Pruritus	Bacterial culture	Antibiosis (topical/systemic). Address underlying cause
Bacterial enteritis	*Escherichia coli, Salmonella*, Tyzzer's disease (*Clostridium piliforme*)	Diarrhoea. Depression. Weight loss. Hypothermia. Abdominal distension. Collapse. Death. High morbidity and mortality in young rabbits	Faecal culture. Postmortem histopathology for Tyzzer's	Fluid therapy. Appropriate antibiosis. Metoclopramide. Cisapride. High fibre diet. Probiotics
'Blue fur' disease	Secondary *Pseudomonas aeruginosa* infection	Moist dermatitis. Blue coloration of fur in moist areas (dewlap, skin folds)	Blue coloration pathognomonic. Culture of *P. aeruginosa*	Clip fur. Keep dry. Topical antiseptic. Address underlying cause
Clostridial overgrowth (see Antibiotic toxicity, above)				
Coccidiosis	*Eimeria* spp. *Eimeria stiedae* (hepatic coccidiosis)	Diarrhoea. Weight loss. Anorexia. Jaundice. Dehydration. Ascites. Death. Can cause high morbidity and mortality in young rabbits	Faecal oocysts. Postmortem examination	Sulpha drugs. Disinfection/good hygiene
Cystitis	Primary or secondary bacterial. Urolithiasis/hypercalciuria from high dietary calcium intake predisposes	Urinary incontinence. Urine scald. Dysuria. Haematuria	Urinalysis, culture and cytology. Radiography	Antibiosis. Analgesia. Fluid therapy. Reduce calcium content of diet
Conjunctivitis	Usually *Pasteurella multocida*. Also irritants – ammonia, dust	Photophobia. Blepharospasm. Chemosis	Bacterial culture	Topical and subconjunctival antibiosis. Topical corticosteroids if irritant and no corneal ulceration

Figure 8.10 Diseases of the rabbit. (continues)

Disease	Aetiology	Clinical signs	Diagnosis	Treatment
Dacryocystitis (infection of nasolacrimal duct)	*P. multocida* and other bacteria	Lacrimation. Purulent ocular discharge	Bacterial culture	Flushing of nasolacrimal ducts until clear – may be necessary over several days. Topical antibiotic instillation. Investigate for underlying tooth root elongation
Dental disease/ malocclusion	Primary congenital incisor malocclusion/mandibular prognathism (esp. dwarf breeds). Acquired dental disease due to insufficient dental wear. Cheek teeth malocclusion and overgrowth can lead to secondary incisor malocclusion. Low dietary calcium intake in some rabbits	Weight loss. Ptyalism. Dehydration. Lack of grooming. Lack of caecotrophy. Facial/ retrobulbar abscesses. Ocular discharge. Dacryocystitis. Incisor wear abnormalities. Palpable swellings on ventral border of mandible. Ulceration of oral mucosa, tongue, cheek, palate, lip. Deep laceration to or scarring of the tongue or cheek. Spikes on the edges of cheek tooth occlusal surfaces. Pain on palpation of maxillary zygomatic process or mandibular manipulation. Food impaction between or around the cheek teeth. Missing teeth	Dental examination. Skull radiography	Burr sharp edges/spikes. Burr crowns to correct form. Tooth extraction. Incisor removal if primary malocclusion or uncorrectable secondary malocclusion. Antibiosis. Analgesia – may be required long term. Oral meloxicam recommended. Euthanasia if severe disease
Dermatophytosis	*Trichophyton mentagrophytes*. *Microsporum* (rare)	Alopecia. Scaling crusting, with or without pruritus	Fungal culture	Clip surrounding hair. Topical antifungal agents, e.g. miconazole, clotrimazole for small areas. Systemic griseofulvin for widespread lesions (25 mg/kg orally sid)
Dysautonomia (degeneration of autonomic ganglia leading to gut stasis; similar to equine grass sickness)	Cause and incidence unknown	Mucoid diarrhoea. Gut stasis. Caecal impaction. Dehydration. Anorexia. Weight loss. Abdominal pain and distension. Death	Histology of mesenteric autonomic ganglia	Fluid therapy. Metoclopramide. Cisapride. Analgesia. High fibre diet. Treatment usually ineffective
Ear mites	*Psoroptes cuniculi* (non-burrowing). 3-week life cycle on host	Pruritus. Head-shaking. Self-trauma. Thick crusts in external ear canal. Lesions can spread to face and neck	Identification of mite	Ivermectin, selamectin. Acaricidal ear drops for mild infections. Soften and remove debris – care not to damage ear canal. Analgesia in severe cases
Encephalitozoonosis (very common; antibodies not protective)	*Encephalitozoon cuniculi* (intracellular microsporidian parasite). Spores shed in urine and ingested or inhaled	Target organs kidney and CNS. Infection often asymptomatic but can cause neurological signs: ataxia; torticollis; posterior paresis/ paralysis (floppy rabbit syndrome); urinary incontinence; tremors; convulsions. Chronic weight loss and polyuria/polydipsia	Clinical signs. Serology. Postmortem examination	Fenbendazole may be effective in eliminating or preventing infection. Albendazole can limit sporogeny. Supportive care. Treatment often ineffective if severe neurological signs. Cleaning and disinfection of environment; quaternary ammonium compounds inactivate spores
Endometrial hyperplasia (common in unmated does)	Ageing: continuum of changes from hyperplasia to adenocarcinoma	Haematuria. Bloody vaginal discharge. Palpably enlarged uterus	Radiography. Ultrasonography. Exploratory surgery and histology	Ovariohysterectomy
Endometrial venous aneurysm (rare)		Haematuria. Blood from vulva	Exclusion of other causes of haematuria. Ultrasonography. Examination of removed uterus	Blood transfusion if severe haemorrhage. Ovariohysterectomy
Entropion	Genetic factors	Keratoconjunctivitis. Corneal ulceration	Ocular examination	Corrective surgery
Eosinophilic granuloma	Usually secondary to parasitic or other skin disease	Skin ulceration. Self-trauma. Moist dermatitis	Direct smear. Histology of skin biopsy	Address underlying cause. Corticosteroids

Figure 8.10 continued Diseases of the rabbit. (continues)

Disease	Aetiology	Clinical signs	Diagnosis	Treatment
Fleas	Rabbit flea *Spillopsylla cuniculi* (important vector for myxomatosis). *Cediopsylla simplex* and *Odontopsyllus multispinosus* in USA. Also cat flea *Ctenocephalides felis*	Often none. Pruritus	Identification of flea or flea faeces	Feline/canine pyrethrum products. AVOID fipronil spray – adverse reactions reported
Fur mites	*Cheyletiella parasitovorax*: 5-week life cycle on host but can survive off host; ZOONOSIS. *Listorophorus gibbus* not pathogenic or zoonotic. *Demodex cuniculi* rarely reported	Alopecia. Scaling. Crusting. Minimal/no pruritus	Identification of mite	Ivermectin. Treat all in-contacts and environment (can use feline/canine environmental flea products)
Glaucoma/buphthalmia	Inherited in New Zealand white: recessive *bu* gene	Enlarged globe. Corneal opacity. Non-painful	Clinical signs. Tonometry	None
Leptospirosis	*Leptospira* spp. ZOONOSIS. Rabbits can acquire disease via contact with wild rodent hosts	Polyuria/polydipsia. Depression. Anorexia. Renal failure	Serology	Penicillin – but be wary of enterotoxaemia. Fluid therapy
Lice	*Haemodipsus ventricosis*	Pruritus. Anaemia	Identification of louse/eggs	Feline/canine louse powders or ectoparasitic shampoos
Listeriosis (rare)	Listeria monocytogenes.	Head tilt/torticollis from meningoencephalitis	CSF culture. Postmortem examination	Penicillin. Tetracycline (rarely effective)
Mastitis. Bacterial: infection of mammary glands (in lactation or in pseudopregnant does). Aseptic: in intact does over 3 years old	Often *P. multocida*, *S. aureus*, *Streptococcus*	Bacterial: Depression. Pyrexia. Anorexia. Polydipsia. Swollen painful abcessated mammary glands. Septicaemia. Death. Aseptic: Non-painful. May exude brown fluid	Bacterial: Clinical signs. Bacterial culture. Aseptic: Clinical signs. Biopsy	Bacterial: Antibiosis. Supportive care. Analgesia. Drainage of abscesses. Surgical excision for severe infections. Wean young Aseptic: Benign condition. Ovariohysterectomy will resolve
Myiasis (fly strike)	Primary or secondary myiasis occurs rapidly in warm weather. Flies often attracted to accumulated caecotrophs in perineal area	Depression. Collapse. Death	Presence of fly larvae	Fluid therapy and supportive care. Sedate and remove maggots. Clip fur. Flush wounds with antiseptic solution. Systemic antibiosis. Ivermectin. Address underlying cause. Fly control for outdoor rabbits
Myxomatosis	Poxvirus spread by the rabbit flea or other biting insects	Facial and genital oedema/swelling. Blepharitis. Conjunctivitis. Ocular and nasal discharge. Pyrexia. Subcutaneous masses. Nasal scabbing only in some cases. Depression. Death	Clinical signs	Supportive care in mild cases. Euthanasia. Prevention by vaccination
Otitis externa	*Psoroptes cuniculi* (see Ear mites, above)			
Otitis media/interna	Usually ascending bacterial infection via Eustachian tube from nasopharynx. *Pasteurella multocida* common	Head tilt/torticollis	Skull radiography. Bacterial culture	Antibiosis. Bulla osteotomy usually unrewarding
Pasteurellosis	*P. multocida* extremely common inhabitant of nasal cavity and tympanic bullae. Overt disease usually follows injury or stressor, e.g. overcrowding, intercurrent disease. Spread by direct and venereal contact, aerosol (slow), fomites, vertical/perinatal	Nasal discharge. Sneezing. Conjunctivitis. Dacrocystitis. Bronchopneumonia. Head tilt/torticollis. Abscesses. Pyometra. Mastitis. Orchitis. Epidydimitis. Depression. Anorexia. Pyrexia. Death	Bacterial isolation. (Serology.) Radiography (turbinate atrophy, pneumonia, pulmonary abscesses)	Antibiosis. Fluid therapy and supportive care. Nebulization with mucolytics (e.g. bromhexine, *N*-acetylcysteine) to break up nasal secretions. *See treatment for abscesses, pyometra, mastitis, metritis, orchitis, epidydimitis*

Figure 8.10 continued Diseases of the rabbit. (continues) ▶

Disease	Aetiology	Clinical signs	Diagnosis	Treatment
Pinworm	*Passalurus ambiguus*	Usually non-pathogenic even in large numbers	Identification of adult worm/ova in faeces or tape test from perineum. Can be seen within gut during abdominal surgery	Fenbendazole 10–20 mg/kg orally repeated in 14 days
Pododermatitis	Bacterial infection (often *S. aureus, Streptococcus*). Secondary to poor husbandry (wet soiled bedding), obesity, inactivity, genetic factors (Rex rabbits lack guard hairs on plantar surface)	Alopecia. Erythema. Skin thickening. Lameness. Ulceration. Abscessation. Osteomyelitis	Clinical signs. Bacterial culture	Antibiosis – topical and systemic. Analgesia/NSAIDs. Bandaging. Improve husbandry. Weight reduction
Pregnancy toxaemia/hepatic lipidosis	Affects pregnant, postpartum and pseudopregnant does or obese rabbits if for any reason anorexia occurs	Depression. Incoordination. Collapse. Dyspnoea. Convulsions. Coma. Death	Clinical signs. Ketonuria. Proteinuria. Aciduria	Intravenous lactated Ringer's and 5% glucose. Corticosteroids. Assisted feeding
Rabbit syphilis/venereal spirochaetosis	*Treponema cuniculi*. Direct contact/veneral spread. Kits can be infected at birth	Ulcerative, crusting lesions around genitalia and in face and legs from autoinoculation. Secondary bacterial infection and eosinophilic granuloma formation. Symptomless carrier state	Detection of organism in direct smear (dark field background) or biopsy (silver stain)	Penicillin – but be wary of enterotoxaemia
Splayleg	Inherited disease, several genes involved	1–4 legs held adducted. Subluxation of hip in some cases	Clinical signs. Radiography	None
Spondylosis/spondylitis ankylosis/osteomyelitis of a vertebral joint	Degenerative change. Infection, usually by haematogenous spread, e.g. *Pasteurella*	Reluctance to move. Paresis. Lack of caecotrophy	Radiography	Antibiosis. Analgesia. Euthanasia
Toxoplasmosis (rare)	*Toxoplasma gondii*	Ataxia. Tremors. Paresis/paralysis	Serology	Trimethoprim/sulphonamides. AVOID clindamycin – enterotoxaemia. Prevent contact with cat faeces
Tyzzer's disease	*Clostridium piliforme*	Watery diarrhoea. Depression. Death. Can cause high morbidity and mortality in young rabbits. Chronic weight loss in older rabbits	Postmortem examination	Poor response to antibiosis. Treatment only palliative once clinical signs observed – try supportive care and tetracyclines. Prevention by good husbandry. 0.3% sodium hypochlorite kills spores
Urolithiasis/hypercalciuria	Associated with high dietary calcium intake	Haematuria. Dysuria. Abdominal pain	Radiography. Ultrasonography. Urinalysis. Uroliths (usually calcium carbonate) can occur in kidney, ureter, bladder or urethra. Common to see radiodense 'sludge' in bladder, with or without clinical signs	Bladder lavage. Cystotomy and urolith removal. Antibiosis. Lower dietary calcium content. Not possible to acidify urine
Uterine adenocarcinoma (extremely common in older unmated does; progressive uterine changes from hyperplasia to adenocarcinoma; rapidly metastasize locally and to lungs)		Haematuria. Vulval discharge. Weight loss	Abdominal palpation. Radiography. Exploratory surgery	Ovariohysterectomy. Always radiograph thorax for pulmonary metastases
Viral enteritis	Rotavirus. Coronavirus (rare)	Diarrhoea. Depression. Anorexia. Death. High morbidity/mortality in young rabbits	Viral isolation	None
Viral haemorrhagic disease	Calicivirus. Spread by direct or indirect contact (fomites)	Usually sudden death. Pyrexia. Depression. Haemorrhagic discharge from nose and mouth	Postmortem examination	None. Prevention by vaccination

Figure 8.10 continued Diseases of the rabbit.

Clinical sign	Differential diagnoses	Further investigations
Abdominal distension	Ileus and gaseous distension of bowel. Ascites. Abdominal mass. Pregnancy. Obesity	Radiography, contrast studies. Ultrasonography. Peritoneal tap. Exploratory surgery
Abdominal mass	Trichobezoars. Foreign body (esp. at sacculus rotundus). Impaction (usually caecal – right hemiabdomen). Neoplasia. Uterine hyperplasia. Pyometra. Metritis. Hydrometra. Abdominal fat. Fetus(es)	Radiography, contrast studies. Ultrasonography. Exploratory surgery
Alopecia	Cheyletiellosis. *Listrophorus* (rare). Barbering. Normal moult. Dermatophytosis	Tape test. Skin scrape. Microscopic examination of hair. Fungal culture
Anaemia	Renal disease. Any chronic disease. Lead toxicity. Uterine hyperplasia/adenocarcinoma. Uterine venous aneurysm	CBC and blood biochemistry. Radiography. Ultrasonography. Exploratory surgery
Anorexia	Dental disease. Any systemic disease, especially gastrointestinal. Pain	CBC and blood biochemistry. Dental examination. Radiography – skull and body. Ultrasonography
Ascites	Abdominal neoplasia. Hepatic coccidiosis. Liver disease. Cardiac disease. Pleural effusion disease (coronavirus – rare)	CBC and blood biochemistry. Peritoneal tap. Radiography. Ultrasonography. Liver biopsy. Faecal analysis (coccidiosis). Virology
Dermatitis	Ectoparasites. Bacterial dermatitis/'blue fur disease'. Eosinophilic granuloma. Dermatophytosis. Self-trauma. Venereal spirochaetosis. Urine scald. Viral infection. Injection site reaction	Tape test. Skin scrape. Bacterial culture. Fungal culture. Skin biopsy. Investigate urinary tract disease (see below)
Diarrhoea	Bacterial enteritis. Viral enteritis. Coccidiosis (young rabbits). Clostridial enterotoxaemia. Low fibre, high carbohydrate diet. Gastric stasis/ileus. Dysautonomia	Dietary history. Faecal analysis – culture, parasitology. Radiography/contrast studies. Postmortem examination
Dyspnoea/collapse	Any respiratory disease. Cardiac disease. Pregnancy toxaemia/hepatic lipidosis. Severe pain	Radiography. Echocardiography. ECG. Urinalysis (ketones). CBC and blood biochemistry
Facial swelling	Myxomatosis. Facial/dental abscess. Cellulitis	Vaccination/contact history. Skull radiography. Dental examination
Haematuria	False haematuria – red/brown porphyrin pigments in urine. Cystitis. Urolithiasis/hypercalciuria. Uterine hyperplasia. Uterine adenocarcinoma. Uterine venous aneurysm. Bladder polyps. Renal infarcts. Disseminated intravascular coagulopathy	Urinalysis – dipstick, culture, cytology. CBC and biochemistry. Radiography/contrast studies. Ultrasonography
Lower respiratory signs	Bacterial pneumonia (esp. pasteurellosis). Pulmonary abscess. Pleural effusion disease (rare). Pulmonary neoplasia (esp. metastases from uterine adenocarcinoma). Thymoma. Cardiac disease	Radiography. Pleural fluid analysis. Bronchoalveolar lavage. Ultrasound-guided biopsy. Echocardiography
Neurological signs	Encephalitozoonosis. Otitis media/interna. Heat stroke. Trauma. Toxoplasmosis. Listeriosis. Baylisascariasis (USA). Epilepsy (rare). Pregnancy toxaemia. Splayleg. Hypovitaminosis A, E (rare)	Radiography (skull, spine). CBC and blood biochemistry. Serology
Paresis/paralysis	Spinal trauma (fracture/luxation). Spondylosis/spondylitis. Spinal abscess. Intervertebral disc disease. Encephalitozoonosis. Toxoplasmosis	Spinal radiography. Serology
Subcutaneous mass	Abscess. Lipoma. Other neoplasia. Myxomatosis. Injection reaction	Fine needle aspiration. Biopsy. Vaccination/contact history
Testicular swelling	Orchitis. Epididymitis. Myxomatosis. Venereal spirochaetosis. Testicular neoplasia	Fine needle aspiration. Bacterial culture. Histology
Torticollis	Encephalitozoonosis. Otitis media/interna. Meningitis. Listeriosis. Toxoplasmosis. Cerebral abscess. Baylisascariasis (USA). Hypovitaminosis A (rare)	Aural examination. Skull radiography. Bacterial culture. Serology. CBC and blood biochemistry
Upper respiratory signs	Pasteurellosis. Other bacterial URT disease. High environmental ammonia. Myxomatosis. Allergic/irritant rhinitis	Bacterial culture. Skull radiography. Environmental history
Urinary incontinence/urine scald	Cystitis. Urolithiasis/hypercalciuria. Posterior paralysis/paresis. Obesity. Renal failure. Hormone-responsive incontinence (spayed does)	Urinalysis. Radiography. Serology. CBC and blood biochemistry. Response to stilboestrol
Vaginal discharge	Pyometra. Metritis. Uterine hyperplasia/adenocarcinoma. Dystocia	Culture and cytology of discharge. Radiography. Ultrasonography. Exploratory surgery
Weight loss	Dental disease. Any infectious or metabolic disease. Neoplasia. Bullying	Dental examination. Radiography. Ultrasonography. CBC and biochemistry. Serology. Faecal sample

Figure 8.11 Differential diagnoses based on clinical signs in the rabbit.

Dental disease

The incidence of dental disease is low in rabbits with conformation similar to those in the wild. If they are permitted to behave normally, feeding on fresh and dried grasses and other herbage, dental disease is rare. Unfortunately the incidence in some rabbits, particularly extreme dwarf and lop breeds, approaches 100% whatever their diet.

Rabbits that do not spend prolonged periods chewing typically show poor jaw bone development, or atrophy at muscle insertions. This is most prominent in the area of insertion of the pterygoid (medial) and masseter (lateral) muscles into the ramus; the bone in this area may be so thin that it is transparent, or there may even be a perforation where the bone has atrophied completely.

Dentistry techniques, including grinding and extraction, are dealt with under Common surgical procedures.

Spikes

There is reduced tooth wear when rabbits eat a higher energy or poorly abrasive diet. The teeth tend to continue growing more rapidly than necessary, with elongation of the exposed and embedded parts. The natural curvature of the cheek teeth, combined with elongation and incomplete surface wear, results in the formation of 'spikes' on the lingual occlusal surface of the mandibular cheek teeth and the buccal surface of the maxillary cheek teeth (Figure 8.12). The higher growth rate of mandibular teeth accounts for the more prominent spikes seen on these.

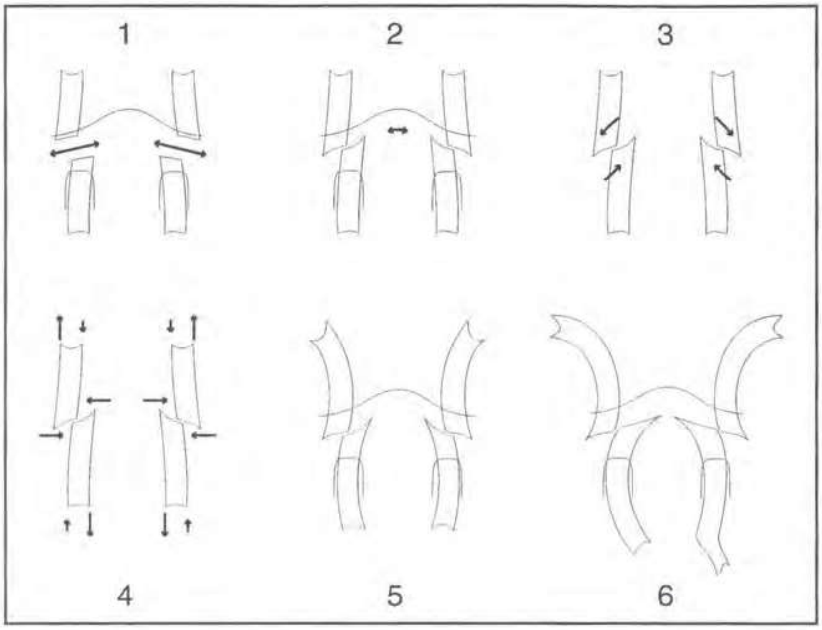


Figure 8.12 The process of cheek tooth 'spike' formation and development of apical deformities in rabbits. (1) Normal cheek teeth: chewing wears the whole occlusal surface evenly and rapidly, this being matched by tooth growth and eruption. (2) Early elongation of the exposed crown: reduced attrition and uneven wear with continued growth and eruption elongate one side of the exposed crowns. (3) Altered occlusal contact: the chewing action changes, altering the forces applied to the teeth. (4) Forces affecting the teeth: increased lateral and occlusally directed forces impede eruption affecting the apical germinal tissues, resulting in increased tooth curvature, and in extreme cases tipping of the teeth. (5) 'Root' elongation: spikes form at the occlusal surfaces interfering with chewing and further reducing attrition; increased occlusal contact reduces eruption but tooth growth continues, resulting in apical elongation and intrusion.

Tooth elongation

The most common dental disease in rabbits is that related to tooth elongation (Figure 8.13). Elongation of the cheek teeth prevents the mouth from closing fully. This separates the incisor teeth, reducing their wear until they have elongated sufficiently to compensate. Beyond a certain level of elongation, the incisors no longer function adequately and occlusal wear abnormalities become apparent.

Changes in incisor wear are also seen associated with jaw length discrepancies in some extreme dwarf and lop breeds. In these cases the problem can be detected at a very early age. When they no longer occlude, it is common for the mandibular incisors to become straighter (reduced occlusal pressure leads to a reduction in tooth curvature), preventing future correction of the problem. The maxillary incisors are not worn, but contact with the mandible maintains occlusal pressure so the tight spiral curvature of growth continues, the teeth eventually penetrating the palate or cheek if left untreated.

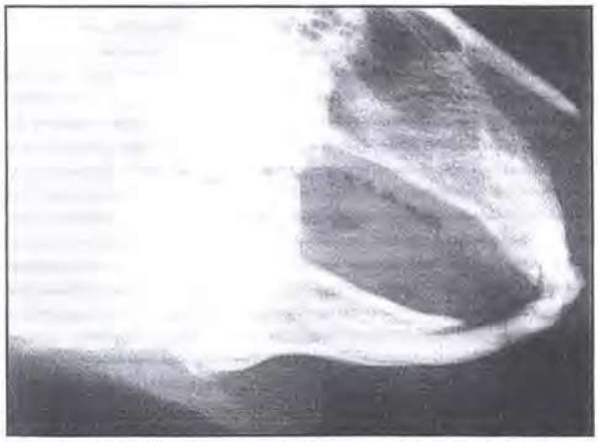


Figure 8.13 If not corrected at an early stage (before detectable apical changes have occurred) the process becomes self-perpetuating. Apical intrusion affects the germinal tissues, resulting in microscopic or, in extreme cases, gross dental dysplasia.

When detected in its earliest stages, uncomplicated tooth elongation can be corrected simply by dietary change, i.e. reduction then elimination of concentrate and processed rations and replacement with fresh and dried natural herbage.

Trauma

Traumatic injury (both accidental and iatrogenic) is a common presentation. Separation of the mandibular symphysis is more frequent than a true jaw fracture or dislocation of the temporomandibular joint. Incisor tooth fracture is quite common. In many cases this can be managed by smoothing any sharp edges and repeated trimming of occluding teeth until the fractured tooth has erupted back into function. Pulp exposure may occur associated with both dental fractures and professional trimming. If the exposure is small and the blood supply to the pulp is undamaged, it may heal unaided; however, pulpitis and pulp necrosis are common, with the formation of abscesses around the premolar tooth roots days to months later.

Abscesses

Mandibular and facial abscesses may also result from periodontal infection or mucosal damage caused by 'spikes'. Abscesses will not resolve without elimination of the cause. Unfortunately most dental abscesses result in gross changes in the surrounding tissues, including the jaw bone, so that there are residual problems even if the abscess is successfully treated. If not treated early, abscesses tend to behave as expansile masses. They can displace teeth over time and tooth roots may adapt, growing to follow the capsule (Figure 8.14).

Caries

High-carbohydrate diets, reduced attrition and arrested eruption predispose to development of caries, which may totally destroy the exposed crown and progress subgingivally, stimulating inflammatory 'root' resorption.

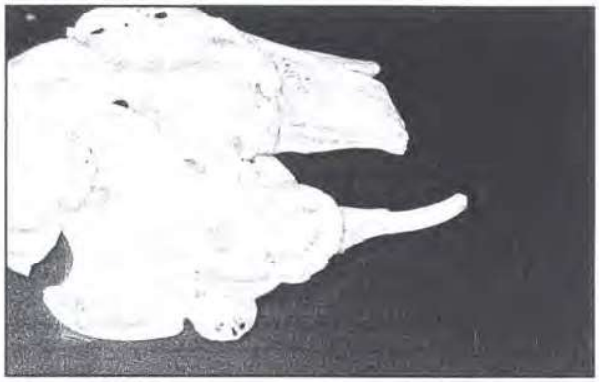


Figure 8.14 Slow expansion of a mandibular abscess has displaced the teeth, affecting the apical tissues and causing formation of an increasingly curved tooth structure which encircles the abscess.

Resorptive lesions

Resorptive lesions are also seen associated with periodontal disease and endodontic abscesses. If affected animals survive long enough, replacement resorption may eventually result in the disappearance of most of the cheek teeth. Affected rabbits often do well on a suitably processed diet, though there are continuing problems with progressive eruption of remaining non-occluding teeth.

Calcium deficiency

Once formed, the teeth are protected from resorption for systemic calcium homeostasis. Tooth formation is little affected by fluctuations in dietary calcium levels, a prolonged period of extreme deficiency being required before tooth growth and development are significantly affected. However, insufficient dietary calcium intake does appear to enhance the progression of concurrent dental resorptive lesions.

Behavioural problems

Rabbits have not been bred for positive behaviour traits and behavioural problems are common. Individual rabbits have distinct 'personalities', from timid to aggressive. In general, smaller breeds tend to be more highly strung.

Aggression is generally learned (the owner leaves the rabbit alone if it behaves aggressively). Other causes are territorial behaviour, boredom, pain, improper socialization and negative association (a previous aversive or traumatic situation). Behavioural aggression can be treated successfully in many cases with techniques similar to those used in dogs.

Does are more territorial than bucks, and as they reach sexual maturity may become aggressive towards other animals (and to their owners). Does may also bite, dig and chew flooring and household items, spray urine and mount other rabbits. If outdoors on soil, the doe may excavate deep tunnels.

Socialization of young rabbits is often overlooked. A well socialized pet rabbit will beg for treats, 'hum' and circle the owner, stand on its hindlegs and licking the owner's hands and arms. Rabbits are inquisitive and enjoy exploring. Picking up objects with the teeth and throwing them is common, as is exploratory chewing.

Supportive care

Injections

Injection sites and maximum volumes are shown in Figure 8.15.

Route	Sites	Amount
Subcutaneous	Scruff, flank	30–50 ml
Intramuscular	Quadriceps, lumbar muscles	0.5–1 ml
Intraperitoneal	Lateral to midline, lower third of abdomen	50–100 ml
Intravenous	Marginal ear vein, cephalic vein, jugular vein	
Intraosseous	Greater trochanter of femur	20 g, 1.5 inch spinal needle

Figure 8.15 Injection sites and maximum volumes in the rabbit.

Nutritional support

Assisted feeding is often necessary and should be instituted as soon as possible if the rabbit is anorexic, preferably within 24 hours. Fluid and electrolyte disturbances should be corrected before nutritional support is given (Figure 8.16).

- Daily maintenance requirements are 75–100 ml/kg/day
- Calculate dehydration as a percentage of bodyweight based on skin tenting and sunken eyes as for other mammalian species
- Use intravenous colloids if very hypotensive or hypoproteinaemic (normal serum protein is 50–71 g/l)
- Routes for fluid therapy are oral (syringe or via nasogastric tube), subcutaneous, intravenous, intraperitoneal or intraosseous (see Figure 8.15)
- If profoundly hypovolaemic, an i.v bolus of 100 ml/kg (preferably colloid) can be given over one hour
- If PCV <12% a blood transfusion can be given. Donors can give 10–15% blood volume of 65 ml/kg into acid citrate dextrose (1 part to 3.5 parts blood). Blood types are not established in the rabbit.

Figure 8.16 Fluid therapy for the rabbit.

Anorexia for 2–3 days or more has serious consequences, including gastrointestinal hypomotility and stasis, mucosal atrophy and hepatic lipidosis. Commercial enteral diets for rabbits are now available. A high fibre intake is necessary, and ground rabbit/alfalfa pellets made into a slurry can be fed via syringe. Probiotics can be added. Fresh hay, greens and the rabbit's normal diet should always be offered. Metoclopramide and cisapride are useful to stimulate gut motility.

High-fibre slurries may not pass down a nasogastric tube. In this case vegetable-based baby foods and vegetable juices are useful in the short term.

Amounts to feed vary with the type of diet selected. As a rough guide, the rabbit should be fed two or three times a day at a rate of 10–20 ml/kg bodyweight. If the calorific value of the food is known, the basal metabolic rate (BMR) can be approximated using the following equation:

$$BMR\ (kcal/day) = 70 \times bodyweight\ (kg)^{0.75}\ kcal/day$$

To calculate the daily requirement, the BMR can be multiplied by illness factors of between 1.2 and 2.0, depending on the individual case.

A severely debilitated animal should not be overfed, as starvation decreases metabolic rate and the risk of inducing or worsening hepatic lipidosis is high. It is recommended to start with approximately 50% of daily requirement and increase gradually to 100% over 3–5 days.

If caecotrophy is absent or reduced, extra B vitamins can be given.

Nasogastric intubation

This is well tolerated and extremely useful for assisted feeding of anorexic animals.

1. Restrain the rabbit securely on a non-slip surface or by wrapping in a towel.
2. Place a few drops of local anaesthetic eyedrops into the nostril or place a small amount of lignocaine gel on the end of the tube.
3. Using a 5–8 French urinary catheter, measure the tube length from the nose to the caudal end of the sternum.
4. Elevate the rabbit's head and insert the tube into the ventral nasal meatus, aiming ventrally and medially.
5. As the tube approaches the back of the pharynx, flex the head so that the tube passes into the oesophagus.
6. *Always ensure correct placement by taking a radiograph.* Rabbits often do not cough if the tube passes into the trachea.
7. Suture or glue the tube to the top of the head.

Anaesthesia and analgesia

Rabbits have an unnecessary reputation for being difficult to anaesthetize. With the correct techniques, there is no reason why rabbits should not be anaesthetized safely and successfully. The main problems are their high susceptibility to stress and underlying respiratory disease.

Preoperative care

It is not necessary to fast rabbits before anaesthesia, as they are unable to vomit, but they can safely be fasted for 2–4 hours to reduce gut fill. Anaesthetic candidates are often dehydrated and hypoglycaemic (if anorexic for any reason) and this must be corrected first (see Figure 8.16). Rabbits with overt respiratory disease are a high risk, and ideally this should be treated before anaesthesia is attempted. Many pet rabbits have inapparent lung disease and damage due to *Pasteurella* infection.

Anaesthesia

Premedication is essential in rabbits as they are easily stressed. A high percentage have serum atropinesterase, so glycopyrrolate at 0.01 mg/kg s.c. can be used as an anticholinergic. Suitable premedicants are fentanyl/fluanisone, medetomidine, xylazine, acepromazine, diazepam or midazolam (Figure 8.17).

Drug	
Acepromazine	0.1– 0.5 mg/kg i.m.
Fentanyl/fluanisone	0.2–0.5 ml/kg (Hypnorm® licensed for rabbits in UK)
Medetomidine	0.25–0.5 mg/kg
Midazolam/diazepam	0.5–2.0 mg/kg (licensed for human use)
Buprenorphine	0.05–0.1 mg/kg tid
Butorphanol	0.1–0.5 mg/kg every 4 hours
Ketamine	25–50 mg/kg
Ketamine/medetomidine	15 mg/kg s.c. + 0.25 mg/kg s.c.
Ketamine/medetomidine/ butorphanol	15 mg/kg s.c. + 0.25 mg/kg s.c. + 0.4 mg/kg s.c.
Ketamine/xylazine	35 mg/kg i.m. + 5 mg/kg i.m.
Xylazine	5 mg/kg i.m.
Meloxicam	0.2 mg/kg orally sid
Ketoprofen	3 mg/kg i.m. sid–bid
Carprofen	4–5 mg/kg sid

Figure 8.17 Sedatives, analgesics and anaesthetics.

Induction using a face mask without prior use of premedication should be avoided. Rabbits hold their breath when exposed to all volatile agents, even at low concentrations, for periods up to 2 minutes. Stress releases catecholamines, and halothane sensitizes the myocardium to these, which is a lethal combination.

Fentanyl/fluanisone or another premedicant, followed by mask induction, results in a smooth onset of anaesthesia. Alternatively, an injectable combination can be used: fentanyl/fluanisone plus midazolam gives 30–40 minutes of surgical anaesthesia. Partial reversal with retention of analgesia can be achieved with buprenorphine or butorphanol.

Another good combination is medetomidine plus ketamine, to which butorphanol can also be added. The addition of butorphanol prolongs anaesthetic time from about 30 to about 80 minutes. This combination can be partially reversed with atipamezole at 1 mg/kg.

When using an injectable regimen it is prudent to administer oxygen concurrently by face mask. Rabbits are easily intubated by either direct visualization or a blind technique (see below). An Ayres T-piece circuit or Bain circuit should be used.

Intubation

Always allow the rabbit to breathe 100% oxygen for 3–4 minutes before intubation is attempted.

With all techniques, never force the tube into the larynx, as this will cause haemorrhage and oedema.

Direct visualization

1. Place the anaesthetized rabbit in dorsal recumbency. Extend the neck. Grasp the tongue gently, retract and hold to one side.

2. Visualize the larynx using a Wisconsin size 1 laryngoscope and insert a 2.5–3 mm endotracheal tube.

Alternatively:

1. Place the anaesthetized rabbit in sternal recumbency. Grasp the back of the head and extend the neck so that the nose is pointing vertically.
2. Visualize the larynx using an otoscope.
3. Place the introducer into the larynx through the otoscope.
4. Remove the otoscope and introduce the endotracheal tube gently over the introducer.
5. Remove the introducer.

Blind technique

1. Hold the anaesthetized rabbit in sternal recumbency with head and neck extended vertically.
2. Pass the endotracheal tube over the tongue and advance it until exhalation is heard loudly (place end of tube to the ear), or until presence of condensation at each breath is observed if using a clear tube.
3. Advance the tube gently as the rabbit inhales, and the tub will pass into the trachea.

Monitoring

Depth of anaesthesia should be monitored by use of the ear pinch. Standard monitoring equipment (ECG, pulse oximeter) should be used wherever possible. Eye position is not useful in the rabbit, and the palpebral reflex is not lost until the animal is dangerously deep.

Postoperative care

This is as for any other species.

- Rabbits should be kept warm but not over-hot
- Handling should be minimized during the recovery period
- Continued fluid therapy may be necessary, and the rabbit should be monitored closely until it is eating again. Force feeding may be required
- After intra-abdominal surgery, gut stasis can be a problem and the use of metoclopramide and/or cisapride is indicated.

Analgesia

Alleviation of postoperative pain is essential, and very important in encouraging the animal to eat and drink again. Buprenorphine and butorphanol (see Figure 8.17) are useful opioid agents and will reverse the respiratory and cardiovascular depressant effects of fentanyl while maintaining analgesia. The NSAID carprofen is also highly effective.

Common surgical procedures

Special considerations

Suture material often provokes a marked caseous and suppurative inflammatory response in rabbits. Modern monofilament absorbable suture materials are preferable to catgut for this reason. Subcuticular sutures for skin closure are recommended, as skin sutures are invariably chewed and Elizabethan collars poorly tolerated. Alternatively, tissue glue or skin staples can be used.

Rabbits are very prone to the formation of intra-abdominal adhesions and great care must be taken not to damage, desiccate or irritate abdominal organs. Verapamil (a calcium channel blocker) is reported to be of use in the prevention of adhesion formation (200 µg/kg orally or slowly i.v. at surgery and then every 8 hours for up to nine doses).

Dentistry

Grinding

Established tooth overgrowth may be helped by repeating mechanical tooth grinding at intervals of 4–6 weeks. Radiographic assessment of tooth roots is essential in all cases before undertaking treatment.

Trimming incisors: In the unlikely event that problems are restricted to the incisor teeth, these can easily be trimmed back to a normal length and shape or, if repeated treatment is needed, extracted. Incisor trimming can be performed without difficulty in conscious animals using either high- or low-speed dental equipment. A high-speed cutting burr rotating at 200,000–400,000 times a second will cut the teeth with minimal effort. Low-speed burrs or the more dangerous diamond disc can be used but they are less efficient.

Under no circumstances should teeth be clipped, as this leaves sharp edges and longitudinal cracks in the teeth and will often expose the pulp. Clipping also releases a considerable amount of energy into the tooth, concussing the pulp, and damages the pulp, periodontal and periapical tissues.

Grinding cheek teeth: It is possible to grind down elongated cheek tooth crowns but this requires general anaesthesia. As oral access is limited, even when using mouth gags and cheek dilators, a straight low-speed dental handpiece fitted with a soft-tissue protector and an extra long shanked burr is required. There is no point in simply removing sharp edges or 'points', as this does not address the main problem – tooth elongation. By taking the exposed crowns down to the correct height, the spikes will also be removed and the teeth will start erupting again, provided there are minimal apical changes.

Rasps are unsuitable for use on the teeth as they apply too much force, often tearing the periodontal ligament and on occasion ripping teeth out of the jaw.

Chewing efficiency is greatly reduced by coronal reduction of the cheek teeth as it temporarily removes the transverse occlusal ridging and also because it takes some time for the jaw muscles to recover their ability to contract fully. By the time the muscles have recovered, the teeth may have erupted back to their pre-treatment length and so repeated treatment is often necessary.

Caries: Early caries lesions may be eliminated by burring away the affected tissue but they will reform unless the diet is corrected. Also, the coronal reduction may result in abnormal wear of opposing teeth.

Periodontal treatment

Periodontal pockets deeper than 3 mm are difficult to clean in rabbits. Standard subgingival curettes may be used but small dental excavators are often more effective. Deeper pocketing is usually associated with abscessation, in which case the tooth will need extracting. This will also result in abnormal wear of opposing teeth.

Extraction

Extraction of healthy rabbit teeth is straightforward but diseased teeth are generally elongated with deformed roots (see Figures 8.12 and 8.13), complicating extraction. Provided the embedded tooth structure has remained relatively normal, the periodontal ligament can be sectioned and torn, using commercial or custom-made instruments with a standard luxation technique. Once loosened, the tooth should be intruded into its alveolus and manipulated to help to destroy any remaining germinal tissue prior to removal. The pulp should remain in the extracted tooth. If not, the germinal tissues are probably intact and should be actively curetted using a sterile instrument. If the germinal tissues are left intact the tooth will regrow, possibly as a normal tooth but more likely with gross deformity, in some cases forming a pseudo-odontoma within the jaw bone.

Castration

Castration will prevent aggression, urine spraying in the house and unwanted litters. The testicles descend into the scrotum at about 3–4 months of age. The procedure is simple: a scrotal skin incision is made and the skin is peeled back away from the tunic; then a closed technique with a transfixing suture is placed above the testicle. Alternatively an open technique can be used. The tunic should be stitched. A large fat pad in the inguinal canal usually prevents herniation of abdominal contents but this should not be relied on.

Ovariohysterectomy

Routine ovariohysterectomy of young female rabbits at about 6 months of age will prevent aggression and territorial behaviour; it will also prevent uterine hyperplasia and adenocarcinoma in later life. A ventral midline approach should be made. The mesometrium is the principal site of fat storage in the doe, which can make identification and ligation of blood vessels difficult. The uterus is often quite friable, especially if the doe is pseudopregnant, and uterine vessels should be ligated. There are often several ovarian vessels to ligate, but these are usually small. A single transfixing suture should be placed just caudal to the two cervices.

Abscesses

Complete surgical removal of abscesses is the treatment of choice wherever possible. The thick capsule must be removed in its entirety. If this is not possible, aggressive surgical debridement should be attempted. The use of antibiotic-impregnated methyl methacrylate has been reported to be of use in the treatment of bony abscesses and osteomyelitis but calcium hydroxide can be associated with severe tissue damage. Injection of gentamicin into the capsule wall has also been reported to be effective.

Drug formulary

Drug	Dose
Antibacterials	
Cephalexin	11–22 mg/kg (may cause enteritis)
Doxycycline	2.5 mg/kg bid
Enrofloxacin	5–10 mg/kg bid (Baytril licensed for rabbits in UK)
Fusidic acid ophthalmic drops	1 drop sid or bid for staphylococcal infections (Fucithalmic Vet licensed for rabbits in UK)
Gentamicin ophthalmic solution	1 or 2 drops tid (Tiacil licensed for rabbits in UK)
Metronidazole	20 mg/kg bid
Penicillin	40,000 IU/kg every 7days for rabbit syphilis
Sulphadimethoxine	15 mg/kg orally bid for 10 days (coccidiosis)
Trimethoprim/sulphadiazine	30 mg/kg bid
Antiparasitics	
Albendazole	15 mg/kg sid
Fenbendazole	10–20 mg/kg orally every 2 weeks, 10–20 mg/kg orally daily for *Encephalitozoon cuniculi*
Ivermectin	0.2–0.4 mg/kg every 7–14 days
Miscellaneous	
Barium	10–14 ml/kg orally (GI studies)
Cholestyramine	2 g orally sid (human licence)
Cisapride	0.5 mg/kg bid (human licence)
Dexamethasone	2–4 mg/kg s.c., i.v. (shock); 0.2 mg/kg s.c., i.m. (anti-inflammatory)
Glycopyrrolate	0.01–0.02 mg/kg s.c. (human licence)
Metaclopramide	0.2–0.5 mg/kg bid
Oxytocin	0.1–3.0 IU/kg
Stilboestrol	0.5 mg 1 or 2 times a week

Figure 8.18 Drug formulary for the rabbit. All drugs are licensed for veterinary use unless otherwise stated.

References and further reading

Brown SA (1993) Incisor removal in the rabbit. *Proceedings of the North American Veterinary Conference 1993*, pp.791–792

Bryer LW (1957) An experimental evaluation of the physiology of tooth eruption. *International Dental Journal* **7**, 432–478

Burling K, Murphy CJ, da Silva Curiel J, Koblik P and Bellhorn RW (1991) Anatomy of the rabbit nasolacrimal duct and its clinical implications. *Progress in Veterinary and Comparative Ophthalmology* **1**, 33–40

Carpenter JW, Mashima TY and Rupiper DJ (1996) *Exotic Animal Formulary*. Greystone Publications, Manhattan, Kansas

Crossley DA (1995) Clinical aspects of lagomorph dental anatomy: the rabbit (*Oryctolagus cuniculus*). *Journal of Veterinary Dentistry* **4**, 131–135

Flecknell P (1996) *Laboratory Animal Anaesthesia, 2nd edn.* Academic Press, London

Flecknell P (2000) *Manual of Rabbit Medicine and Surgery*. BSAVA Publications, Gloucester

Harcourt-Brown FM (1995) A review of clinical conditions in pet rabbits associated with their teeth. *Veterinary Record*, **137**, 341–346

Harkness JE and Wagner JE. (1995) *The Biology and Medicine of Rabbits and Rodents, 4th edn.* Lea & Febiger, Philadelphia

Hillyer EV (1994) Pet rabbits. In: *Exotic Pet Medicine II. Veterinary Clinics of North America: Small Animal Practice* **24**(1) 25–66

Hillyer and Quesenberry (1997) *Ferrets, Rabbits and Rodents. Clinical Medicine and Surgery*. WB Saunders, Philadelphia

Kertesz, P (1993) Dental diseases and their treatments in captive wild animals. In: *A Colour Atlas of Veterinary Dentistry and Oral Surgery*. Wolfe Publishing, London

Laber-Laird K, Swindle MM and Flecknell P (1996) *Handbook of Rodent and Rabbit Medicine*. Pergamon, Oxford

Lobprise HB and Wiggs RB (1991) Dental and oral disease in lagomorphs. *Journal of Veterinary Dentistry*, **8(2)**, 11–17

Okerman L (1994) *Diseases of Domestic Rabbits, 2nd edn.* Blackwell Scientific, Oxford

Paul-Murphy J and Ramer JC (1998) Urgent care of the pet rabbit. In: *Critical Care. Veterinary Clinics of North America: Exotic Animal Practice* **1**(1), 127–152

Ramer JC, Paul-Murphy J and Benson KG (1999). Evaluating and stabilising critically ill rabbits. Parts I and II. *Compendium on Continuing Education for the Practicing Veterinarian* **21**, 30–40 and 116–125

Steenkamp G and Crossley DA (1999) Incisor tooth regrowth in a rabbit following complete extraction. *Veterinary Record* **145,** 585–586

Swartout MS and Gerken DF(1987) Lead-induced toxicosis in two domestic rabbits. *Journal of the American Veterinary Medical Association* **191,** 717–719

Suter C, Muller-Doblies UU, Hatt J-M, *et al.* (2001) Prevention and treatment of *Encephalitozoon cuniculi* infection in rabbits with fenbendazole. *Veterinary Record* **148,** 478–480

Wiggs RB and Lobprise HB (1995) Dentistry in pet lagomorphs and rodents. In: *Manual of Small Animal Dentistry, 2nd edn,* ed. DA Crossley and S Penman, pp. 68–92. BSAVA Publications, Cheltenham

Wiggs RB and Lobprise HB (1997) Diseases in rodents and lagomorphs. In: *Veterinary Dentistry, Principles and Practice*, ed. RB Wiggs and HB Lobprise, pp. 518–537. Lippincott-Raven, Philadelphia

9

Ferrets

Nico J. Schoemaker

Introduction

Ferrets are kept for many purposes, particularly hunting. Besides hunting rabbits in the field, ferrets can be used to control rat populations in areas where shooting is too risky, e.g. in buildings. The latter was the original reason why ferrets were taken to the USA, though there are now many states where 'working' is not allowed. Ferrets are increasingly being kept as pets.

Many people believe that the ferret *Mustela putorius furo* should not be kept in captivity. This animal, however, can be considered a domesticated creature of which no wild counterpart exists. Its closest relatives in the wild are the European polecat *Mustela putorius* and possibly the Steppe polecat *M. eversmanni*. Aristophanes (c. 450 BC) was probably the first to describe an animal which may have been a ferret in one of his comedies. In the literature from 2000 years ago both Strabo and Pliny describe the use of ferrets for hunting rabbits (Thomson, 1951).

Life expectancy	8–10 years (max. 15 years)
Average bodyweight hob	1200 g
Average bodyweight jill	600 g
Sexual maturity	First spring (March) after birth
Breeding season (Northern hemisphere)	March–September
Breeding season (Southern hemisphere)	August–January
Gestation period	41–42 days
Average litter size	8
Weight at birth	8–10 g
Eyes open at age	4–5 weeks
Eruption of deciduous teeth	3–4 weeks
Eruption of permanent teeth	7–10 weeks
Weaning age	6–8 (preferably 8) weeks
Heart rate	200–250 beats per minute
Respiratory rate	33–36 breaths per minute
Rectal temperature	38.8°C (range 37.8–40°C)

Figure 9.1 Biological data for ferrets.

Biology

The ferret is a carnivore with an average bodyweight of 1200 grams in hobs (males) and 600 grams in jills (females). Chapter 1 discusses ferret anatomy and physiology and there is a good overview in Fox (1998).

Although most of the ferret's biological features can be compared with the other pet carnivores, there are some differences. Compared with the cat, the ferret's reproductive season is even more influenced by the length of the day. In order to ovulate, jills need vaginal stimulation and they also need to be dragged around by the male. The lifespan is a little shorter than that of the dog and cat, but much longer than for most other small mammal pets. Figure 9.1 gives an overview of most of the biological data of the ferret.

Husbandry

Housing

The size of a ferret cage is not important as long as the owners regularly let their animals play, under supervision, outside the cage. Most importantly it should be well built, as ferrets are good at escaping. It should be high enough to allow the ferret to stand on its hindlegs to investigate its surroundings, and it should be big enough to provide a sleeping area (nest box), a litter box, a feeding area and some room to play. Mesh or solid materials can be used for the bottom of the cage. In cages with solid bottoms litter boxes should be placed away from the food and water and sleeping area. Water can be provided in either a bowl or a bottle. Most owners prefer bottles because ferrets tend to play with bowls and make a mess. Bottles should be thoroughly cleaned and refilled daily. Food can be provided in a bowl attached to the cage or in a bowl heavy enough to prevent the ferret from tipping it up. The sleeping area should be some kind of box for them to hide in. Cloths, towels or old T-shirts can be used for bedding material. Hay, straw and wood shavings are not recommended as inhalation of dust may lead to chronic irritation of the upper respiratory tract (Jenkins and Brown, 1993). Ferrets can be housed either inside or outside. When housed outdoors ferrets should be provided with protection against the elements. The resting area should be dry and clean and give them enough insulation against freezing conditions.

Under supervision ferrets can be kept with dogs and cats but not with rabbits or rodents.

Diet

The ferret is a carnivore and can therefore be maintained on a good quality high protein diet. The fat content can vary from 9% to 28%, but both the carbohydrate and fibre fraction should be low. Specific ferret diets as well as good quality cat diets, commercially available in the past decade, are suitable for ferrets. Some ferrets fed specific diets seem to have firmer stools that smell less strongly. Although ferrets can be fed canned products, dry pellets are preferred. These stay fresh longer and seem to decrease the amount of dental calculi formed. Fresh water should be available, especially when pellets are fed. Because ferrets have a short gut and a fast gut transit time they should be fed *ad libitum*. Ferrets may also be fed the traditional and more natural diet of whole rodents or rabbits [Editor].

Handling and restraint

Most pet ferrets are used to being handled, so the risk of being bitten is no greater than with a cat or dog. Ferrets should be picked up by placing one hand around the thorax and supporting the hindlegs with the other hand (Figure 9.2). Ferrets struggle if their hindlegs are held too firmly. If struggling is excessive the neck should be gripped more firmly. Scruffing of the loose skin at the back of the neck may be necessary for restraining difficult ferrets. Ferrets can be distracted by applying a liquid diet to the abdomen; most owners can manage to clip the nails of their pets while they are licking the food.

Figure 9.2 Gentle restraint around the neck, with support of the hindlegs, is usually sufficient to carry a ferret.

Diagnostic approach

Physical examination

Physical examination of the ferret is basically similar to that of the dog and cat. Some features, such as the peripheral pulse, however, are almost impossible to check.

As with any consultation a thorough case history is mandatory. Alertness and attitude should then be assessed. In the carrier the ferret may appear quite sleepy, but once out of the carrier it should be highly active. Ferrets normally arch their backs when they walk or run.

Handling of the ferret may alter its body temperature, heart rate and respiratory frequency. The author prefers to measure respiratory rate prior to handling. Heart rate measurement necessitates handing. The rectal temperature can then be measured, preferably with a digital thermometer. Reference values can be found in Figure 9.1.

Checking the hydration status of any small mammal is one of the most important features of a physical examination, and can be performed by assessing: the skin turgor of the upper eyelids; skin tenting in the neck; and the moistness of the oral mucosa. While checking the oral mucosa, attention should also be paid to the teeth, which should be free from tartar.

Since ferrets often have ear mites, special attention should be paid to the external ear canals. The neck, axillary, inguinal and popliteal lymph nodes should be checked. They may appear enlarged in overweight animals. If they are also firm, a fine needle aspirate should be taken to check for lymphoma. Both auscultation of the thorax as well as an abdominal palpation are finally included in the standard physical examination. An enlarged spleen is a common finding on palpation.

Sample collection

Blood

As a general rule blood comprising 1% of the bodyweight of a healthy ferret can be collected, although usually far less is necessary. Most laboratories can do haematology and full biochemical analysis with 2 ml of blood.

Techniques for bleeding, such as toenail clipping and cardiac or periorbital puncture, should be considered obsolete today. Much better locations are the lateral saphenous vein or cephalic vein for small amounts of blood (up to 1 ml) and the jugular vein or the cranial vena cava for larger amounts. The author prefers a 26 gauge needle and a 2 ml or 5 ml syringe for drawing blood. The jugular vein is approached as for cats and can be performed in docile ferrets without anaesthesia (Figure 9.3). The cranial vena cava approach is best performed under isoflurane anaesthesia, although this is not necessary in debilitated ferrets. Isoflurane anaesthesia can artificially lower the red blood cell count and PCV by up to 40%. Changes in plasma protein and the white blood cell count are not seen. Red cell changes return to normal after approximately 45 minutes of anaesthesia [Editor].

Figure 9.3 In docile ferrets blood may be collected from the jugular vein in a manner similar to that in cats and dogs.

No premedication is necessary. The ferret should be placed in dorsal recumbency and the needle inserted into the thoracic inlet just cranial to the connection between the manubrium and the first rib and then directed towards the contralateral hindleg at a 30 degree angle (Figure 9.4). As the heart is located relatively caudally within the thoracic cavity and the needle is only 1.2 cm long, there is no risk of cardiac puncture from this technique.

Figure 9.5 shows reference ranges for haematological and biochemical parameters.

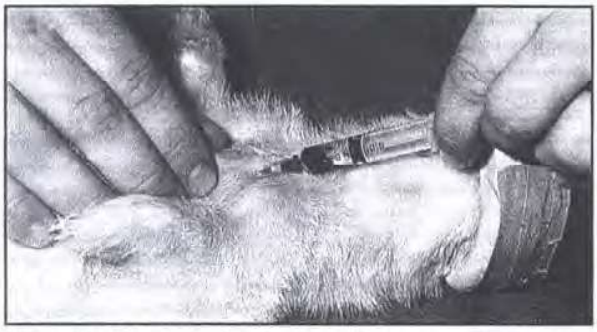


Figure 9.4 Blood collection from the vena cava is best performed in an anaesthetized ferret.

Parameter (SI units)	Range	Mean
WBC (x 10^9/l)	2–10	5.7
PCV (%)	36–53	47.3
Heterophils (%)	13–48	28.2
Lymphocytes (%)	40–82	53.8
Monocytes (%)	7–9	6.9
Eosinophils (%)	2–8	5.02
Basophils (%)	0–3	1
Blood urea nitrogen (mmol/l)	0.2–16.1	10.4
Creatinine (µmol/l)	8.8–106	53
Alkaline phosphatase (IU/l)	14–144	41
Alanine aminotranferase (IU/l)	48–292	138
Aspartate aminotransferase (IU/l)	46–118	68.3
Lactate dehydrogenase (IU/l)	222–377	278
Bile acids (µmol/l)	1–28	9.1
Creatine kinase (IU/l)	98–564	245
Glucose (mmol/l)	6.66–7.99	6.69
Calcium (mmol/l)	1.9–2.4	2.04
Total protein (g/l)	43–60	52
Albumin (g/l)	34–48	39
Globulins (g/l)	2–24	13

Figure 9.5 Reference ranges for haematological and biochemical parameters in the ferret. Data from Fudge (2000).

Common conditions

Viral diseases

Canine distemper

On a worldwide basis canine distemper (caused by a paramyxovirus) is the most serious viral infection of ferrets and is almost always fatal. The disease is seldom seen in ferrets nowadays owing to vaccination.

The classic symptoms are dermatitis on the lips and chin and around the inguinal region, 7–9 days after infection. Other common signs are mucopurulent ocular and nasal discharge, pyrexia (over 40°C), sneezing, coughing and anorexia. Just as in dogs, ferrets can develop hyperkeratosis of the footpads (hardpad).

Diagnosis is based on fluorescent antibody tests on conjunctival smears and/or brain tissue. As vaccination is performed with a modified live virus, vaccinated ferrets give a positive result with this test and therefore only non-vaccinated ferrets should be tested.

The USA is the only country with a registered canine distemper vaccine (Fervac-D, United Vaccines, Madison, WI) available for use in ferrets. Some veterinary surgeons have reported adverse reactions to this vaccine. Standard modified live vaccines developed for use in dogs can be used provided they are derived from non-ferret cell lines, as ferrets subjected to these can develop distemper from the vaccine. Manufacturers will provide veterinarians with data on the use of their products in ferrets. Many of these products have been used safely in hundreds of ferrets.

Influenza

Ferrets are highly susceptible to several strains of human influenza virus and therefore influenza should be considered a zoonosis. Humans can infect ferrets and *vice versa*. Veterinarians or staff with minor symptoms of influenza either should not treat ferrets or should wear a mask to prevent the spread of the virus.

Many of the symptoms of influenza are similar to those of canine distemper but less severe. Nasal discharge is mucoserous instead of mucopurulent, there is more sneezing and coughing and the fever is usually over before the animal is presented to the veterinary surgeon. Just as in humans, the infection is self-limiting and usually not fatal.

Aleutian disease

Aleutian disease is caused by a parvovirus, unrelated to that causing bloody diarrhoea in dogs. Of the Mustelidae the mink is the most susceptible, but a ferret-specific strain has been found (Porter *et al.*, 1982). As no vaccine is available to prevent infection, mink farms routinely check their animals for antibodies. Aleutian disease is considered more of a problem in the UK than elsewhere. Although infection has been suspected several times in the Netherlands, the diagnosis was only confirmed once. Aleutian disease has been diagnosed in ferrets in the USA, and screening of 500 clinically normal ferrets housed in shelters in northern America resulted in the detection of antibodies against Aleutian disease in about 10% of the animals.

Aleutian disease is an immune complex-mediated condition, resulting in multiple organ failure. Clinical signs in mink include wasting, hepatomegaly, splenomegaly, melaena, recurrent fevers and eventually hindleg paralysis and other neurological signs. Most mink die within 5 months of infection. Ferrets seldom develop such severe symptoms. Although serum countercurrent immunoelectrophoresis is necessary to confirm the diagnosis, a hypergammaglobulinaemia together with chronic wasting signs suggests Aleutian disease (Figure 9.6).

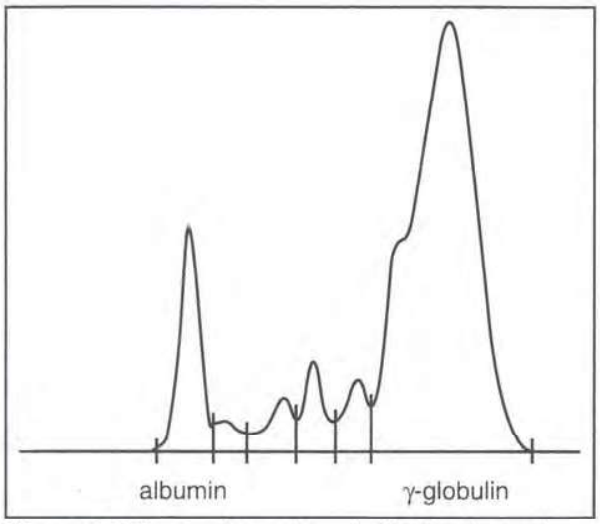


Figure 9.6 Protein electrophoresis of a blood sample from a ferret with Aleutian disease. Note the extremely high concentration of gamma-globulin.

As with almost all viral infections there is no specific treatment, but antibiotics and steroids have been reported to give some relief.

Parasitic infestations

Ear mites

The ear mite *Otodectes cynotis* is the most common ectoparasite found on ferrets (Figure 9.7). Massive infestations can cause pruritus, but many ferrets have low-grade infestations without showing many signs. Mites may be seen during a routine otoscopic examination but can also be easily overlooked. The best diagnostic technique is to place a sample scraped from the ear canal on to a microscope slide with potassium hydroxide (KOH). The mites can be seen moving around.

Reports of treatment with subcutaneous injections of ivermectin have shown it to be ineffective and in some instances tissue necrosis has occurred. Application of ivermectin or fipronil drops within the ear canals seems to work well. Recent trials with the topical application of selamectin at the base of the skull have shown promising results. Although no side effects have been reported in ferrets with either fipronil or selamectin, these drugs are not registered for use in ferrets. An advantage of topical selamectin is that it does not need to be administered within the ear canal and there is therefore no risk of an ototoxic effect if the eardrum is not intact.

Fleas (*Ctenocephalides felis)*

Ferrets are just as sensitive to flea infestations as are dogs and cats and the clinical manifestations are similar, although the author has never seen or heard of flea allergy in ferrets. Just as in dogs and cats, treatment of the environment is just as, if not more, important than treatment of the ferret alone. Sprays used on dogs or cats are suitable. Owners who regularly wash their ferrets use a flea shampoo containing permethrin for this purpose. Fipronil or selamectin can also be used for flea control.

Worms

Usually ferrets are free of gastrointestinal parasites. Routine deworming is therefore not recommended. If worm eggs are found in the faeces, ivermectin (0.2 mg/kg i.m.) can be given. The new avermectin, selamectin, can also be used for endoparasitic infestations. Therefore this drug can be used in young animals for the combined control of ear mite and possible worm infestations.

Endocrine disease

Persistent oestrus

Female ferrets (jills) are seasonal breeders and come into oestrus under the influence of light. Day lengths exceeding 12 hours induce oestrus, which continues until the day lengths decrease again to less than 12 hours. Therefore under natural light conditions the oestrous season is approximately from March until September. A firm stimulant, in the form of dragging by the scruff of the neck and mating, is necessary for ovulation. If the jill is not mated, she will not ovulate, as ferrets are induced ovulators. This results in increased oestradiol levels. Oestradiol levels remain high until the end of the oestrous season. Continued high levels of oestradiol can lead to alopecia (Figure 9.8) and bone marrow suppression, resulting in a

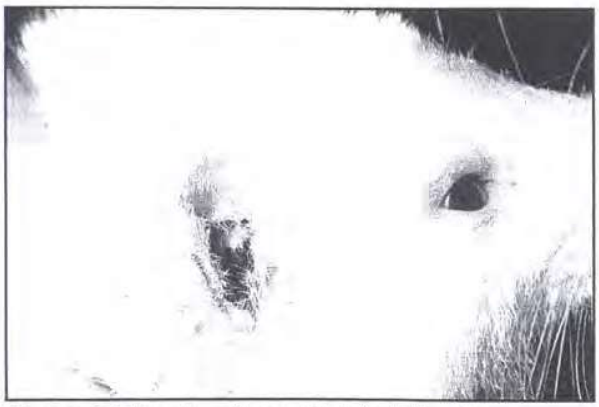


Figure 9.7 Ferrets with ear mite infestations have a crusty black secretion in the outer ear canal.

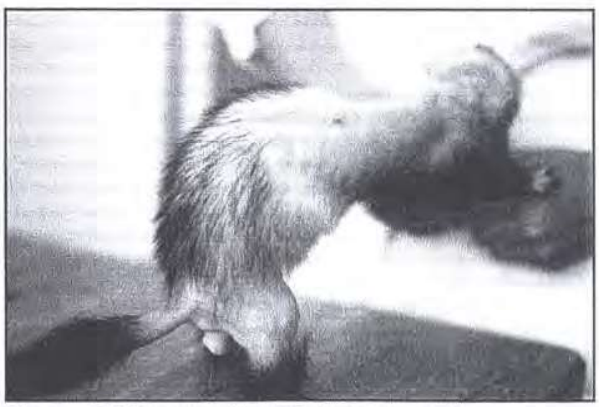


Figure 9.8 Ferrets with persistent oestrus show symmetrical alopecia and swelling of the vulva.