Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

CHAPTER

8

Viral, bacterial and mycotic diseases

'Ferrets are susceptible to canine distemper and should be vaccinated yearly against this disease. This is very important because canine distemper is always fatal to ferrets.'

Wendy Winsted, Ferrets, 1981

An overview

Anyone concerned with ferret health will quickly realize that the ferret seems to stand between the dog and cat as regards disease problems, being the third companion animal. Considering viral conditions, ferrets get rabies like other carnivores. They can get canine distemper and many people working ferrets believed they also got feline influenza, in fact ferrets actually get human influenza. All viral infectious diseases in early twentieth century ferret books came under the title of 'the sweats'. With my first ferret, Fred, I gave him both canine distemper and feline enteritis vaccines a week apart to be sure! He showed no ill-effects on using 1/6 dog/cat dosage.

Added to all other woes, the ferret has been used extensively in biomedical research as a considered good 'model' for the passage of viral and bacterial diseases, besides being used for a variety of experiments on various subjects. Ferrets have been used for the detection of various avian type influenza viruses such as H5N1.[1] Human isolates were fatal to intranasally-inoculated ferrets. Experimentally, ferrets have been found to be susceptible to pseudorabies, poliomyelitis, Newcastle disease, encephalomyelitis and sclerosis.[2]

The Australian 1999 Newcastle disease outbreak in poultry, for instance, was said to be a mutation of the non-virulent Newcastle strain and not an imported virus (Commonwealth Agriculture Department, May statement). With the possible genetic changes of viruses over time and between species, the possibility of new disease patterns arising cannot be discounted. Human influenza was considered in a 1989 review of zoonotic diseases related to ferrets, as being the only disease for which there was a case report concerning transmission from ferret to man. Rabies is still a contentious subject regarding ferrets in the USA even though there has been no infection of man due to ferret bites.[3] Rabies has not been recorded naturally in ferrets in the USA, UK, Europe, Japan, Australia or New Zealand.

There was some concern from American authorities on the rabbit calicivirus possibly mutating between species but, as yet, there has been no proof of the disease being in any other wildlife, or dogs, cats, or ferrets. The horror of human Creutzfeldt–Jacob disease is well known. The possibility of the disease complexes known as transmissible spongiform encephalopathy (TSE) affecting ferrets, from contaminated meat products, is debatable. TSE disease has been seen in farmed mink in the UK.[4]

In Australia, the Hendra virus (HENV) (family Paramyxovidae, genus Henipavirus) killed horses and two men in 1994. A similar virus, the Nipah virus (NIPV) (genus Henipavirus) was found in pigs in Malaysia in 1999, originally suspected to be Japanese encephalitis (JE), which is spread by mosquitoes.[5] *Note*: ferrets get heartworm disease from mosquitoes (Ch. 10). NIPV was suspected of killing more than 100 people; the symptoms were high fever, aches, eventually coma and death. NIPV, related to but distinct from HENV, is a 'new' megamyxovirus, a genus of the paramyxovirus family. HENV only transmits easily between flying foxes (fruit bats *Pteropus* species) which are the natural hosts to HENV, NIPV and Australian Bat Lyssavirus (ABL).[6] It is

considered that a fruit bat first infected pigs with NIPV; however, NIPV seems to be able to transmit easily between pigs and also between pigs and other animals including humans, horses, dogs, goats, and bats.[5]

The position of the ferret in the scheme of things regarding virus infection is still of concern. The 2003 SARS disease complex involving the active coronavirus (an RNA virus)[7] has killed over 700 people in Asia and

Table 8.1 Main infections and parasites in wildlife of European concern regarding veterinary public health

Type	Name	Host	Species frequently mentioned
Virus	African swine fever	Porcine	Wild boar
Virus	Aujeszky disease	Porcine/carnivore	Wild boar/fox
Virus	Avian influenza	Birds	Birds (wild boar?)
Virus	Avian pox	Poultry	Birds
Virus	Classic swine fever	Porcine	Wild boar
Virus	Foot and mouth disease	Ruminants and porcine	Cervid, wild boar
Virus	Hantavirus	Human	Field mice and voles
Virus	Myxomatosis	Rabbit	Wild rabbit
Virus	Newcastle disease	Poultry	Birds
Virus	Rabbit viral haem. disease	Rabbit	Wild rabbit
Virus	Rabies	Mammals	Fox and bats
Bacteria	Anthrax	Mammals	Ungulates
Bacteria	Avian botulism	Ornamental birds	Waterfowl
Bacteria	Avian cholera	Poultry	Birds
Bacteria	Avian tuberculosis	Poultry	Birds
Bacteria	Bovine brucellosis	Bovine	Ungulate
Bacteria	Bovine tuberculosis	Bovine, caprine, human	Cervid, wild boar, badger, carnivore
Bacteria	Leptospirosis	Mammals	Commensal rodents
Bacteria	Listeriosis	Humans	Mammals
Bacteria	Lyme disease	Human	Mammals
Bacteria	Paratuberculosis	Ruminants	Ungulates
Bacteria	Pasteurellosis	Porcine	Mammals
Bacteria	Salmonellosis	Most	Vertebrate
Bacteria	Sheep /goat brucellosis	Ovine and caprine	Ungulate
Bacteria	Swine brucellosis	Porcine	Wild boar, hare
Bacteria	Tularaemia	Hare	Mammals
Rickettsia	Q fever	Ruminants	Terrestrial vertebrate
Protozoa	Leishmaniasis	Human, dog	Wild carnivores?
Protozoa	Toxoplasmosis	Human, cat	Mammals
Cestode	Echinococcosis/ hydatidosis	Human, ovine	Wolf, fox, rodents
Nematode	Trichinellosis	Porcine	Wild boar, fox
Acaria	Mange	Ruminant, equid	Mountain ungulates, fox
Trans enc.	Bovine spond. enc.	Bovine	Zoo animals
Encephalopathy	Encephalopathy	Bovine	Zoo animals

Trans enc., transmissible encephalopathy; Bovine spond. enc., bovine spongiform encephalopathy.
Adapted from Table 1 in Artois et al 2001.[8]

North America and has been traced to cats, raccoons and badgers which are sold in Chinese markets It is thought that the masked palm civet (genetically related to ferrets and cats) transmitted SARS to humans. The SARS coronavirus (SCV) has been shown to infect cats and ferrets and consequently these animals are possible 'models' to test antiviral drugs or vaccine candidates against the disease. The coronavirus can spread fairly well between humans and needs no vector. In a world where air travel is easy it is possible to visualize human to ferret transmission, to pet ferrets, remembering the incubation period in humans can be 2–10 days. In addition, the virus is able to survive outside the body in respiratory secretions or faeces. It is not susceptible to some common household detergents.

Note the ability of the coronavirus to be generally pathogenic in many species is considered to be a result of its RNA make-up. DNA viruses can be accurate reproductions of their own kind, but RNA viruses have errors in replicating (mutation trends) so that the mutation changes are a type of survival mechanism for the virus in adverse conditions, i.e. change from one body to another, animal to man, man to man.[7] The SARS coronavirus in this way shows an ancient similarity to the avian and bovine coronaviruses. Zoonotic virus distributing between the reservoir host (Hr) and the secondary host (Hs), which could in the future be the ferret, has been discussed by Childs.[6]

The control of infectious diseases in Europe and indeed worldwide, in wildlife relates directly or indirectly to those diseases getting to the mustelids, polecats, feral ferrets or even domesticated ferrets.[8] The point is made in Europe that with rabies the dog reservoir is replaced by the red fox (*Vulpes vulpes*) and the bovine form of tuberculosis has been picked up by the Eurasian badger (*Meles meles*). A table of infectious diseases in general

Table 8.2 Comparative viral and bacterial disease susceptibility of the three major carnivores kept as pets; and humans

Disease	Mustelidae	Canidae	Felidae	Humans
Rabies	+	+	+	+
Human influenza	+ fr	–	–	+
Canine distemper	+	+	–	–
Canine hepatitis	–	+	–	–
Canine parvovirus	–	+	–	–
Canine parainfluenza	–	+	–	–
Feline distemper (enteritis)	+ frn	–	+	–
Feline rhinotracheitis	–	–	+	–
Mink viral enteritis	+ frn	–	–	–
Aleutian (parvovirus) disease	+ fmp	–	–	–
Feline chlamydia disease	–	–	+	–
Bordetella bronchiseptica	+	+	–	–
Botulism	+	–	–	+
Leptospirosis	+	+	–	+
Tuberculosis	+	+	+	+

Key to comparative disease susceptibility table:

Mustelidae	Domestic ferrets plus mink, otters, badgers, stoats, weasels, etc.
Canidae	Domestic dogs plus foxes, dingoes, etc.
Felidae	Domestic cats plus tigers, leopards, etc
Human	The reader
+	Affects family in question
–	Does not affect family in question
fr	Indicates that only ferrets get human influenza in the Mustelidae
frn	Indicates that only ferrets do *not* get feline enteritis or mink viral enteritis in the Mustelidae (it was thought that feline panleukopenia could replicate when *injected* into a ferret but no clinical signs developed) (Finkler, pers. comm. 2005)
fmp	Indicates that both ferrets and mink get Aleutian disease in the Mustelidae

After Dinnes.[45]

(Table 8.1) and their hosts is interesting to consider with the fate of the mustelids wild or domestic, in mind. The extent of viral and bacterial infections alone can stimulate thoughts of possible infection of ferrets. In the virus field, the adaptability of any virus to leave its primary host and mutate to invade another species may arise. This may thus threaten all mustelids in the future.

A comparison of disease susceptibility between ferrets, dogs, cats and man is shown in Table 8.2.

Ferret viral diseases

Virus structure is dependant on RNA strands. The taxonomy becomes hard to keep up with as viruses, etc. are broken into groups of nucleic acid 'variations' pathogenic or otherwise. Table 8.3 illustrates the present viruses that could possibly affect ferrets. (Coronaviruses and rotaviruses are discussed further in Chapter 9.)

Rabies

The rabies virus occurs worldwide, with the exception still of Australia, New Zealand, UK, Hawaii, Japan and parts of Scandinavia. These countries do not routinely vaccinate against rabies. Rabies occurs in wild foxes in Europe. A WHO survey, 1977–1998, recorded 464 cases of rabies in wild polecats across Europe. During the rabies surveillance, 48 of the 464 total polecats were said to be rabid ferrets (W. Mueller, WHO/OIE Reference Center for Rabies, Tübingen, Germany, pers. comm. 1998). Dr Mueller was of the opinion however, that the determination of species, whether polecat or ferret, was not always correct. Identification was done by veterinarians not biologists! Ferrets running wild and easily interbreeding with polecats could make identification difficult and it is fairly sure that the 48 rabid ferrets reported were in fact rabid polecats. In a 1998–2004 survey concerning pine marten and other mustelids, Latvia, Lithuania, Poland and Ukraine registered higher number of rabies cases with higher incidence in the targeted pine marten (*Martes martes*). The total rabies cases incidence peaked in 2002 for pine martens and in 2003 for other mustelids (W. Mueller, pers. comm. 2005).

Regarding quarantine, ferrets are not yet allowed to be imported into Australia. In the opinion of the WHO authorities, rabies vaccination for ferrets is not likely to be compulsory in the UK. This might be a safe bet for pet ferrets but it might be different for working ferrets. Rabies is of concern in the USA, where it has been given as the main reason for banning ferrets as pets in California (Ferrets Anonymous, California, pers. comm. 1996). It has been noted experimentally, that ferrets fed rabies-infected mice did not become infected and no serum antibodies were found in the ferret serum, which indicates the bite as the main means of transmission.[3] The mice probably did not get a chance to bite the ferrets!

A Finnish veterinarian in 2004 showed concern that the EU had removed Russia from the list of high-risk countries.[9] Thus Russian owners of dogs, cats and ferrets need not show blood test results. Russians love their pet ferrets and hopefully desire to vaccinate them against rabies. The EU decision was considered political, not scientific and is a worry to Finland. The Baltic States have a problem with sylvatic rabies so the world's guard against rabies cannot be dropped with the advent of more open borders and fast travel. Australia is lucky being an island continent but in respect to rabies the northern islands of Indonesia and New Guinea could be a worry if a dog incubating rabies reached our shores from a fishing boat, etc.

Rabies symptoms: It has been shown experimentally that an incubation period of 28–33 days is possible with death in 4–5 days.[10] The animal shows anxiety and

Table 8.3 Nucleic acid differences of common viruses that may affect ferrets

Viruses	Family	Nucleic acid	Envelope	Size (nm)
Rabies	*Rhabdoviridae*	ssRNA	Yes	70–88 × 130–380
Distemper (CD)	*Paramyxoviridae*	ssRNA	Yes	150–300
Parvovirus (AD)	*Parvoviridae*	ssDNA	No	18–26
Influenza (HI)	*Orthomyxoviridae*	ssRNA	Yes	90–120
Coronavirus (ECE)	*Coronaviridae*	ssRNA	Yes	60–220
Rotavirus	*Reoviridae*	dsRNA	No	80–130
Infectious bovine rhinotracheitis	*Herpesviridae*	dsDNA	Yes	46–48

CD, canine distemper; AD, Aleutian disease; HI, human influenza; ECE, epizootic catarrhal enteritis (Ch. 9); ds, double stranded; ss, single stranded.
After Langlois.[16]

lethargy with possible posterior paralysis.[11] With definite suspicion of infection, e.g. a non-vaccinated ferret and possible exposure to a rabid animal, it must be euthanized and its brain tissue subjected to fluorescent antibody test. The worrying fact to North American pet ferret owners is that if their ferret strayed and was picked up by the local authorities, the ferret, even though vaccinated, might be euthanized directly. A Canadian report study recommended a suspect ferret from a bite situation be kept under observation for 10 days.[12] There is no treatment for rabies bites in animals, though a human survived after being bitten by a rabid bat and given a combination of drugs and an induced coma.[13]

Research on an inactivated rabies vaccine specific for ferrets was carried out.[14] The potential of an immunoperoxidase technique for the diagnosis of general rabies in fresh tissues was found superior to other standard methods e.g. fluorescent antibody test.[15]

The major rabies vaccine for ferrets for the past few years has been IMRAB 3 (Merial) in the USA and Canada. The initial rabies vaccination is a single shot (1 mL) given at 12 weeks of age. The usual yearly boosters apply (Brown, pers. comm. 1999). The vaccine Imrab 3TF (Merial) is used in the USA /Canada, while the latter country also uses Prorab (Intervet Canada).[16]

Rabies vaccination is not carried out in Australia except by the special request of people working in rabies-affected countries like Indonesia. Regarding Australia and New Zealand, rabies would be of extreme concern if introduced and would require a complete rethinking of our vaccination requirements.

Vaccination site reactions

A technique of giving a vaccination in the ferret neck, between the shoulder blades, was described in the USA, which is higher than I gave injections in dogs, cats or ferrets. It has been known since 1991 that, 3 months to 3 years after FeV or rabies vaccination, cats can get a site tumour, which may be a fibrosarcoma, a malignant fibrous histiocytoma or some sort of mesenchymal tumour. Murray in 1998 demonstrated concern about a ferret vaccine sarcoma in a letter to the AVMA.[17] The damage could be a combination of mechanical trauma and/or reaction to the vaccine material injected. In a 2000 study with dogs and cats, the outcome was a proposal of triennial vaccination at least for cats.[18]

A 2002 assessment of response to commercial vaccines showed that cats differed from mink and ferrets.[19] A total of 24 1-year-old ferrets, 20 4-month-old mink and 20 4-month-old cats were vaccinated with three rabies virus vaccines, two leukaemia virus vaccines, alum adjuvant and saline to see what the local response would be on marked spots of the shaved dorsum area. Injections were given under anaesthesia. Histological findings showed significant differences in the tissue response to the vaccinations between the three species with the cat showing more lymphocytic response to the three rabies vaccines. Production of collagen, fibroblasts and macrophages differed among the three killed aluminium-adjuvant vaccines in the cats but not in the ferrets or mink. In response to the two adjuvanted leukaemia virus vaccines, mink and ferrets produced more binucleate cells. It was considered the response differences in cats were because cats were more likely to get vaccine-associated sarcomas (VAS).

In a retrospective 2003 survey however, ten ferrets were checked and seven were found to have fibrosarcoma development in the areas usually used for vaccination, being the intrascapular aspect of the neck and dorsal aspect of the thorax.[20] Four sample ferrets had been vaccinated with rabies/distemper combinations, two just with rabies, while four had no record of vaccination. The remaining three ferrets each had neoplasia but on the base of the tail, the ventral abdomen and the carpus. The ferret with the ventral abdominal tumour was one vaccinated with rabies/distemper combination. Of the seven, six had definite records of vaccination so the neoplasia were considered to be vaccination site fibrosarcoma or VSF. The tumours were nodular and 10–15 mm wide in the subcutis. The ferrets with VSFs were aged 1–9 years. Follow-up on three ferrets' post-surgical removal of the VSFs showed one tumour recurred after 3 months while the other two ferrets were clear at 8 and 12 months post-operation. The authors of the survey considered the results positive for VSFs in another species besides the cat. There is as yet no proof of a retrovirus involvement in VSFs in the cat or ferret. The location of these tumours at vaccination sites in ferrets suggests that vaccine material may predispose them to reactions.

Lyssavirus of bats in Australia

A human case of Australian Bat Lyssavirus (ABL) (family Rhabdoviridae, genus Lyssavirus) infection has occurred in a person in contact with bats.[21] Tests on dogs and cats that have been inoculated with the rabies-related virus, show that they are susceptible to it, but an epidemic would be unlikely. No work has been done on ferrets. It is considered that domestic animals would be 'dead-end hosts' so there is minimum danger to humans from that source. However, the symptoms of ABL and rabies would be the same. The finding of ABL in two flying foxes[22] in Western Australia illustrates the spread of the disease across the continent. Pet ferrets would only be at risk in the rare chance of them finding an infected carcass.

Human influenza (HI)

The ferret is highly susceptible to human influenza and has been important as an experimental model in influenza research since 1935.[3] Ferrets were used to test a potent new Australian-designed drug, GS4104 (Relenza), which has been found to protect them against some of the most dangerous strains, giving hope for similar effects in man.[23] With close contact between people and ferrets, especially in apartment dwellings with closed confined air-conditioning in the USA and other ferret-loving countries, the risk of mutual infection between humans and ferrets has increased, as inhalation is the main means of transmission of 'flu viruses.[3] Ferrets are very susceptible to influenza virus type A.[24] This causes respiratory disease in man, animals and poultry. Influenza with its collection of virulent viruses has been the basis of the fear of a global epidemic.[25]

Clinical signs: Typically, after 48 hours incubation, the ferret has a temperature of 40°C with a moist nose and inappetence. Sneezing occurs and the temperature fluctuates on alternate days as it does with humans. If the ferret continues eating consistently or intermittently, it is a good sign but if a purulent nasal discharge occurs despite medication, the outlook is a possibly fatal pneumonia. That working ferrets can succumb to pneumonia if kept in cold draughty conditions was even pointed out by the writer Nicholas Everitt in 1897.

Treatment is by good nursing, keeping the ferrets in warm and draught-free accommodation, plus broad-spectrum antibiotics for secondary infections. The prognosis is good. Human decongestive room sprays, if available, are useful for ferrets. Interestingly, ferrets can recover within 5 days and will obtain immunity for at least 5 weeks against that particular flu strain.[26] As the nasal sinuses are a particularly vascular area, any permanent cellular damage by persistent infection may lead to a 'snuffles' condition, as described later in this chapter. The human influenza condition must be differentiated from canine distemper.

A neurological syndrome in laboratory ferrets has been recorded where the symptoms were weight loss, high fever, head tremors and ataxia, but recovery occurred with treatment. No infectious agent was isolated but two investigators had succumbed to human 'flu 2 weeks before the ferrets fell sick.[27] (Such neurological symptoms in ferrets living outside, can possibly arise from a meningeal cryptococcosis, see Ch. 12).

H5N1 virus and ferrets

In 1997, the virus H5N1 (a variant of influenza type A) as found in birds caused a human death in Hong Kong and human deaths have occurred since in Vietnam, Cambodia, Thailand and Indonesia.

The lethality of H5N1 has been tested on ferrets from isolates of the virus from humans and poultry.[1] The highly pathogenic H5N1 was found in poultry all over East Asia as from 2004. At the time of writing the H5N1 virus is apparently moving across Europe in migratory birds and infecting domestic poultry in eastern Europe. Vietnamese scientists considered bird flu could mutate to a more dangerous form.

The prevention of any H5N1 epidemic requires a vaccine. Antibodies against both the haemagglutinin (H) and neuraminidase (N), glycoproteins of the virus, are essential to protect against infection and spread, so that any vaccine must contain these proteins. In addition, isolating the H and N genes from a dangerous pandemic virus and altering them to make them user-friendly to humans could produce designer viruses. They can be mixed with another flu virus in the laboratory and used as a vaccine.[25] There is no doubt the ferret continues to play a part in viral experimental research.[28]

Vaccination of ferrets with the usual human influenza vaccine is not usually advised as the disease in ferrets is considered mild. There is wide antigenic variation in the human virus type and the actual immunity conferred is short-lived in ferrets.[29]

Note: swine influenza (SI) virus, another type of influenza virus, affects mice and ferrets and thus could be a problem for working ferrets in country areas near pig farms if an outbreak of SI occurred.[30]

Note: the family Paramyxoviridae includes mumps, Newcastle disease, parainfluenza 1, 2, 3 and 4 plus simian myxovirus SVS and the morbilliviruses. The morbilliviruses include important pathogens like measles (MV), rinderpest (RPV) and canine distemper (CDV). All morbilliviruses are contagious by air contact.

Canine distemper (CDV)

This is 100% fatal to ferrets and has an incubation period of 7–14 days. Treatment is difficult. In Australia and other countries with ferrets as working animals, the risk comes from contact with foxes that sometimes have dens next to rabbit warrens. The foxes will not disturb the local rabbits but will use them later for training of the fox cubs (Bert Geodes, ferreter, Perth, WA, pers. comm. 1980). The native dingo in Australia is also a possible carrier of distemper. Unfortunately, outback dogs and cross-bred dingoes belonging to aboriginal peoples may not be vaccinated so that the distemper pool may be maintained. Household pet ferrets in Australia and overseas are less likely to contact distemper unless in contact with unvaccinated family dogs bringing in the disease. Thus, overall protection must be advised for dogs and ferrets.

In America, even with blanket vaccination of pet ferrets, a distemper outbreak occurred in a ferret shelter

in Westchester country, New York and one case in Chicago, a month apart.[31] Basic education on distemper is still put out by the American Ferret Association. Incidentally, an outbreak of distemper in pet skunks (*Mephitis mephitis*) was recorded in Southern Florida with classic signs (C. MacCullough, pers. comm. 2005). The disease was also seen in Gainesville and Orlando and with cases in Iowa. There was concern that the infection was via pet shops.

Clinical signs: I have seen only one classic canine distemper in the ferret, but have been told of other cases around Australia. The ferret develops anorexia, vomiting, ocular and nasal discharges, which occur after the incubation period, followed by diarrhoea. A characteristic rash develops under the chin and in the inguinal region 10–12 days after exposure. The ocular/nasal discharges become increasingly purulent and as the disease progresses, the foot pads swell up, to become hyperkeratotic. The ferret will die 12–16 days after exposure to the ferret-adapted strain or 21–25 days with the canine strain.[26] The usual progression is for CNS signs with hyperexcitability, excess salivation (which might suggest rabies in some countries) plus muscular tremors, convulsions and eventual death by coma. Classic signs of canine distemper infection in the ferret are shown in Figures 8.1–8.5. Comparative clinical signs of canine distemper and human influenza are illustrated in Table 8.4. The pyrexia of HI fluctuates to high temperatures over days and can be 40°C plus. The CNS signs are seen in the advanced stages of CD but most infected ferrets are euthanized before that point.

Treatment: This is not easy and ferrets usually die of the disease. Some have tried using hyperimmune ferret serum (1.0–1.5 mL i.v., i.o.) from well-vaccinated ferret donors (M. Finkler, pers. comm. 2002). An interesting situation occurred in the USA in 2003.[31] A ferret owned

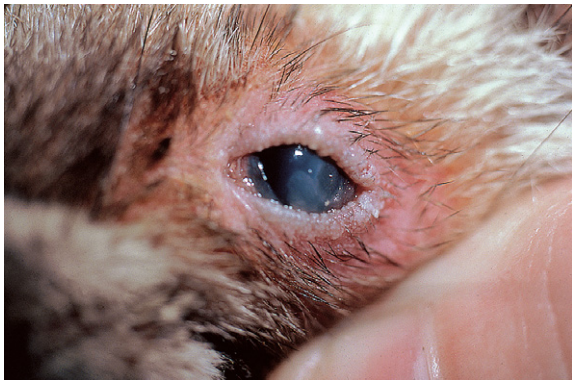

Figure 8.2 Ferret eye discharges. (Courtesy of Dr M. Davidson.)

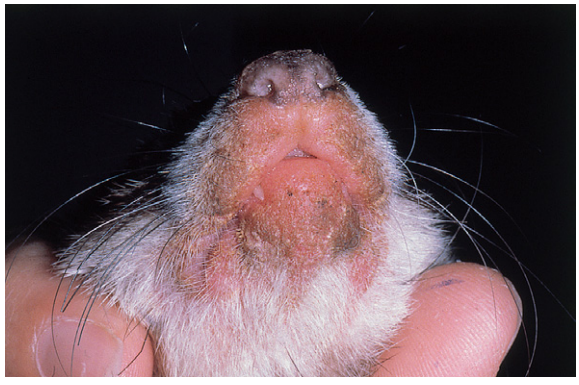

Figure 8.3 Ferret chin rash. (Courtesy of Dr M. Davidson.)

Figure 8.1 Ferret blepharitis. (Courtesy of Dr Michael Davidson, College of Veterinary Medicine, North Carolina State University, Raleigh.)

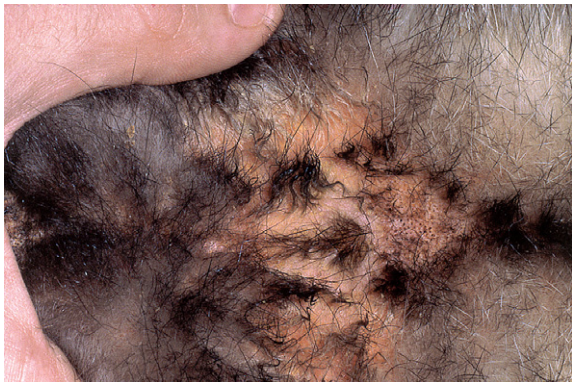

Figure 8.4 Ferret inguinal rash. (Courtesy of Dr M. Davidson.)

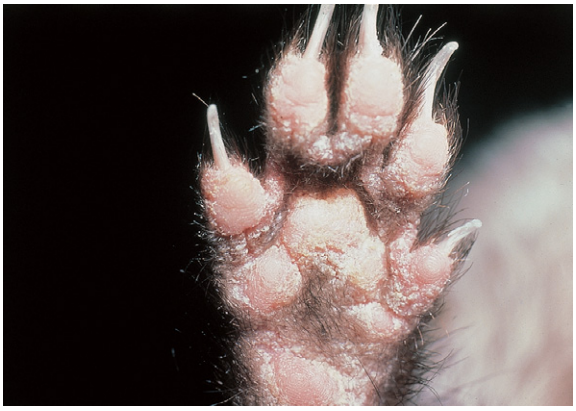

Figure 8.5 Ferret hyperkeratosis of pads. (Courtesy of Dr M. Davidson.)

by a vet hospital manager had sneezing fits and was put on amoxicillin for ferret 'flu. The ferret improved slightly but the manager also had a dog with upper respiratory disease. The dog was a 'rescue' dumped because it had parvovirus and, though nursed through the disease, had not been vaccinated for distemper. The ferret had been vaccinated with Fervac 2 years before but the vaccination was not boosted annually. There was no history of distemper in the hospital but the owner had a large number of raccoons in the front yard where the dog played. (There had been an outbreak of distemper in raccoons on Long Island the previous year.) Both ferret and dog progressed rapidly into classic distemper symptoms. They were vigorously treated against the disease with transfusion, interferon and bovine colostrum for the ferret along with other medications. The dog survived but the ferret succumbed after 5 weeks of treatment.

There is no single vaccine in Australia. Only multivalent vaccines are available, which can be used with care. The vaccines are produced in various mammalian cell lines. Any vaccine produced in ferret cell culture can be fatal to ferrets by actually producing the disease. *Note* that in American native black-footed ferrets, there was an occasion when four ferrets died within 21 days after vaccination with a modified live canine distemper virus vaccine and it was found that there had been insufficient attenuation of the vaccine for the species. The genetic relationship of the black-footed ferret (*Mustela nigripes*) to European ferrets (*M. furo*) remains uncertain, but in the same reference the European ferret has been vaccinated with the vaccine in question without any pathological effects.[32]

Canine distemper vaccination schedules

In the USA, the American Ferret Association has a policy of advising booster vaccinations for canine distemper in healthy ferrets at 8, 11 and 14 weeks of age by s.c. injection.

Vaccines available are:

1. FERVAC D (United Vaccines) modified live virus (MLV) only currently approved ferret vaccine of chick embryo origin.
2. PUREVAX FERRET (Merial) recombinant vaccine, viral-vectored (attached to canarypox virus) able to stimulate both cell-mediated humoral responses to the canine distemper HA and F glycoproteins.

The use of multivalent vaccine for ferrets is not recommended, as it is considered to give a vaccine-induced disease.[33] (However, in Australia we have no option, see below.)

Table 8.4 Canine distemper and human influenza differentiation

Clinical comparative signs	Canine distemper (CD)	Human influenza (HI)
Nasal/ocular discharges	+++	+++
Type of discharges	Severe mucopurulent	Usually mucoserous
Sneezing	+	+++
Coughing	+	+++
Pyrexia	+++	++
Dermatitis	+++	–
Footpad hyperkeratosis	++	–
Central nervous system signs	+	–
Prognosis	F	S

+, May be present; ++, Common; +++, Usual presentation; – Negative. F, fatal; S, self-limiting, can be fatal in neonates or if progressing to pneumonia. After Rosenthal, with permission.[29]

MLV is a modified virus giving immunity without disease however, it must infect cells to do the job and must survive long enough to stimulate a body immune response. It is suggested that anything which interferes with virus growth prevents enough virus being present to trigger the reaction. The immunity given to the kitten via the mother can interfere with the vaccination and is active for up to 6 weeks or more. This timing of the first vaccination is important.

It has been stated that FERVAC D has some side-effects and fatal reactions.[33] These range from depression with vomiting (sometimes bloody) to bloody diarrhoea, collapse, coma and death. Initial reaction can be pruritus and skin erythema. The ferret can go into shock with pale to gray mucous membranes, a drop in body temperature and a thready pulse. The vaccine reaction can occur anywhere between a few minutes and several hours afterwards, though most occur in the first 20 minutes.

PUREVAX has caused a reaction in a young ferret which had two shots as recommended 2 weeks apart.[34] The ferret slowly declined in health more noticeably after the second injection. It became anorexic with a PCV of 11 (normal 40) but improved on antibiotic, feeding and prednisone in 4 days when the PCV rose to 42. The ferret's appetite resumed and it was suggested by Merial that overstimulation of the ferret immune system had led to a haemolytic anaemia. (As with people, there can be individual reactions to any vaccination.)

It is considered that if rabies and canine distemper vaccinations are given together, any reaction will be from the CD. Both are regularly given together, the reason being that the clients of some practices have to travel long distances for an appointment (S. Brown, pers. comm. 1999).

Greenacre, USA, in a retrospective study into the incidence of an adverse reaction to vaccination with distemper or rabies between 1995 and 2001, found that 14 out of 143 ferrets reacted within 25 minutes.[35] Ten of the ferrets had both vaccinations; three occurred after distemper vaccination alone and one after rabies vaccination alone. They all had a general hyperaemia, mostly on the nose, mucous membranes and footpads. Hypersalivation and vomiting occurred, with five developing dyspnoea; of these, two were cyanotic. Also five had diarrhoea and two of these had haematochezia. One ferret, which reacted to the double vaccination, also had a reaction again the following year with a single rabies vaccine. It should be noted that 9 of the 13 ferrets that had reacted were not supposed to have had any history of previous vaccination but it needs to be remembered that all pet ferrets were derived from Marshall Farms, New York, stock. These ferrets would have been sterilized, descented and vaccinated against canine distemper at 6 weeks of age as were all laboratory ferrets.

Moore et al., USA, also carried out a retrospective study, between 2002 and 2003, on the incidence and risk factors for adverse events associated with distemper and rabies vaccination in ferrets and found the rate very low.[36]

Precaution at vaccinations

It is suggested that ferrets be checked for half an hour after the vaccination for any reaction. In the event of a reaction, the ferret is treated with 0.1 mL of 1:10 000 epinephrine s.c./i.m. for a major reaction, or Dexason SP (1 mg/500 g, i.v./i.m.) or 1 mg diphenhydramine (1 mg/500 g, i.v./i.m.) for minor reactions. *Note*: some American vets routinely pre-treat with 1 mg diphenhydramine before vaccination. Hospital support might be required in severe cases.[33]

Vaccination timing

A check of vaccination timing in a group of kittens would show the level of antibody (titre) dropping with time. Thus, there is a time when the kittens' titre level is dangerously low and the animal is susceptible to infection.

This moment could be as early as 6 weeks in some and as late as 14 weeks in others. Figure 8.6 shows the situation with two ferret kittens.[37] Kitten 1 (white line) has received a high level of passive immunity starting at 25 antibody titre. Kitten 2 (black line) has a lower level of immunity starting at 15. Thus if the titre level 10 is required for infection protection we see kitten 1 becom-

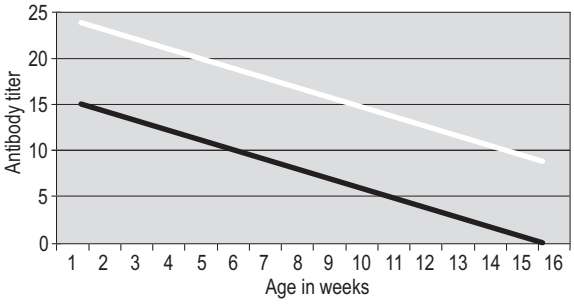

Figure 8.6 Vaccination schedule. The lines represent two different kits. Kit No. 1 (white) received a high level of passive immunity (starting at 25). Kit No. 2 (black), a lower level of immunity (starting at 15). If we assume that a titer of 10 (bold line) is required for protection against infection, then Kit No. 2 becomes susceptible at 6 weeks of age and Kit No. 1 does not become susceptible until 14 weeks of age.

ing susceptible at 6 weeks of age and kitten 2 susceptible at 14 weeks of age.

Thus in a population of kittens, if vaccination was given only at 6 week of age or 8 weeks of age there would be part of the population which would not respond to the vaccination and therefore become susceptible to infection. If the first vaccination was at 14 weeks of age many of the kittens would have already lost their immunity. Heiler comments on the problem of assessing titres and what they mean.[38] She points out there are three main methods of measuring antibody levels, being fluorescent molecules technique, haemagglutination inhibition assay and serum neutralization test. In the latter, serum mixed with antibodies is mixed with live virus and is assayed to see how much active virus is still present. The serum goes through dilutions to find out what dilution protects, e.g. titre 1:10 etc. It could be that a titre of 1:32 is effective. Heiler points out that to get the absolute assurance of protection, challenge studies must be done on live animals and that would require sacrificing ferrets in a laborious and costly procedure. She suggests using only approved and proven vaccines and reminds us that the risk of reaction, although very real, cannot be avoided by running a titre. More studies are required on ferret vaccination against canine distemper, which again would require using ferrets.

Galaxy D (Shering Plough Animal Health Co., Omaha, Nebraska) is another commercial USD approved modified live virus chick embryo cell-attenuated vaccine which is used by some but is not labelled for ferrets (M Finkler, pers. comm. 2004). Serological evaluation of the efficacy and safety of live Galaxy D vaccine has been carried out with young ferrets with success.[39]

There has been some research in the USA to indicate that canine distemper vaccine protection might last for up to 3 years. Fort Dodge, Australia has 'Duramune Adult' for dogs for a 3-year vaccination programme (Rapheal, pers. comm. 2005).

Caton has remarked that a statement in *Current Veterinary Therapy XI* pointed out that 'almost without exception there was no immunological requirement for annual vaccination and the immunity to viruses could persist for years or the life of the animal'.[40] This has led to some veterinarians considering annual 'wellness' checks rather than annual vaccinations, however they still agree that some degree of vaccination is needed. Author, Wendy Winstead, at the head of this chapter, was insistent on vaccinations for the deadly canine distemper disease.

Vaccination reactions have been considered previously as anaphylactic shock but Caton points out that ferrets can get lethargy, fever, abdominal tenderness and sore joints. It is also possible that in ferrets with pre-existing health problems, vaccination decreases their immune system and makes them worse. Thus many ferrets with chronic conditions may fail to respond to traditional treatment and homeopathic treatment devotees insist that the vaccination has interfered with the body's ability to heal itself.

Ferrets do not get canine parvovirus, canine adenovirus or canine parainfluenza and thus vaccinations carrying these components are not required for ferrets. At times of virus mutation in the future this might not be the case.

It was considered that multivalent vaccines could cause reactions in ferrets.[33] In Australia and New Zealand, we have only multivalent vaccines and in consultation with the two main vaccine producers, Commonwealth Serum Laboratory Ltd. and Fort Dodge it was established that their multivalent canine vaccines, though not registered for ferrets, can be used.[41,42] Webster's (now Fort Dodge) stated years ago that the global experience with vaccines has been cautious and professional and fitch (ferret pelt production) industries recommended in the past a dose range from one-half to one-sixth of the recommended dog dose. This is despite the fact that the safety and efficiency of these vaccines has been demonstrated at levels five times the fitch dose. Webster's used to have a univalent canine distemper vaccine but it was replaced by a multivalent vaccine so there is probably no chance of getting a single dose vaccine for ferrets yet down under.

However, I have used multivalent vaccines with ferrets with no reaction, providing a recommended dilution technique is used. I originally used Webster's Distemper vaccine at their recommended dose rate of one vial serving six ferrets. Thus using an accurate 1.5 mL sterile water to make up the dog dose, then using a tuberculin syringe for accurate dosing, the individual ferret could be given no more than 0.25 mL s.c. Use of 0.20 mL could be standard. I adapted this procedure with the multivalent vaccines.

I use CSL vaccine 3-1 (Canvac 3) on my own ferrets with no adverse effects. All three living attenuated viruses are produced in continuous cell lines and freeze-dried. I have heard in the past of some deaths in ferrets using 0.5 mL or more of a multivalent vaccine. I have also used the CSL 4-1 at 0.25 mL s.c. with no adverse reaction. Some veterinarians have used the CSL Distemper Hepatitis vaccine. The procedure with CSL Canvac of giving 0.25 mL of a reconstitute vial using 1.5 mL sterile water has been placed in the technical update material for vaccination of ferrets. It is emphasized that there is actually no vaccine currently registered for ferret use in Australia (C. Trumble, Pfizer Animal Health, pers. comm. 2005).

Note. It is considered that canine parvovirus and canine adenovirus are non-pathogenic to ferrets. The

canine parvovirus cannot protect against Aleutian disease but I would query if ferrets in some situations are not affected by canine adenovirus, e.g. ferrets boarded in dog kennels.

Whatever multivalent vaccine is used, a whole dog dose is definitely not recommended. Webster's also stated that the effective immunizing dose of vaccines is based on dose titration studies. (In the British Veterinary Codex, 1953, the ferret/fitch dose of an egg-adapted distemper vaccine was $^{1}/_{1000}$th of the dog dose.) Webster's recommended minimal immunizing dose will therefore differ between vaccines of different origins, depending to a large extent on the nature of the virus isolates themselves and the reproduction media and methods employed. It should be recognized therefore that it is the antigenic mass and not the volume *per se* that is important in defining an immunizing dose.

With the multivalent vaccine, it might be prudent to give one dose at 12 weeks of age and then yearly boosters. In the USA, criticism of the yearly booster regime had been stated.[31] It is considered that there is no immunological requirement for the annual re-vaccination. (Only vaccinations involving toxins require boosters.) The AFA recommendations for ferret vaccination still stand as shown previously.

The vaccine-associated sarcoma (VAS)

This has been commented on as relating to rabies and in particular to cats.[20] In the cat, it was found that live vaccines, not attenuated, were associated with VAS. The vaccine aluminium adjuvant was first suspected as an irritant. One veterinarian has quoted vaccine reactions as induced sarcoma, arthralgia (stiffness or pain in the joints) hives, gastrointestinal distress, 'blue eye', autoimmune disease and anaphylaxis in dogs, cats and ferrets.[31]

Annual check-up times

The subject of 'over-servicing' in regard to vaccination programmes has been aired, pointing out that the duration of immunity is a key factor. It is considered, in some quarters, that yearly vaccination has little merit in keeping the antigen titre, of whatever vaccine, up to a protecting level where 3- or 4-yearly boosters would be sufficient and cause less stress on the animal or the pocket of the client. Yearly annual general check-ups should be recommended as a basic procedure whether associated with vaccination or not. It would depend on client compliance but in respect to the ferret-owning clientele, this should be forthcoming in my opinion if they are advised of the need to seek early signs of FADC and insulinoma diseases at the very least.

There have been no trials in Australia to assess if an initial ferret vaccination would suffice for 2 years or more as has been indicated in American literature.[33] At the present time, the vaccination routine is at 6–8 weeks, 12–14 weeks and then a yearly booster of a small accurate dose of a multivalent vaccine as indicated previously. The vaccination incorporates examination, vaccination and certification. Vaccination should be carried out in a *stress-free* environment for the ferret (and vet). That is definitely *not* on ferret show days, ferret-racing days or before ferreting expeditions.

In the UK and Europe, the vaccine Nobivac puppy DP (distemper/parvo) is used only for the distemper fraction. The other vaccine is Delcavac DHPPi (Intervet). This is a combined live vaccine. The distemper fraction again is used from the Onderstepoort strain grown on a Vero cell line. The hepatitis, canine parvovirus, parainfluenza fraction, not really needed, does not appear to harm the ferret. The UK ferrets get a first dose from 12 weeks of age with, note, boosters every 2 years (Oxenham, pers. comm. 1998). In the USA DHPPi is sold as Proguard 5 (i.e. Proguard 7 in combination with Nobivac Leto and Proguard 8 in combination with Nobivac LC0).

Regarding protection of ferrets from canine distemper virus (CDV) a trial was carried out using recombinant pox virus (RPV) vaccines, expressing the H or F gene of the rinderpest virus, which is related to CDV. A single injection of vaccinia virus expressing the H or F genes of RPV was able to protect 60% of 27 ferrets trailed with a challenge from a high dose of CDV.[43] This indicated that RPV antigens expressed by vaccinia virus are able to protect ferrets against a related Morbillivirus and it might lead to a new vaccine for ferrets.

Concern has been raised about other viruses similar to CDV that may affect ferrets. Two strains of Lion (*Panthera leo*) Morbillivirus, Californian and Serengeti types are antigenically related to CDV.[44] (It has been found that ferrets become anorectic at 5–6 days post-intraperitoneal injection of the strains. This leads to ocular nasal discharges at 9–12 days and then deaths from 12–22 days. It is interesting that ferrets vaccinated against mink distemper virus (Onderstepoort strain) are protected against the effects of the two lion strains (Table 8.2).

In Japan, where ferrets from the USA and New Zealand and Europe are the rage, there is no FervacD available, so they have to use multivalent vaccines as in Australia. It appears the vaccines used are Dohy Vac 5 (Krouritsu Shoji Company) and Canine 3 (Kyoto Biken) which are grown on chick embryo. The ferrets are given the full canine dose without any reactions (Yasutsugu Miwa, Tokyo, pers. comm. 2005). This goes against my

precise diluting of Canine 3-1 vaccine and worrying about vaccination reactions! It needs more investigation. Of course giving the whole canine dose to one ferret might be wasteful if you could use the vial for four ferrets and get the same protection.

Other ferret diseases

Canine hepatitis is not a disease of ferrets but has been found in mustelids; in skunks. It was postulated that other carnivores may get an asymptomatic infection.[45] Canine parvovirus does not affect ferrets in Australia. A serious overseas disease of ferrets and mink, called Aleutian disease is caused by a different parvovirus. Canine parainfluenza virus does not affect ferrets but another component of the canine cough syndrome does; the bacterium *Bordetella bronchiseptica* in America. Feline distemper (enteritis) does affect mink and other members of the Mustelidae family and may affect ferret kittens. Feline rhinotracheitis does not affect ferrets. However, I have been worried over the years about a 'snuffles' condition in ferrets, which is similar to the rhinitis and sinusitis of cats. Feline chlamydia does not affect ferrets.

Aleutian disease (AD)

This is caused by a parvovirus first discovered in an Aleutian strain of mink on a mink farm (USA) in 1956.

The mink (*Mustela vison*) of primary concern was the gunmetal-coloured Aleutian mink with two autosomal recessive genes for the pelt colour which is called the Chediak–Higashi syndrome.[46] These mink were bred for their remarkable pelt but were highly susceptible to the Aleutian Disease Virus (ADV). In the mink farms in early times, the spleens of distemper-infected mink were used to make an autogenous vaccine to give to other mink and ferrets, which were also farmed. Thus infection passed to ferrets and the ferret ADV would be a mutant of the more virulent mink ADV with the ferret parvovirus showing a feature of sharing a DNA segment like that of the hypervariable capsid region of the mink parvovirus.[11] Initially AD was a chronic wasting disease of mink but only a subclinical problem in fitch ferrets.

There are four strains of AD that affect mink and probably a ferret strain. With mink and ferrets, the severity of the disease depends on the strain of AD but the genetic make-up of the infected animal might also be a factor (M. Oxenham, pers. comm. 1993). Aleutian disease was recorded in ferrets in the USA (1967), then New Zealand (1984), UK (1990), Sweden (1994), Japan (1999), Belgium and the Netherlands (2004).

Differentiation of the AD strains was made possible only by the development of the counter-current immunoelectrophoresis (CIEP) technique in America.

Transfer of AD infection from mink to laboratory or pet ferrets is not explained but AD is highly contagious and an animal handler may have been involved. If laboratory ferrets were taken as pets, the disease could have been dispersed into the relatively high ferret pet population in the USA. In Sweden, there are about 200 mink farms with 80% of mink infected with AD. In 1994, pet and farm ferrets were tested using the CIEP test. Around 150 pet ferrets were tested and found negative. In 1994, ferrets from a farm where they also kept mink were infected with AD. Three ferrets positive for AD were found on the farm, indicating that Swedish ferrets can be infected with the disease, but no pet ferrets were found affected (L. Berndtsson, Fur Animal Dept., National Vet. Institute, pers. comm. 1994).

In New Zealand, where old fitch-farming businesses were active, the possible source of AD infection was originally introduced by breeding stock from the USA. Ferrets have escaped from fitch farms and some farms released their stock into the wild when fitch-farming became unprofitable. Feral ferrets, some possibly from original polecat crosses introduced in the nineteenth century, do occur and there is a policy for trapping them, more out of concern about them killing ground birds and harbouring bovine tuberculosis than AD. If ferret breeders in NZ used captured feral ferrets, which can be quickly domesticated, there might be a possibility of feral ferrets carrying AD bringing the disease to the stock.

In the UK, pet and working ferrets could contract the disease from stray ferrets or polecat contacts, which feral mink might have infected. The latter have been deliberately released by Animal Liberationists and have thrived over time in competition with the native otter. In 1986, an otter death in Norfolk was attributed to possible AD symptoms. Otters can kill and eat mink. Ferrets were interbred with mink on mink farms to increase litter size; thus ferrets are at risk and AD is now endemic in wild mink in the UK. In Russia, European mink have been crossed with ferrets to produce the hybrid Foonoters.[47] There is no AD in that country to date. In Australia, if the import ban on ferrets is lifted and new stock comes in from other countries, they must all be screened for AD.

An excellent account of AD in the UK by Oxenham, with reference to screening, has been done in association with the Wessex Ferret Club (Oxenham, pers. comm. 1993). Basically, AD affects mink and ferrets, but antibodies have been detected in other mustelids. When considering the effects of AD on the body, he

Author's clinical example

To show the difficulty in diagnosis

A sable jill 'Peanut' vaccinated with CSL 3-1 vaccine at 8 and 12 weeks of age developed vestibular disease at 5 months. She was a pet shop ferret and fed Iams food. She was presented with profound weakness on the left front and rear limbs with UMN signs in all four limbs but mostly on the left. She was mentally depressed with reduced appetite. The vestibular signs were on the left side and ear mites were detected bilaterally. The clinical signs suggested a lesion on the left side of the brain stem level of CNVIII. A provisional, broad-range diagnosis was made of parasitic/bacterial otitis being externa, media or possibly interna with a secondary meningitis with a differential of distemper, trauma, toxicity, thiamine deficiency, Aleutian disease and lymphoblastic encephalitis. The jill was treated with Del-Mycin Ear Drops (Delta Labs) on a 5-day course then 10-day break followed by a 5-day course, plus an antibiotic course of clavulanic acid/amoxicillin. A blood check under Domitor sedation proved normal. There were some periods of intermittent improvement over the following weeks but the jill deteriorated, stopped eating and became very weak, losing consciousness. It was euthanized on request. No post mortem was possible.

However, a repeat scenario occurred which is interesting with regard to the wide speculation of causative disease and the possible occurrence of Aleutian disease. A replacement sable hob, Gizmo, from the same pet shop and possibly same breeder, had been vaccinated and fed on Iams kitten food as before and was presented at 7 months of age with vestibular signs similar to the jill. He had a mild right foreleg weakness. Gizmo weighed 1500 g and had ear mites, which were treated this time with intra-aural Ivomectin (0.3 mL repeated 2 weeks later). No other antibiotics were given initially. The treatment removed the mites. He was bright but still weak on the right side. The owner agreed to further antibiotic cover using clavulanic acid/amoxicillin (Pfizer) and enrofloxacin (Baytril). A general weakness occurred with the ferret being immobile and inappetent, with urinary incontinence, so a switch of drugs was made to trimethoprim-sulphamethoxazole for better CNS penetration. A meningitis/encephalitis or brain abscess was suggested or something resembling GME in dogs. Unfortunately, chloramphenicol, another good CNS drug, is not available in New Zealand. In addition, the hob was treated with B vitamin complex for possible thiamine deficiency and was on dexamethasone (0.25 mg/kg s.c.) repeated intermittently every 3 days. There was some improvement in appetite, alertness and less incontinence but this was possibly due to steroid therapy as the hob did continue to decline showing ataxia, weakness and hyperflexion in all limbs. Various suggestions for differential diagnosis were put forward including Aujeszky's disease, toxoplasmosis, canine distemper or a possible parvovirus, the Aleutian disease. The hob had shown no respiratory or skin clinical signs of distemper and had been vaccinated like the previous jill with CSL Canvac 3-1, which was usual in NZ. Eosinophilic gastroenteritis (EG) was even suggested, which is a rare disease in ferrets, dogs and humans and may be an allergic or immunological response to foods. Gizmo was put to sleep at 67 days after the start of problems at 1400 g, immobile and inappetent, while Peanut was put down at 47 days.

A full post mortem was done on Gizmo and was interesting as it put Aleutian disease as a possible underlying cause. The morphological diagnosis showed the cerebrum/cerebellum with a moderate lymphocytic meningitis and mild encephalitis. The brain stem had a severe lymphocytic meningoencephalitis and the spinal cord a severe lymphocytic myelitis and meningitis. Celia Hooper (Auckland Animal Health Lab pathologist) commented that the lumbar spinal cord also contained lesions but at this level, they were more severe in the meninges than in the neuropil. The most severe lesions were in the cervical spinal cord and caudal brain stem. No protozoan agents were seen in numerous sections but that does not rule them out. Viruses remained a possibility and though the clinical history and lesions were not typical of CD it could not be ruled out. She stated that Aujeszky disease had not been completely eradicated from New Zealand and could be included in the differential diagnosis but as the inflammation was not suppurative, the negative bacteriology was not surprising. Aleutian disease is certainly a possibility but it is usually more severe in visceral organs and it would be an unusual manifestation to have the most severe lesions in the brain. However, the pancreas, liver, lungs and stomach did contain moderate to severe infiltrations of lymphocytes. The stomach and intestines showed mild to moderate infiltration of eosinophils and plasma cells.

Dr A. Lindsay, Torbay Vet Clinic, Auckland, NZ, pers. comm. 1998.

states that comparisons with diseases of other animals are often mentioned, which include diseases that follow a similar pattern to AD but are in fact quite rare. Examples given are equine infectious anaemia, African swine fever and lymphocytic choroid meningitis of mice.[48] The normal response of an animal to invasion by a virus is to produce specific antibodies that bind that virus and neutralize its effects. If these antibodies do not overcome the virus then the disease progresses. This usually involves the destruction of specific areas of tissue within the body, such as the brain (rabies), liver (canine hepatitis), surface tissue (foot and mouth), etc. What makes AD an unusual type of disease is that mink and ferrets

produce massive amounts of immune substances or complexes as a response to the virus, which are deposited in various organs of the body. It is these deposits, which cause the symptoms of AD. Most mink die of kidney dysfunction whilst the symptoms in ferrets are much more variable and in some cases mild to none at all. There has been an interesting study on the effect of repeated live-virus vaccine as a model for vaccine-induced glomerular injury.[49]

Clinical signs

In mink, features of AD were weight loss, lethargy, anorexia, polydipsia, anaemia and melaena with poor pelts.[46] The chronic wasting also leads to infertility, small litter size and stillbirths increase. The Aleutian mink is dramatically affected by the virulent strain of AD while non-Aleutian mink may suffer three classes of infection, the progressive Aleutian strain, persistent non-progressive strain or the nonpersistent, non-progressive strain, which clears in time. It is not known if these conditions relate to ferret infection, which usually show the chronic wasting disease and posterior paresis or paralysis of CNS involvement. In Australia, with a case of posterior paralysis, we would still consider a number of conditions before AD.

Immunology aspects

Although antibodies are produced by the mink and ferret, for some still unknown reason, they do not neutralize the AD virus, hence the persistence of the infection. Another feature of AD is that the virus causes some degree of immunosuppression, so that the ferret is unable to mount a defence against other types of infection. Thus, an AD case surfacing in Australia may be diagnostically masked.

Post mortem signs

AD cases show signs of inflammation in internal organs. In Aleutian mink, the kidneys are small and there is splenomegaly, mesenteric lymphadenopathy, hepatomegaly and bowel haemorrhage.[46] Similar results are seen in ferret post mortems. Kidney sections show glomerulonephritis. The ferret could have respiratory and cardiac disease features in ADV positive cases. With the lungs, consolidation of lobes can occur after an intense coughing illness and results in lung collapse and pleural effusion. CNS involvement can occur some time after the respiratory symptoms giving a posterior paresis leading to an ascending paralysis with effects on bowel and urinary function. The cardiac effects are cardiomyopathy resulting in arteritis showing up at post mortem. The arteritis results from deposition of immune complex substance.

Disease infectivity

With mink, oral or aerosol spread of ADV was likely. The AD can be shown to spread by inoculation of whole blood, serum, faeces, saliva or bone marrow of sick mink. The disease can also pass from mink jills to young with either the progressive or non-progressive subclinical disease, resulting in highly-infected litters. It is not known if this happens with ferrets but oral and aerosol methods are suspected. Infection of kittens from jills is also suspected. It is thus important that strict quarantine measures are taken before accepting in ferrets from AD suspect colonies.

Diagnosis

This can be difficult as demonstrated by the New Zealand example. Other features of the disease besides hind leg lameness are weight loss, which is progressive. Only Gizmo was weighed. Thirst is a sign and sometimes bleeding gums and tarry scats occur plus respiratory symptoms so the signs have a wide spectrum. There can be sudden deaths in stressful situations like ferret shows, etc.

In the UK, a diagnosis of Aleutian disease should ideally be made by:

1. Typical clinical signs.
2. Gammaglobulin levels >20%
3. A positive serological CIEP test (can be used on mink and ferrets).
4. The histopathology picture.
5. Possible electron microscopy with parvovirus particles in bowel lymph gland.

Treatment

There is no treatment possible but hopefully Australia will remain free of such a destructive disease. Affected ferrets must be eliminated from breeding stock. Unfortunately, although AD is caused by a parvovirus it is not the canine parvovirus so that vaccine would not protect. However, in the USA, the ferret AD is considered clinically rare though in some localities 20–30% of ferrets will test positive. In a survey of 500 ferrets in ferret shelters in Illinois, USA, 13% were positive to AD yet only two ferrets developed signs within 3 years (S. Brown, pers. comm. 1997). A prominent USA ferret pathologist reported only 10 cases per year based on submitted PM samples (B. Williams, pers. comm. 1998).

Experimental attempts at treating ferrets with AD have been recorded.[46] Cyclophosphamide in mink was given at 10 mg/kg i.p. 3 times weekly for 13 weeks with a good effect in suppressing host antibody response and deposition of immune complexes in the kidneys, in

effect protecting the kidneys at least. *Note* the level of virus growth was not affected by the treatment, which may indicate that direct viral damage to the host is not the cause of classic AD. In ferrets with AD, only fluid therapy is possible to maintain hydration for kidney function and giving nourishment by oral syringe or stomach tube.

Aleutian disease testing in the UK

Accurate diagnosis by blood-testing ferret stock is carried out in the UK and also USA, using the CIEP test (counter-current immuno-electrophoresis test). Infected ferrets (CIEP-positive) are culled. A survey found that not all ferrets in contact with CIEP-positive animals themselves became infected as not all the CIEP-positive ferrets were shedding at the same time.[48] In a 1993 survey, it was found there had been several isolated outbreaks of AD in areas other than central southern England; Berkshire, London, Oxfordshire and Lancashire were affected. The source of infection in ferrets originated from the Wessex area. Evidently, very little ferret screening had been done around the country and only a few positives have been found in areas checked. The routine screening carried out over some years in the Wessex area is shown in Table 8.5. Aleutian disease is a condition to be aware of in ferrets for the twenty-first century with the possible increase of transmission of viral diseases around the world.

The table shows a steady reduction of positive AD until 1992 and then a rise in 1993. The very low incidence in previously-tested ferrets is attributed to the efficient control measures in Wessex and indicates the continuing need for AD screening.

Epidemiology: Oxenham has suggested that wild mink in the UK could be a reservoir of the disease.

A yearly blood test would be required on pet and working ferrets if AD was recorded in Australia. With negative results, ferret breeders would naturally breed with other tested-negative stock and the new stock must be monitored. Cleared ferrets would have to be separated from untested animals. It is known that mink enteritis parvovirus (not AD) can survive outdoors for 5–10 months so this might be the same with mink disease parvovirus (ADV). Cleaning of cages of any suspect ferrets by hot disinfectant washing and drying is to be done. All utensils associated with the ferrets must be cleaned regularly against contamination.

With positive results, the heartache would be whether to keep the ferret/ferrets for the rest of their possible life span. If I had a positive AD case in a ferret colony, the positive would have to be euthanized and the negatives retested at monthly intervals to check the AD clearance. Not a happy prospect for any ferret owner!

In the UK situation of 2005, the small colony of AD-positive ferrets have been maintained for several years. In a letter to the National Ferret Welfare Society, Dr J. Chitty made some interesting points on the status of ferret AD and the future regarding diagnosis (see previous list) and fate of positives. It seems that with the small colony their life span has not shortened and they have died of other diseases. He asserts that a lot the identification of AD disease relates to clinical examination. There are no 'classic' signs of the disease but those listed include hindquarter paresis/paralysis, melaena, lethargy and liver/spleen enlargement. Lymphoma is becoming a common factor of ferret illness. Thus, the cause could be myriad. He has examined seven ferret post mortems with hindquarter paralysis and found six had spinal abscesses and one a spinal haemorrhage. There was no histopathological evidence of AD.

The gammaglobulin level test is useful. However, it is expensive to do and not routine in all laboratories. Moreover, the gammaglobulin levels might also be raised by recent vaccinations, other infective agents or tumours of the antibody-producing white blood cells. There are AD-positive ferrets, which do not have raised gammaglobulins.[50] The CIEP test is little help in these situations as it has been reported that finding the antibody is not synonymous with having the disease. The test is

Table 8.5 Screening tests carried out on Wessex ferrets for Aleutian disease

Year	1990	1991	1992	1993	Totals
No. tested for first time	245	201	242	148	836
No. positive	26 (10.6%)	12 (6.0%)	6 (2.5%)	17 (11.5%)	61 (7.3%)
No. previously tested		154	188	198	540
No. positive		2 (1.3%)	0	2 (1.0%)	4 (0.7%)
Overall total	245	355	430	346	1376
No. positive	26 (10.6%)	14 (3.9%)	6 (1.4%)	19 (5.5%)	65 (4.7%)

M. Oxenham, pers. comm. 1998.

again expensive and not usually done on one sick animal. Ideally, all dead ferrets should have histology examinations, so typical AD lesions may be found and correlated with the preceding clinical signs and testing results. There again typical lesions may be seen without clinical signs,[51] or there may be even no histological changes.[52] It is important that AD diagnosis be accurate to avoid the heartache of destroying a pet ferret.

There is concern for the routine testing of ferrets for AD antibodies. Many ferrets could fluctuate between positive and negative and it may be difficult to decide on these results. Evidently, the main problem appears to be that ferrets do not produce the same level of antibody in response to the AD virus as mink. It has been found experimentally that the rise in gammaglobulin in infected ferrets of 0.5–1 g/dL was lower than that of mink given the same challenge.[53] This shows that the tests for the mink are not sensitive enough to find the smaller rise in ferrets. Thus some ferrets' results could fluctuate with the test. The ideal screening should therefore be very sensitive. The ferrets that are then tested positive are therefore *really* positive. Chitty considers the saliva test less sensitive than the blood test and more difficult to do with the conscious ferret.

Mink produce more antibody than ferrets, which is why the ferret results are so variable. Also with mink, high antibody production is the reason for the severe disease in the species with clumps of antibody and it is the high antibody, not the virus, which causes the damage to small blood vessels, kidneys, heart etc. Thus, the main factor is the mink's highly reactive immune system compared to the ferret. Questions can be asked, if the ferret is not 'hyperactive' in immune response to the virus, will it produce the same disease? Ferrets can get AD but how often and how severely? Should the clinician worry about other diseases such as distemper and lymphoma?

There is also the question of different strains of AD. It was noted in 1982 that when ferrets were inoculated with ferret strains and mink strains of AD, neither produced lesions in the ferrets as severe as those in the mink.[52] So it is seen that current tests do not distinguish between strains of the virus and therefore it may be that some strains are more significant than others.

The question comes back to should AD-positive ferrets be culled? If they are really positive they will go on to infect others and therefore should be culled. But the situation is not clear from the tests to hand. Referring back to the colony of AD-positive ferrets, all but one were very healthy 5 years on from the beginning of the project. The sick ferret was being treated for cardiomyopathy signs. *Note*: none of the AD-positive ferrets in the project had any sign of clinical AD.

Could these ferrets infect others? It was found in 1982 that low levels of virus could be found in the spleens of ferrets 180 days post-infection.[51] No further studies on this point have been made or on virus excretion. Stress and disease cases should be studied on their response to AD.

Is *en masse* testing appropriate? If ferrets do excrete AD and are like the mink, then bringing together many ferrets for testing sessions is not the way to go as it may be a dangerous ideal opportunity for disease spread. It is noted with mink that AD can be aerosol spread and crowding should be avoided.[54]

The situation of UK ferrets with possible positives will be sketchy until there is a more sensitive test. In 1982, using the CIEP test it was found that 42% of 214 healthy ferrets had low levels of antibody.[51] It would be interesting to know how the real situation was with UK ferrets at the present time (J. Chitty, pers. comm. 2005).

European/NZ/Japan AD

Belgium and the Netherlands were previously free of ADV but the disease was brought into Europe apparently by imports of New Zealand ferrets. In early 2004, about 50–100 ferrets were imported from the ferret farm, Southland Ferrets. Other ferrets were imported later from Mystic Farms. The ferrets were beautiful but appeared not to be healthy and several of them died early (H. Moorman, Netherlands, pers. comm. 2005). Post mortems in Holland did not reveal any cause.

In March 2005, a 1-year-old ferret from New Zealand died too early with symptoms of coughing, lethargy, diarrhoea and hind limb weakness. On post mortem, a chronic lymphoplasmacytic inflammation was seen in numerous organs, most prominently in the kidney, liver, spleen, lymph nodes and lungs. Moorman sent tissue to the University of Georgia for testing and Aleutian disease was diagnosed as the cause by the DNA *in situ* hybridization test.

In May 2005, a lot of CIEP tests were performed on ferrets in Holland, 772 ferrets were already tested and 46 showed positive CIEP results. Unfortunately, a Dutch ferret breeder/shelter had given shelter to three New Zealand ferrets in the early months of 2004, until they were euthanized last summer because of a positive CIEP test. *Note*: 33 of 46 ferrets tested positive with the CIEP test were housed at the shelter.

Fortunately, the AD in Holland has not spread very fast but veterinarians and owners are alert to the danger. Several Dutch ferrets were infected mostly because of direct intensive contact or indirect by contaminated cages. The mortality in New Zealand seems much higher than in Dutch ferrets.

Further research on AD in ferret is being carried by Haneke Moorman supported by the Dutch Ferret Foundation 'Stichting de Fret'. The organization paid for

samples to be sent to the USA out of widespread concern (Stephenie Bass, pers. comm. 2005).

Japan has an enthusiastic pet ferret ownership with imported ferrets. However, a case of spontaneous Aleutian disease was recorded in 1999.[55] A 3-year-old 1060 g pet jill ferret showed signs of acute dyspnoea and posterior paresis. Though symptomatic treatment was carried out the ferret died 5 days later after becoming comatosed. At post mortem, the body condition appeared good which is a feature of spontaneous AD. There was no hypergammaglobulinaemia in the blood chemistry and histology demonstrated severe inflammatory infiltrates in many organs especially the kidneys. Using PCR products from the kidneys, the gene encoding of the viral capsid was positive for Aleutian disease.

Recently, a survey of 66 ferrets with suspected clinical signs of AD at one private veterinary hospital, between 2003 and 2005, showed the presence of positive results in 23 ferrets using the ELISA test. The origin of the AD ferrets is interesting (Yasutsugu Mawa, pers. comm. 2005). Of 46 ferrets from New Zealand, 19 were ELISA-positive; there were two positives from five Netherlands ferrets and two positives from 15 American ferrets.

This survey does not encourage importation of pet ferrets from some commercial outlets. Where could Australia get clear ferrets from, if importation restrictions were lifted? Russia!

Immune-complex mediated glomerulonephritis (ICGN)

This disease of idiopathic origin of concern to mink farmers[49] is mentioned here as it affects the kidneys, the main target of disease in AD above. A study was carried out as to the effect of repeated vaccination as a possible cause. The vaccines used were against canine distemper, *Pseudomonas aeruginosa* infection, botulism and mink viral enteritis. Canine distemper was given singly to some ferrets and in combination to others. The results did not prove any link between repeated vaccination and ICGN.

However, with the multidosing, there was an increased deposition of immunoglobulin in the kidney glomeruli and this finding deserves further study as vaccines with toxoids, killed bacterial products and inactivated viruses do present a higher antigenic load and are also formulated with adjuvants which are strong immune-stimulating agents. Thus, these vaccine products could more probably result in hyperimmunization and adverse immune-mediated conditions than live virus products. Could the use of multivaccines over a long period have the same effects (see multivalent vaccines reactions earlier)?

Bacterial diseases

Bordetella bronchiseptica

This organism is part of the canine kennel cough (CKC) syndrome and is recognized in the USA as causing disease in ferrets boarded with dogs at a dog kennel or in a veterinary premises.[56] Reference has been made to the problems of boarding ferrets with dogs and cats. In my veterinary hospital, I have experience of a hacking cough of undiagnosed cause in ferrets, which have shared the air with contact dogs in enclosed rooms. It is considered a condition of ferrets in overcrowded conditions and could be of concern in research or breeding establishments where ferrets are kept near dogs (J. Bell, pers. comm. 1999). Vaccination of ferrets for *Bordetella* was carried out by breeding companies, e.g. Marshall Farms, where they also breed dogs. Ferret kittens from Marshall Farms for the pet market are not placed in pet shops till they are 8–10 weeks of age when they are considered safe from kennel cough. Some other commercial breeders sell their kittens to stores at 4–6 weeks but then the kits are not already sterilized at 6 weeks of age as with the growing trend.

Bordetella can cause a thick yellowish nasal discharge and an illness, which can develop into pneumonia. It is prevalent in stressed ferrets, which might well be the case in ferrets boarded with noisy dogs. Only one of my ferrets had shown the cough and this I put down more to the 'snuffles' condition, as related to cats. In many instances, the ferrets are in air contact more with cats than dogs, as the former stay longer in the hospital. Personally, I have never experienced *Bordetella* in ferrets with a severe nasal discharge but usually a unilateral discharge, which has been treated as snuffles. The *Bordetella* pneumonia in ferrets is evidently difficult to treat but the *B. bronchiseptica* isolated from snuffles conditions responds to antibiotics after sensitivity tests on the nasal discharge. However, *Bordetella* can produce a toxin, which will result in convulsions and death and may be confused with a canine distemper diagnosis in ferrets. *Bordetella bronchiseptica* can be avoided by a vaccination 2 weeks before boarding ferrets. It should be boosted on the day of entry for boarding.[56] I have used CSL Canvac BB on my ferrets but have not eliminated unilateral nasal discharge periodically in one ferret, which I consider to be a 'snuffles' case. The vaccine appears safe for ferrets, being a killed product with the dog dose set at one vial. No laboratory trial has been done on ferrets to determine whether a part dose could serve, as with the distemper vaccination. It is important to note that the new intranasal vaccine for *B. bronchiseptica* with canine parainfluenza virus is not suitable for ferrets and could induce the disease.[56]

Ferrets can cough for numerous reasons. Considering they are susceptible to lung conditions, it might be prudent to give a coughing ferret an oral antibiotic. I have done so with a ferret living in overnight coughing. It worked. Clavulox palatable drops is a good broad-spectrum standby and one dose may well stop a lot of troubles. I have not regularly vaccinated ferrets in recent years for *Bordetella bronchiseptica*.

'Snuffles': a complex upper respiratory problem

I have compared the cat 'snuffles' to what I call 'snuffles' in ferrets.[57]

Symptoms: With some ferrets, there are sudden paroxysmal bouts of sneezing, with or without nasal discharge. The ferrets have noisy snuffling respiration at times but are not sick. There are a number of differential diagnoses that may apply. In my experience, it has occurred in jills and not hobs. Curiously, with hobs I have had problems with mycotic nasal infections but not in jills (Ch. 12). The finding is purely arbitrary.

At Marshall Farms, New York, it was considered that ferrets' sneezing is related to the human influenza virus (J. Bell, pers. comm. 1997). It could make ferrets sneeze so violently that they fell over, but, like my cases, the ferrets were not actually sick. Bell considered that a *Streptococcus* type C is associated secondarily with the infection. She did say that the sneezing could be due to allergy to the pine and cedar wood chips litter, which we never use. A review of respiratory toxicity of pine and cedar wood bedding has been done.[58] However, Bell used the litter at Marshall Farms for breeding ferrets and also at home with her pet ferrets with no problems. Sneezing as a consequence of pollen allergy with ferrets living outside in a ferretarium, garden or cage situation could be considered.

Marshall Farms used to sell ferrets for influenza research and they were all blood-tested. The pharmaceutical companies required serum from different ferret groups to find a group that had no antibodies. It was evidently difficult to find one, as the people who cared for the ferrets refused to wear masks and there was an infection factor from humans back to ferrets. Again, the ferrets were not sick and the kittens did not even sneeze most of the time. It was concluded that it takes a lot more 'flu virus to affect a ferret than it does a human, which is a comforting thought (J. Bell, pers. comm. 1997).

Diagnosis of 'snuffles'

From the practitioner's point of view, the concern of a snuffles condition is that it may progress to something worse such as pneumonia. The culture of nasal discharge or blood sampling, with bacteriology and sensitivity tests and treatment usually results in 'snuffles' cases being cured. The bacterial picture may be one of certain natural bacteria of the nasal/mouth flora becoming pathogenic to some extent, possibly in a ferret stress situation. Though there is an apparent cure, 'snuffles' can recur. When this happens, it could be that a different bacterium has become dominant and pathogenic in the nasal/mouth flora.

Author's clinical example

'Snuffles' treatment

Two ferrets were involved, jills Tippy and Lucky.[59] A culture of nasal discharge showed similar organisms to those in cats with rhinitis/sinusitis problems. Bacterial flora cultured included those organisms commensal in the nasal cavity, which can become pathogenic in certain circumstances: haemolytic *Escherichia coli*, beta-haemolytic *Streptococcus, Staphylococcus aureus, Pasteurella multocida, Haemophilus* sp., *Bordetella bronchiseptica* and *Pseudomonas aeruginosa.* For both jills, the major bacterial growth was *P. aeroginosa* and the drug sensitivity is shown in Table 8.6. Chloramphenicol at the time (1994) was considered the drug of choice for ferrets but in this case, the *Pseudomonas* was resistant.

Treatment: Tippy was treated successfully with clavulanic acid/amoxicillin (Clavulox palatable drops, Pfizer) and Lucky with doxycycline (Vibravet Paste 100, Pfizer, no longer available in Australia). Of the eight ferret colony members, only Tippy and Lucky showed signs of 'snuffles'. The ferrets respond well to antibiotic, they are not off their food, but there can still be some irritating occasional sneezing bouts without nasal discharge. Possibly, the nasal turbinate membranes are damaged? With another 'snuffles' case, the prominent bacterium was *Pasteurella* sp., sensitive to doxycycline and also to enrofloxacin (Baytril 50 available in injection and oral form).

Table. 8.6 Sensitivity of 'snuffles' organisms in two ferret cases

Antibiotic	Tippy (800 g body weight)	Lucky (980 g body weight)
Tetracycline	R	S
Chloramphenicol	R	R
Doxycycline	R	S
Clavulox	S	R

R, resistant; S, sensitive.

Author's clinical example

The possibility of viral involvement or even sinus problems is shown in the yet to be conclusively diagnosed condition of Teddy of Tasmania. Teddy, born 11 February 2003, is a light sable and arrived in Launceston as an 8-week-old kitten with two brothers and three sisters. He had a slight nose deviation to the right. In this case of possible 'snuffles', the jills were okay but Teddy started sneezing within 3 days of arrival, opposite to what I had found previously.

The ferrets had travelled on a flight from Adelaide to Melbourne and then on to Launceston. On the latter flight, the ferrets shared a compartment with day-old chicks. Quantas do not spray animals in the holds and declared that if there were several animal consignments on board they are kept as far apart as possible. However, in a plane, air circulates and we can all pick up colds!

About 1 month after arriving in Tasmania, Teddy saw a vet. He had been sneezing and coughing for several weeks and became worse 24 hours before the vet visit. He had an increased temperature and was put on Vibravet (doxycycline) 12.5 mg (¼ 50 mg table) b.i.d. for 10 days. On the re-visit, 10 days later, the sneezing had ceased but Teddy was still chesty though sounding better on auscultation. He had however gained weight. He started another course of doxycycline for 8 days.

The owner found out that Blackfoot, one of Teddy's two brothers, had the same clinical signs as Teddy, had been treated with two courses of antibiotic, temporarily improved, but never fully recovered. The other hob, Boofhead, had signs but not as severe and as of March 2005 had no coughs or sneezes for 3 months. *Note*: no other ferrets in contact with Blackfoot or Boofhead developed symptoms.

Teddy had never been vaccinated against canine distemper but received *Bordetella bronchiseptica* vaccination in July 2003 and was sterilized in the August at 1500 g weight. Teddy showed a nasal discharge (Fig. 8.7) and in February 2003, a culture proved negative, only showing normal oral flora. His coughs and sneezes appeared to be coming in cycles, a few days on, a few days off.

In December 2004, Teddy had a bad time coughing and radiographs were done (Fig. 8.8). These were not conclusive. However, Teddy was put on a terbutaline (bronchodilator) syrup and was on Vibravet for 2 months. He was having at least 10 coughing fits a day. In March 2005, he was coughing 2–3 times a day. He was active and eating but his weight was down to 1200 g.

He had two lots of medication, in April and July/August 2005. On examination in August, his heart and lungs were fine. The nasal discharge had some inflammatory cells and lymphocytes and scant bacteria so it was decided to take him off antibiotics for a while. In November 2005, he had been weaned off terbutaline and only coughed occasionally and produced some mucus. With twice daily exercises, he had no problem with clearing his throat and nose. The nasal discharge was the consistency of egg-white. Being off terbutaline his owner noticed 'he has put on weight from 1180 g in August to 1250 g and his body feels firmer, more muscular and he is stronger'.

It would be speculative to put a finger on the direct cause. A slight nasal septum deformation (bent nose), whereby a chronic infection of the fine nasal cartilage might result with a constant discharge, could account for a nasal discharge. The septum damage could be heredity or early trauma. The discharge might have turned pathogenically negative after the intense antibiotic cover earlier. I have always wondered if someone would find a lost *Aelurostrongylus abstrusus* nematode in the ferret, as ferrets do eat snails and slugs (Ch. 10), but not in this case. The virus theories are always hovering in the background, especially when birds are anywhere involved. A RSV association would be interesting to consider. At least Teddy is still active and hopefully a true cause can be discovered of this ongoing case (Christina and Klaus Bernhard, pers. comm. 2003–5).

Figure 8.7 Ferret, Teddy, with unilateral nasal discharge and nose bent to the right. (Courtesy of C. Bernhard.)

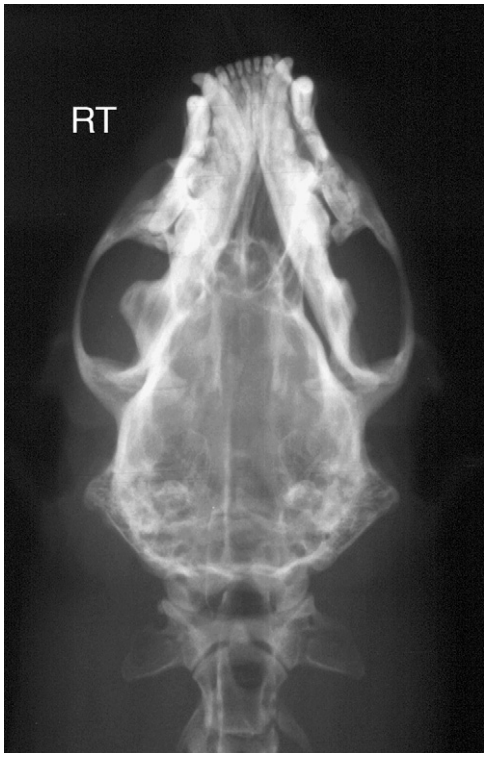

Figure 8.8 Teddy's skull; ventrodorsal. *Note*: deviation to right (compare with Fig. 2.12b). (Courtesy of Dr K. Barrett.)

Speculated conditions leading to 'Snuffles':

1. Sinus damage from viral infection such as human influenza or even (?) by feline rhinotracheitis from a passing cat or unvaccinated cat in hospital.
2. Cryptococcosis, a fungal disease that can go quickly to the brain (see Ch. 12).
3. Nasal septum deformation as in the breeding problem 'bent-nose' (Fara Shimbo, Ferret Unity and Registration Organization, Colorado, pers. comm. 1990).
4. Respiratory syncytial virus (RSV) was isolated from chimpanzees in 1956 and is considered a universally important pathogen in infant humans. In the chimpanzees, the disease caused coughing, sneezing and mucopurulent discharge. In humans, it can cause repeated infections throughout life and has been studied as a pathogen for ferrets by Prince and Porter.[60] The virus can cause bronchiolitis and interstitial pneumonia; they were able to replicate the virus in ferret kittens in the nasal tissue but not in the lungs. Although the clinical picture in the kittens showed no nasal discharges or mortality, the post mortem histological sections were consistent with mild rhinitis as seen in human infant infections. It was postulated that RSV could be more pathogenic in the younger animal and decreases in pathogenicity as the animal ages. An unknown mechanism, as the animal ages, acts in the lungs, but not the nose, to depress the pathogenicity of the virus. Thus if ferrets are somehow infected with such a virus from human contact, the nasal passage could harbour an ongoing infection similar to a repeat infection in humans.

Pseudomonas and ferrets

This organism is interesting as a possible pathogen in ferrets. It occurs widely in nature (compare cryptococcosis) and comprises over 140 species. *Pseudomonas aeruginosa* (syn. *pyocynea*) is one of three species pathogenic to man and animals.[61] It is found in soil, water, decaying vegetation and also found on skin, mucous membranes and in faeces. In mink, it causes haemorrhagic pneumonia and is fatal, affecting mink of all ages. It is associated with the stress of autumn moults in laboratory mink. The animals are usually found dead. In the UK, where escaped mink established themselves around rivers, the possibility of this disease of mink affecting other mustelids could be of future concern. In the old fitch farms in New Zealand, ferrets, like mink, would show a bloody nasal discharge and on post mortem signs of haemorrhagic pneumonia in one or more lung lobes. There is no cure but clinically disease-free stock can be vaccinated.[62]

Pseudomonas aeruginosa can become resistant to some antiseptics and disinfectants. In human hospitals it is considered difficult to eradicate the bacterium once it is established so some concern could run parallel with veterinary hospitals in the future.[63] It is found that *P. aeruginosa*, when injected s.c. into rabbits, guinea pigs and mice can produce fever and local abscess formation so its pathogenicity should not be underestimated in small mammals such as ferrets in the right circumstances.[64] Thus ferrets living outside in a garden or ferretarium may be as much at risk as hunting ferrets, which might get the disease in an abscess developing from a bite wound.

Ferret pneumonia

This is a complex and challenging subject; ferret pneumonia can be caused by a number of agents, including viruses, bacteria and parasites, as described in this chapter, plus pathogenic fungi and some internal parasites.

Bacterial pneumonia

The bacterial flora of the nasal cavity and mouth already indicated in relation to 'snuffles' can be implicated in bacterial pneumonia of ferrets. The group of PPLO organisms can feature in lung disease.

Mycoplasma (pleuropneumonia-like organisms: PPLO)

These are part of the normal flora in the respiratory tract of many animals. *Mycoplasma* causes specific diseases in cattle, sheep and goats, fowls and turkeys, mice and rats.[64] It is possible that PPLO are associated with more upper respiratory and pneumonia diseases in ferrets than has been recognized at the moment worldwide, being opportunistic in viral infections. Fox has stated that PPLO are to be found in clinically-normal ferrets as part of the bacterial flora of the mouth and nasal mucosa. This was seen in laboratory-kept ferrets in Japan. In addition, an organism labelled as *Mycoplasma mustelidae* was discovered from the lung tissue of clinically-normal mink kittens in mink farms in Denmark, but has not been recorded widely to date.[65]

The lungs can be invaded by various bacteria as a primary or secondary cause of pneumonia. It has been recorded that *Streptococcus* organisms, e.g. *S. zooepidemicus* along with *Streptococcus* Groups C and G, were implicated in a primary pneumonia as found at post mortem of a ferret after an influenza epidemic in a laboratory ferret colony. *Pseudomonas* infections in 'snuffles' can lead on to pneumonia as suggested earlier. The lungs of ferrets are susceptible to *E. coli* and *Klebsiella* infections along with *Bordetella bronchiseptica* pneumonia, which has been isolated from neonatal ferrets. Thus, there is a wide spectrum of pathogens possibly affecting ferret lungs.

Pneumonia symptoms: It is possible for pneumonia to arise from the nasal infection 'snuffles' with a continuous nasal discharge plus lethargy, pyrexia, anorexia, laboured breathing and increased lung sounds. Chronic cases of pneumonia have cyanotic membranes and cough with sepsis leading to death. A post mortem would show severe lung involvement with suppurative inflammation of all tissues infected.[65]

Diagnosis: This is on clinical signs with radiology and blood check. Examination of tracheal washings is suggested with cats but this might be too stressful for ferrets, especially with severe breathing difficulties. Radiology shows the pattern of alveolar destruction as with other animals. The CBC shows typically elevated total white cells of 20 000 or higher.[66] For differential diagnosis of ferret pneumonia there could be an underlying cardiomyopathy. With outside-living ferrets, there could be heartworm infection, fungal infection, e.g. C*ryptococcus neoformans* or a secondary cancer condition.

Treatment: The use of broad-spectrum antibiotics, good nursing with fluid therapy and possibly forced feeding is the key to success but can be difficult to attain. Chloramphenicol injectable has been a good first choice before sensitivity results are available but resistance is possible as seen with 'snuffles' cases. No oral chloramphenicol is available but the injectable form can be adapted to be given orally. A strong sugar solution is needed, as it is very bitter. Oral trimethoprim-sulfamethoxazole is another useful first-choice antibiotic and synthetic penicillins, like ampicillin.

Chemical-induced pneumonia in ferrets

Chemicals in the air are a major public worry and will also affect ferrets. Aerosol sprays should not be used around ferrets and they should not be left, even for a short while, in underground car parks while their owners go shopping, as they can succumb to petroleum fumes toxicity.

Botulism

Botulism is one of the clostridial infections that can be fatal to ferrets. With ferrets kept outside in a garden, ferretarium or cage, the ferret's tendency to hoard food can be a serious risk to health, especially in hot climates. This is one reason why I decided to feed my ferrets a definite amount of food, initially to eat overnight, so there would be no waste or storing away of food that might spoil the next day.

Free-living indoor ferrets are known to store food in odd places, in and under cupboards, under the fridge, etc. Fortunately, the bacterium is susceptible to antibiotics but the effects on the nervous system of the endotoxin produced by the organism are rapid. Ferrets, like mink, are less resistant to endotoxin effects than are dogs or other carnivores. The type C toxin is highly lethal. *Clostridia* bacteria multiply in decaying carcasses so that working ferrets could be at risk coming across a dead rat or rabbit if they are hungry. Thus ferrets should have some food before working warrens (Bert Geddes, Ferreter, Perth, WA, pers. comm. 1985).

Clinical signs: These occur 18–96 hours after consumption of the botulism toxin, with the ferret showing paralysis, which starts with the hind legs and continues to extend forward for some days. Sensation remains and there is usually no temperature rise. Respiration is shallow with partial paralysis of the intercostals and diaphragm. Salivation, protrusion of the third eyelid, not usually easily seen in ferrets, occurs and finally death results from respiratory failure.

Diagnosis: Done on vomitus, scats or suspect stomach contents at post mortem.

Treatment: Must be quick if the disease is suspected. Most cases will die. The ferret is treated with penicillin, vitamin injections and forced feeding. One may get a cure but it takes time. In mink farms, heavy losses can occur with botulism but it is considered that if mink are alive after the 4th day they will get better in 2–3 weeks. Mink can be vaccinated.[62]

Prevention: Vaccination with a *Clostridium botulinum* type C vaccine is done with mink but is impractical with house or garden pet ferrets. Ferreters with numbers of working ferrets might be able to get in with a local sheep farmer to have stock vaccinated with the sheep. Removing excessive food from the ferret is the best method. Ferrets usually sleep during the day, especially in hot climates, (unless working) and should be encouraged to eat late evening or late evening and early morning.

Author's clinical example

Ferret botulism case

A 3-month-old sable hob, Jack, was presented with the insidious onset of paralysis, beginning classically in the hind limbs and moving forwards to involve the forelimbs over a period of 4–5 days (Christmas 1993). He also had green diarrhoea, which was considered later a suspect sign of epizootic catarrhal enteritis (ECE) type disease but not proved. Jack's appetite remained good and he had attempted to play but it became more difficult as time progressed. Clinically, the temperature was normal. Respiration rate had spurts of laboured breathing consistent with respiratory muscle toxicity. Cranial nerve function seemed unaffected but motor reflexes were diminished in both fore and hind limbs. Urine analysis indicated elevated bilirubin levels. Jack unfortunately had a history of food hoarding in the house. Botulism was soon suspected.

Treatment: This consisted of a penicillin injection i.m. and vitamin B_1. He was also commenced then on amoxicillin drops (Beechams) at 1 mL twice daily for 10 days, plus he was given a Felobit tablet crushed and concealed in 2 teaspoons of plain yoghurt as a supportive measure. (*Note* the yoghurt might well have helped with the green diarrhoea.) Jack took 3 months to recover with a lot of TLC from his anxious owner.

A follow-up of Jack found that he led a normal life but remained small. A result of being so ill in his growing period? At 5 years of age, Jack started adopting a vague/spaced out stare, remaining standing, but had minor twitching of the whole body. The twitching lasted 15–30 seconds and was intermittent in episodes. He also developed a hind leg weakness. An insulinoma attack might be suggested? However, blood tests were taken with normal results. Fasting blood glucose was taken as well, using another ferret of similar age, colour and sex as a control. The results were normal.

External examinations/palpation found no abnormalities but Jack began to lose weight approximately 2 months after the onset of the vagueness/twitching episodes. He also had some bouts of nausea. Jack continued to deteriorate and after 5 months, he was put to sleep. An exploratory laparotomy had shown no gross abnormalities and a post mortem by a pathologist who had an interest in ferrets found there were certainly no other abnormalities except that one brain hemisphere was a little smaller than the other. Was this some result of the botulism toxicosis in the past?

Val Hucheon, Victoria, Australia, pers. comm. 2005.

Leptospirosis

Ferreters are aware that using ferrets, in conjunction usually with Jack Russell terriers, to clear out rats and mice in hay sheds, exposes them to rat and mice urine that might contain *Leptospira* organisms. Ferrets have a natural resistance to infection but *L. grippotyphosa* and *L. icterohaemorrhagica* have been isolated from ferrets.[67] In New Zealand, no evidence of leptoviral antigens could be found in a selection of wild weasels, stoats and ferrets. In another survey, a low percentage of stoats in Denmark showed exposure to the bacterium, while weasels and polecats checked were negative. In the UK, however, serological titres for serovars sejroe and Bratislava were detected in weasels.[30] One author does not include leptospirosis in a list of ferret zoonoses.[2]

Clinical signs: The typical findings in the dog include fever, sore muscles, stiffness, weakness, anorexia, depression, vomiting and rapid dehydration. There is possibly bloody diarrhoea, icterus, spontaneous cough and difficulty in breathing. There is polyuria and polydipsia followed later by no urination. Bloody vaginal discharge can be present. Deaths can occur without clinical signs.[68] Relating these symptoms to a possible ferret case shows the wide range of presenting signs. I have known of a ferret with severe jaundice, after definitely eating a mouse. The ferret died even with antibiotic treatment. Unfortunately, no post mortem was possible.

Treatment: Use of penicillin G given i.m. 40 000 IU/kg q.24 h or divide q.12 h until kidney function returns in such cases. Alternatives to penicillin are ampicillin or amoxicillin. Regarding dogs, dihydrostreptomycin is used to eliminate *Leptospira* from the kidney interstitial tissue. (10–15 mg/kg, i.m. q.12 h for 2 weeks). Streptomycin was used if the animal was not in renal failure.[68] Ferrets should not be given any more than 50 mg streptomycin if using the drug at 12-h intervals, as it is toxic in high doses.[26] Now streptomycin is not available on the drug list.

I do not feed my animals outside. My ferret Pip, let out into the garden one evening after being fed, then killed a rat and refused to give it up. He would not come in and could have eaten it overnight. The next morning his character changed. He was not his 'weasel' dancing self but somewhat depressed. He did not stop eating however but was more inclined to curl up and sleep. The depression idea panicked me. Was he a leptospirosis case? On the other hand, he could have had a stomach-ache! He was given amoxicillin 10 mg/kg orally b.i.d. and Animalac to drink as I worried that his depression might be liver function related. He continued for a couple of days to be edgy and non-cooperative. Then he seemed to come out of it, became alert and was taking interest again. Had he been infected by eating the rat? Had my quick intervention with an antibiotic done the trick? I had no blood tests etc. done. I had wondered about vaccination but leptospirosis vaccination is only possible by using a 5-1 vaccine. I might have to consider such vaccination. If ferrets do have a natural resistance to *Leptospira*, could I be worrying for nothing?

Tuberculosis (TB)

Tuberculosis is a serious wasting disease in relation to human health and from this aspect, the presence of *Mycobacterium bovis* etc. in wild and domestic animals is always of concern. Ferrets can get bovine, avian or human strains of tubercle bacillus. In a UK 2002 review, the role of the badger (*Meles meles*) as a reservoir host was discussed.[69] The fox (*Vulpes vulpes*) has been found infected but this was probably due either to its scavenging infected deer carcasses or its habit of occupying abandoned badger setts. In the Mustelidae, negative results were found in a MAFF survey (1996–97) for the stoat (*Mustela erminea*), weasel (*M. nivalis*) and polecat (*M. putorius*) but one positive was found in a mink (*M. vison*) and a second in a stray ferret (*M. furo*).

Mink are feral in the UK having been released from mink farms. The authors note that TB had been found in farmed mink in 1936. Feral ferrets do exist and some have mated with polecats but the density of feral ferrets is nothing to the problem apparently with feral ferrets in New Zealand. It is interesting that six TB cases were found in the domestic cat (*Felis domesticus*).

An otter (*Lutra lutra*) was suspect for TB and again it was surmised that this was because otters had the habit of visiting abandoned badger setts. This could be the reason for an odd feral ferret or polecat cross being infected with TB as they are inquisitive animals. The UK MAFF survey failed to find any native polecats with TB. Tuberculosis infection was found in the mole (*Talpa europaea*) and the brown rat (*Rattus norvegicus*). These are pasture and barn animals so closer to cattle areas. The question of badger involvement with bovine tuberculosis in the UK and the role of rabbits have been discussed at length.[70–72]

Fox reports on early cases of TB in research facility ferrets in the UK and Europe.[65] The disease was considered rare in the UK.[73] Pet ferret cases of TB were recorded in Germany in 1997 (Henke, G., Berlin, pers. comm. 1999). In the USA, *Mycobacterium avium* was found in a ferret on laparotomy for suspected granulomatous enteritis.[74] A single case *of Mycobacterium microti* was found in a ferret which possibly ate a vole (R. Malik, pers. comm. 2005).

In Norway, a case of *Mycobacterium celatum* (type 3), which affects humans, was found in a 4-year-old male ferret in March 1999.[75] It was noted that there could be a possibility of infection from humans where ferrets were kept as indoor pets. The ferret lost weight and showed coughing over a period of 6 months. It was depressed on examination and showed dyspnoea, dehydration, emaciation and a poor coat. The lungs showed harsh dry sound on auscultation and a radiograph revealed both lungs with multiple disseminated nodular and peribronchial densities. The lung parenchyma looked cystic and the animal was euthanized as the prognosis was grave.

Post mortem results showed an extensive mycobacterial infection with granulomatous inflammations in the lungs and the stomach, with extensive acid-fast bacteria in epithelioid cells and macrophages. Special identification kits were used and the PCR procedure carried out to give a result of *Myobacterium celatum* present as long, slender, sometimes branching bacteria in the ferret tissues.

Person-to-person transmission of non-tuberculous mycobacteria has not been demonstrated, but the ferret did live within a household and would be shedding *Myobacterium celatum* in oral lung excretions and faeces. Thus, the environment would have been contaminated. In humans, immunocompromised patients may show isolates of the bacterium. The pet ferret did not have a history of previous disease so was unlikely to have been immunodeficient. However, in the case of chronic respiratory disease in a ferret, mycobacterial infection is a rare but possible cause.

In Australia, Lucas et al. (2000) recorded two ferrets with *Mycobacterium genavense* infection.[76] This is a new species in the *Mycobacterium avium* complex (MAC) and has been associated with human patients with AIDS and generally as a bird pathogen. The two ferrets were seen by vets regarding eye problems. A 5-year-old castrated sable ferret had hyperplasia of the conjunctiva of the right eye and a peripheral lymphadenomegaly. The second 4-year-old silver jill ferret had a swelling of the conjunctiva of the left eye (Fig. 8.9). The general condition of the two ferrets was unremarkable.

Figure 8.9 Silver jill with swelling of conjunctiva due to *Mycobacterium genavense*. (Courtesy of Dr R. Malik, Post Graduate Foundation in Veterinary Science, University of Sydney.)

The 1200 g male was anaesthetized and smears taken from FNA of the popliteal lymph node, which suggested a mycobacterial infection, i.e. acid-fast bacteria (AFB). The 700 g jill was first treated with antibiotic tetracycline eye ointment with no effect and was later anaesthetized and a section of the swollen conjunctival tissue was taken for histology testing, which proved positive for AFB, with an associated possible mycobacterial rhinitis and cellulitis. Later, biopsy material from both ferrets was RNA tested using the polymerase chain reaction (PCR) and *Myobacterium genavense* was confirmed in both animals.

After examination under anaesthesia for tissue samples, both ferrets recovered and were put on oral medication for the myobacterial infection. The male received 30 mg rifampicin, 12.5 mg clofazimine and 31.25 mg clarithromycin once daily. The antimicrobial agents were well taken in Energel supplement. However, after 3 months, the ferret became inappetent though it was considered cured. It became rapidly worse and had azotaemia, hyperphosphataemia and isosthenuria and was euthanized with suspected renal failure.

The female deteriorated during the days following the biopsy operation. She went on to become depressed, inactive and somewhat aggressive when handled. However, she was given 14 mg rifampicin daily starting 7 days post-biopsy. She did improve and settled down in 4 weeks. At 8 weeks, the medication was stopped but 2 months later, the jill showed a moribund state with an enlarged abdominal mass, which was possibly an ovarian tumour, and died. Unfortunately, a post mortem was not allowed. (I have seen aggressive behaviour in one of my albino jills suffering an ovarian tumour.) Lucas et al. point out that *Myobacterium genavense* is an important avian pathogen but had only twice been reported in companion mammals.

Lunn et al. in Australia (2005) isolated the first cases of pneumonia due to *Mycobacterium abscessus* in two ferrets in the Sydney area.[77] Both ferrets suffered from a chronic pneumonia and were from the same household living indoors but out in the garden for short periods during the day. Both ferrets were on prophylaxis for heartworm (*Dirofilaria immitis*). The two ferrets were presented for examination 6 months apart.

Ferret A was a 560 g 2-year-old sterilized jill with a history of coughing and lethargy for 6 weeks. The ferret had been losing weight as the condition had worsened. The ferret was lean on presentation with increased thoracic breath sounds on both sides. On tracheal palpation, a dry unproductive coughing was initiated. Initially treatment involved doxycycline (5 mg/kg b.i.d.) p.o. (Pfizer Vibravet paste) for 3 weeks, whereby the ferret coughed less and improved over a week. However, the ferret deteriorated in the latter weeks and was represented showing a weight loss to 490 g with more frequent coughing.

A bronchoalveolar lavage (BAL) was decided on to check lung infection. This technique involved the ferret being under isoflurane anaesthesia (Ch. 16). *Note*: butorphanol (0.1 mg/kg s.c.) and midazolam (0.5 mg/kg s.c.) were pre-meds. The ferret was pre-oxygenated with 100% oxygen (flow rate 2 L/min) and then masked down with isoflurane. Next, it was tubed and left on isoflurane at 1.5–2.5%. The ferret breathed spontaneously and radiographs were taken.

The BAL involved allowing the ferret to recover the cough reflex after the isoflurane was discontinued. An open-ended sterile infant feeding tube ($3^1/_2$ French) was passed through the lumen of the endotracheal tube to wedge in the main bronchus. Then 2 mL aliquots of warm saline were injected and immediately aspirated and sent for culture. The ferret recovered well after the ordeal and went home to await culture results. (Diff Quik examination of aspirate showed mucus with numerous inflammatory cells, 91%.)

Blood agar culture aerobically at 25–37°C for 5 days found AFBs which were typed as *Mycobacterium abscessus* by the Queensland Mycobacterium Reference Laboratory. *Myobacterium abscessus* is classified as a rapid growth mycobacterium unlike slow-growing avian species. Quick accurate diagnosis of these dangerous conditions is vital. (Eight other rapid growth mycobacterium (RGM) species exist.) The *M. abscessus* was sensitive to clarithromycin but resistant to many other drugs: enrofloxacin, orbifloxacin, chloramphenicol, doxycycline and the sulfa drugs.

Treatment: The clarithromycin (powder form) was used in oral solution at 150 g/5 mL b.i.d. over 3 months, when the ferret was re-examined and found to be

recovering. Body weight was back to 5600 g, so the treatment was stopped as the coughing was becoming rare.

Ferret B was a repeat of Ferret A's condition and underwent the same treatment plus surgery for enlarged spleen and left adrenal gland disease. It had developed alopecia, pruritus and coughing. After surgery, it was placed on prednisolone (1 mg/kg) p.o. daily but its alopecia persisted. It improved on medication and was taken off clarithromycin.

Mycobacterium abscessus is a ubiquitous environmental organism and as dangerous as *Cryptococcus neoformans* (Ch. 12). Being in soil, water and decaying material gives a wide scope for infection of ferrets outside and it can colonize pipes. *Myobacterium abscessus* is saprophytic and infection may be by contamination of wounds, aerosol inhalation, or water. It is apparently more easily treatable than *Cryptococcus neoformans* as long there are effective antibiotics to call on.

The causes predisposing ferrets to develop disseminated mycobacteriosis are not clearly understood, though ferrets digging and 'nosing' soil is a problem. It is known from some epidemiological evidence that ferrets could become infected with a retrovirus capable of inducing a lymphoma but at the moment, there is no evidence that the virus concerned, if it exists, can cause immune deficiency. It can be noted that cryptococcosis, lymphoma and disseminated mycobacteriosis all occur in ferrets so it is theorized that ferrets might have their own immunodeficiency virus. This might indicate cause in the above ferrets with TB and with my two ferrets with cryptococcosis in 1996/97.

In New Zealand, there was concern about feral ferrets being vectors for bovine TB along with possums, deer, pigs, goats, cats and stoats.[78] In May 1994, a report on ferrets, weasels, stoats and cats, tuberculosis in many cases is considered to come from them eating infected carcasses. In one of the TB endemic areas in 1992/93, tuberculosis-positive wild ferrets were found, while ferrets and cats have been incriminated in some cattle breakdowns. The Animal Health Bureau, NZ considered that in a country overrun with rabbits, the ferret prey, ferrets are likely to be the major vector of TB for cattle and deer.[78] The report was concerned about the slow acceptance by veterinary interests of the potential role of other vectors.

It considered that the wide distribution of wild (feral) ferrets and the prevalence of TB in ferrets in some areas highlighted a potential additional vector problem. In the ferrets' defence, they may be important as rabbit calicivirus disease (RCD) vectors. It is known that rabbit calicivirus can survive passage through the dog intestine and can also be transported on external surfaces, so it is thought likely that feral ferrets working burrows move the virus around rabbit areas. As young rabbits are not susceptible to RCD, the use of feral ferrets as a vector for RCD could be important.[79] Thus, the elimination of wild ferrets would increase wild rabbits. There was an opinion that no conclusive proof has been found that ferrets have passed TB on to any other species (Ginkel, M.V. Technical Advisory Officer, MAF New Zealand, pers. comm. 1998).

Further work in New Zealand found that tuberculous possums were the major underlying cause of *Myobacterium bovis* in ferrets.[80] It is also noted that horizontal transmission of *M. bovis* could occur in ferrets in experimental housing conditions.[81] The occurrence of ferret infection with *M. bovis* was found higher by assessing lymph nodes of ferrets carrying the disease but not yet showing symptoms.[82] Thus the feral ferret is a victim of being susceptible, from being let loose in the first place and thus exposed to a terrible disease, TB.

New Zealand fitch farms in their heyday had problems with TB in ferrets due to the eating of infected meat. Therefore, the meat or offal food had to be obtained only from TB-tested cattle. Fitch ferrets were protected from avian TB by bird-proofing the fitch houses and keeping infected poultry and other bird carcasses off the diet. Possibility of the spread of human TB between human and fitch was considered remote.[83] Possum meat, which could be TB-infected, in the fitch diet in some regions of NZ was a concern (Ch. 4).The use of possum meat for feeding working ferrets in the past might be why ferrets were thought to spread TB to cattle.

Mycobacterial disease

Clinical signs: Weakness and wasting with tuberculosis could be confused with Aleutian disease and hind leg weakness with botulism in suspect working or pet ferrets. Bovine mycobacteria cause weight loss, anorexia, lethargy and death. TB-affected farmed mink in the UK and USA show weight loss, emaciation, some abdominal distension, enlarged spleen and lymph nodes and TB is another reason why mink should not be reared near fitch ferrets.[62]

Bovine TB strains tend to be more disseminated around the animal body as infected tubercles while human and avian TB strains provoke local slow-growing tubercular infections. *Note*: because the TB clinical signs in ferrets and mink can at first be vague, there is high zoonotic concern with regard to possible spread to humans as seen in example cases.

Diagnosis: Tubercular lesions are usually found post mortem but they can be picked up by radiography. TB testing of ferrets is possible and has been done

experimentally using Freund's complete adjuvant (FCA), which contains killed *Myobacterium tuberculosis*, with a reaction to 10 000 units (200 µg) of tuberculin. However, there are inconsistencies; mink in a colony tested with bovine tuberculin i.d. did not show any delayed hypersensitivity reaction.

Prevention: Farmed ferrets and mink are not treated for bovine TB but culled from farms and breeding establishments. Incidence, if any, is very rare and especially with controlled diets. Bovine TB has been eliminated in Australia. It is said that pet or working ferrets are protected by being on commercially prepared foods. However, these foods themselves could produce possible problems and should be avoided in favour of fresh, infection-clear meats fit for human consumption (Ch. 4).

Listeriosis

Listeriosis has been recorded since 1926 as one of the food-borne diseases and an active animal pathogen.[84] The bacterium is a saprophyte and common in soils. The two pathogenic *Listeria* are *L. monocytogenes* and *L. ivanovii*. Both these agents have groups of genes that facilitate invasion, survival, multiplication and mobility in the intracellular environment. People handling stock can get the disease, people and animals also get it from infected food or feeds. Apart from these contacts, there is no clear evidence of *Listeria* passing between humans and animals or vice versa. In the UK, there appears to be an autumn peak of human listeriosis and a spring peak for animal listeriosis so the two groups do not have a causal relationship. The incubation period between contact with infected food and disease onset can be from 1–90 days. The possibility of serious infection of humans is very low through the food chain. It is important to prevent contamination from the processing environment, which is from raw products or plant and machinery.

This disease can be highly fatal in many animals including ferrets and man, though, as noted above, it had been thought a really mild pathogen. Medical clinicians saw an increase in cases in the 1980s around the world.[84] Fox et al. recorded the presence of *Listeria monocytogenes* in a ferret with adrenal gland disease and cardiomyopathy with concurrent pneumonia and hepatitis. A Russian sable (*Mustela zibellina*) has been shown to carry the organism.[65] *Listeria* is considered a potential risk to ferrets alongside TB and *Salmonella*.[29] Infection can be from soil, which is comparable with cryptococcosis, and clinical signs would be of CNS involvement. Treatment would require very broad-spectrum antibiotics with CNS penetration ability.

Salmonellosis

Food poisoning: a problem of contaminated meat, to be differentiated from botulism. If feeding ferrets natural meat, should it be cooked or uncooked? The latter can be the subject of quick contamination in the Australian climate but it is known for humans to get salmonellosis from market meat products. The Gram-negative facultative anaerobes, *Salmonella newport*, *S. typhimurium* and *S. choleraesuis* have been associated with diseases in ferrets.[3] With ferrets on a meat diet, I have had only one case of salmonellosis, associated with idiopathic otitis interna.[85] The *Salmonella* involved were *S. lavana* in kangaroo meat pet food and *S. muenchen* in butchers' mince. Only one ferret in a colony of 10 was affected. Kangaroo and poultry are considered by some to be high-risk meats for *Salmonella* contamination. Ferreters who are shooters feed their ferrets fresh and frozen culled kangaroo without trouble (A. Geddes, ferreter, Perth, pers. comm. 1998). Some ferret breeders promote feeding day-old chicks. Working ferrets can be fed killed rabbit and will eat the whole carcass including the viscera.

Salmonellosis is considered the most common zoonotic disease in humans, but producing only a gastroenteritis.[86] It is generally known that in most animals *Salmonella* is asymptomatic; these animals can become carriers, including ferrets.

Clinical signs: include vomiting, diarrhoea, fever, inappetence, malaise, abdominal pain and dehydration.

Diagnosis: from the clinical signs and culture of the vomitus or faeces for the Gram-negative pathogen, which can be typed. At post mortem, *Salmonella* is cultured from internal organs.

Epizootology: *Salmonella* disease occurrence is relatively rare in ferrets but has been associated in the past with fitch and mink farms where disease outbreaks could occur from contaminated food. *Salmonella choleraesuis* has been isolated from mink in abortions and ferrets are likewise affected at some times. In a USA survey of laboratory ferrets, various *Salmonella* serotypes were found in the scats, being *S. hadar*, *S. enteritidis*, *S. kentucky* and *S. typhimurium*; the infection was blamed on uncooked meat.[3] A 1965 UK medical microbiology book referring to ferrets advises feeding raw meat and gives no indication of *Salmonella* as a disease of laboratory ferrets.[63] Stress is given as a factor leading to salmonellosis in dogs and cats in overcrowded situations and this could also be said for ferrets. Perhaps in the UK in 1965, laboratory ferrets were not as stressed as they are today? Other possible stresses on ferrets could be unsanitary conditions; in the veterinary hospital, there is conjecture that anaesthetics, surgery and even antibiotics could bring on stress or just the mere change of food/water is

said to produce stress in animals and this could be true of both ferrets and mink.

Differential diagnosis: Must include canine distemper, botulism and colibacillosis.

Treatment: Must be by the precise use of the specified antibiotic so that the carrier states can be eliminated plus attention to replacement fluid balance by use of i.v. catheters or s.c. injections.

Colibacillosis

The normal mouth and intestinal flora of the ferret has been recorded.[87] It is known that under some circumstances, organisms can become pathogenic and *Escherichia coli* is one, as seen in 'snuffles'. This gram-negative bacterium is also isolated in acute diarrhoea cases in neonatal ferrets, as it has been picked up in sick puppies and kittens (J. Bell, pers. comm. 1996). The *E. coli* found in the scats does not necessarily point to infection but blood-borne bacteria are highly suspicious. I have seen adult unsterilized unmated jill ferrets, which had developed post-oestrous anaemia (POA), die with a high blood *E. coli*.[57] Ferret kittens may be born to jills, which begin an endometritis for some reason, and the kittens are at risk of a coliform infection. This is seen in aging jills. Thus, jills with poor nutrition and colostrum deficiency can produce sickly kittens and all factors of poor husbandry can play a part.

Treatment: Sick ferrets with colibacillosis showing acute enteritis and septicaemia should have rehydration fluids, good nutrition and warmth plus a suitable broad-spectrum antibiotic based on bacterial culture. Toxicity to some drugs may be higher in ferrets than dogs and cats, e.g. doxycycline (Vibravet Paste, Pfizer) is a fluoroquinolone, which should not be used in young kittens as it causes cartilage damage.

Prognosis: With young ferrets it is guarded, though the possibility of zoonosis between the kittens and ferret owner is unlikely compared with salmonellosis. However, young children who are fascinated by young ferret kittens should be kept well away and any immunosuppressed people should avoid contact with them. Standard hygiene procedures should apply after handling sick ferrets.

Note the condition of haemolytic uraemia syndrome involving *Escherichia coli* has been studied.[88] Fifteen strains of beta-haemolytic *E. coli*, from diarrhoea and diseased tissues of infected ferrets, were found positive in specific PCR assays showing the presence of the candidate virulence factor strains CNF1, hlyA and pap1. The authors suggested s further study of the bacterial strains. *Note*: the gastrointestinal 'wasting' diseases are discussed in detail by Burgess in Chapter 9.

Anaerobic bacterial diseases

Anaerobic bacteria are of interest when considering ferrets found in unhygienic conditions and possibly working ferrets which have been involved in fights but have not had wounds immediately attended to, as with ferreters going bush. They should be of historical interest only but are worth looking out for with regard to working ferrets. A number of species of non-sporing anaerobic Gram-negative rod-like bacteria inhabit the oral cavity, upper respiratory tract, intestinal tract, and genital tract in man and animals.[89] Some of these organisms have been isolated in inflammatory processes, particularly accompanied by necrosis and ulceration. Many of these bacteria have been overlooked in bacteriological diagnosis because they grow only under strict anaerobic conditions and need special growth media for isolation.

Examples: Fusiformis species (now *Dichelobacter nodosus*); *Bacteroides* species (*Bacteroides fragilis*)

Cultures of these organisms have a characteristic foetid odour and they grow only with difficulty from serum, blood and tissue in anaerobic conditions with excess CO_2. These two anaerobic species are however obligate parasites of man and animals and may under certain conditions become pathogenic and invade tissues. Usually the anaerobic bacteria are found mixed with other organisms, e.g. *E. coli*, and it is difficult to know if they are invaders.

Fusiformis

Fusiformis infection used to occur in ferrets in unsanitary conditions and was called 'footrot' by ferreters as it is a disease akin to footrot in sheep.

Symptoms: The ferret develops raw sore necrotic feet pads with progressive tissue destruction. The infection should rarely, if ever, be observed now, except in cases of ferret neglect in wet muddy areas. It has been known in the past in Australia and the UK. *Note*: nowadays it would be a case for the RSPCA. Footrot should not be confused with mange in ferrets, as some ferreters are prone to call mange footrot, which it is not. Ferret mange (from sarcoptic scabies mite) should be called foot mange as it develops basically from the feet and thus the confusion with footrot.

Treatment: by isolation of affected ferrets in dry conditions and treating with sheep footrot preparation spray.

Bacteroides

These types of infections I have seen in swollen lesions in the groin of a working ferret, which had a history of fighting. When the lesion was excised under G/A, it revealed a terrible-smelling pus-filled gland, which had to be completely excised. The foetid pus was produced by a heavy growth of a mixture of *Bacteroides* and *E. coli* found on laboratory culture.

Treatment: This is by daily chloramphenicol injections with the wound left open to drain and flushed daily with hydrogen peroxide. The treatment takes over 2 weeks to resolve the wound. *Note* that some *Bacteroides* infections are drug-resistant and can lead to deaths in ferrets.

Streptococcus/Staphylococcus infections

Streptococcus and *Staphylococcus* bacteria, along with *E. coli*, affect pet ferrets similarly to fitch ferrets and mink.[90] *Streptococcus* infections occur in kittens where the jill has sustained a milk-borne infection due to unhygienic conditions. *Staphylococcus* infections are associated with mastitis, acute and chronic, in the lactating jill and will be the major cause of deaths of the litter and even the jill if not treated promptly.[91] Working ferrets, especially hobs, if fighting during the mating season, can sustain *Staphylococcus*-infected wound abscesses (Fig. 8.10). Therefore, hobs should be kept separate during this time. Working ferrets have the chance of being bitten by feral cats or kicked by buck rabbits. Requires drainage under G/A.

A dental abscess at the root of a broken tooth was seen in one ferret as a swelling on the side of the face below the eye (Fig. 8.11). With the animal under gaseous G/A and tubed, inspection of the broken tooth showed pus from the infected gum (Fig. 8.12). With the broken tooth removed, an awl was passed upwards from the mouth to open up the root abscess which was drained as shown in Figure 8.13. With the flushing of the wound, healing was commenced under antibiotic cover. Laboratory ferrets can sustain abscesses from sharp objects in cages and breeding colonies should be monitored for males fighting near the mating season.[92]

Staphylococcus infections can occur in the ferret mouth due to bone spicules, where the ferret's powerful bite forces a spicule deep into the tissues. It can

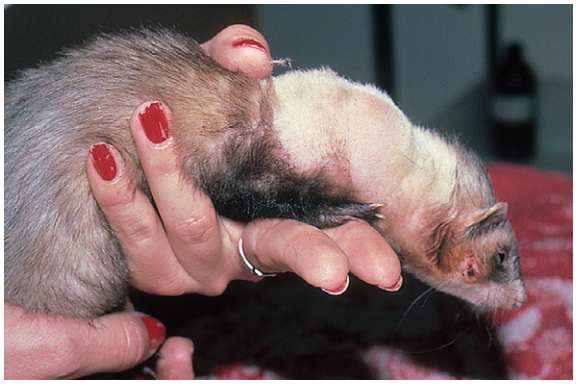

Figure 8.10 My hob ferret, Sammy, after being bitten. *Note* the swelling on dorsal part of neck – soft abscess, opened under G/A and drained.

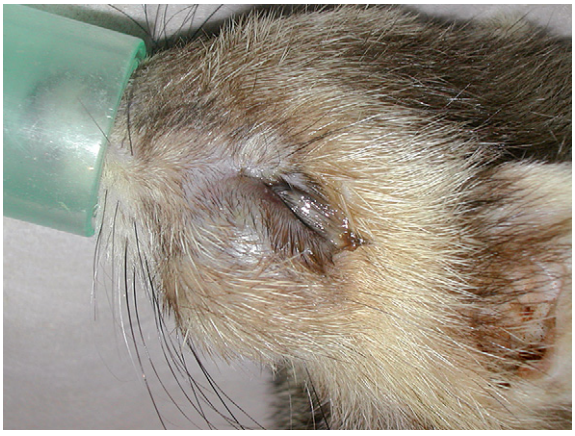

Figure 8.11 Swollen ferret face from canine root abscess. (Courtesy of William Lewis, The Wylie Veterinary Centre, Essex, UK.)

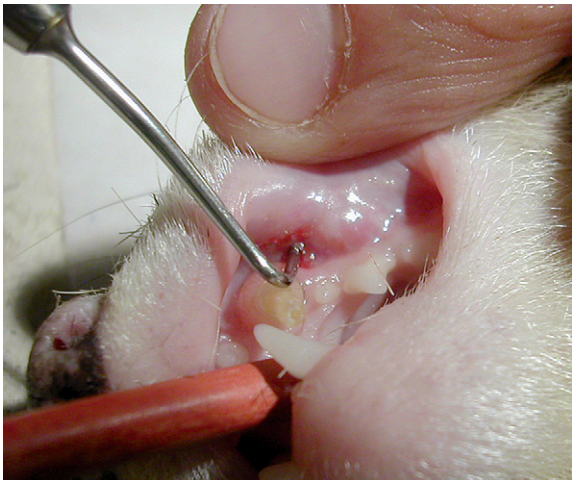

Figure 8.12 View of broken canine tooth of upper jaw. (Courtesy of William Lewis.)

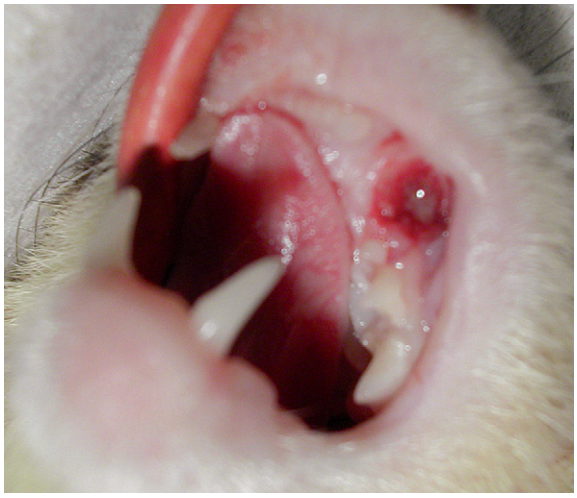

Figure 8.13 Tooth removed and pus draining. (Courtesy of William Lewis.)

result in a submandibular swelling and mucocele of the sublingual tissues.[57] Sublingual mucoceles are tight fluid-filled cavities on the ranula of the tongue (see Fig. 2.16). Mucoceles can also occur in the salivary glands if damaged by sharp objects such as penetrating grass seed awns.

Treatment: By a general anaesthetic, incision of the mucocele and antibiotic cover. Once incised and cut, the surface is dressed with a swab of dilute iodine to kill the surface cells. Salivary gland mucoceles require incision and possible removal of the salivary gland by delicate surgery. The positions of the five salivary glands are shown in Figure 2.14.

Grass seed abscesses

In Western Australia and many countries with hot dry summers, ferrets living outside or working ferrets face the problem of grass seed awns penetrating the skin. Hob ferrets can get suppurative wounds in the groin and penis sheath due to grass awn penetration, when working in the bush or simply urine-marking their territory, by moving along the ground, pressing their groin area down, urinating and chattering as they go. *Staphylococcus* abscesses are the result. For this reason ferrets should not be bedded down or play in hay in large sheds or ferret courts. Straw is better.

Treatment: An abscess requires vigorous attention with surgical drainage and flushing the wound plus essential broad-spectrum antibiotic cover. Liquid or paste drugs are preferred and are easily administered; the owner should be encouraged to give a complete course to prevent development of drug resistance.

With reference to possible antibiotic resistance, the presence of vancomycin resistant enterococci (VRE) has been found in New Zealand food animals.[93] Nearly 90% of VRE isolates were recovered from broilers and this has happened in Australia. The possibility of drug resistant microbes affecting ferrets fed on chicken produce could then happen?

Mycotic diseases of ferrets

Skin pathogens: Skin mycotic diseases affecting ferrets are uncommon.

Ringworm: The common fungal invader of dogs, cats and ferrets. Includes *Microsporum canis* and *Trichophyton mentagrophytes*. I have never come across ringworm. It would be a zoonosis problem, as with cats, especially with small children. There is a record of a ferret colony which did get infected from a cat as did some mink, where cats were allowed to sleep in bedding stored for the mink.[94] Ryland also recorded *Microsporum canis* in young ferrets possibly infected by cats.[26] Spread of disease is by contact between animals or with contaminated areas of bedding and thus housed ferrets in colonies are at risk.

Animal attendants could be infected and the zoonosis aspect of skin fungi is well known. Attention to separating infected ferrets ands strict hygiene is required.

Clinical signs: Classic ringworm lesions, with young animals to be most at risk. The circular areas of alopecia and inflammation can occur anywhere on the body. The skin becomes thickened, itchy and then scaly.

Diagnosis: Usually by the Wood's lamp technique and checking hairs microscopically for the characteristic arthrospores.

Treatment: Any infected ferrets can be treated with griseofulvin at 25 mg/kg by mouth but the disease can be self-limiting.

Mucormycosis

Seen in New Zealand fitch farm ferrets, the fungus *Absidia corymbifera* (syn. *ramosa*) was commonly found in association with *Otodectes cynotis*. It is not normally present in ferret ears though it is widespread in the environment like other fungi.[95] The avoidance of mouldy litter is advised. Strict cage disinfection was standard practice in fitch farms.

Clinical signs: Ear scratching is the classic sign of ear mite and along with it fungal infection found in the brown earwax. In severe cases, the ferret may be

depressed and lethargic. A torticollis is seen as associated with inner ear infections (Ch. 12). There is a loss of balance, circling, even prostration, with the affected ear turned down towards the body (see Fig. 12.5). The disease can lead to damage to the petrous temporal bone showing granulomatous inflammation and necrosis with a following granulomatous meningoencephalitis. In extreme infection the temporal and pyriform lobes of the cerebrum show lesions, which may appear on the cerebellum and brainstem areas.[94]

Diagnosis: By finding the ear mites associated with the fungi in external auditory wax. The fungus can be extracted from the regional lymph nodes and demonstrated on tissue section.

Treatment: Requires the immediate removal of the ear mites and ear cleaning. The question of antibiotic use on the fungus is questionable in itself as the antibiotic might predispose the ferrets to getting a secondary fungal infection. Possibly prevention is better than cure in this condition and keeping ears clear of mites is the right way to go.

Malassezia infection

Malassezia is becoming responsible for increasing incidence of dermatitis especially in dogs. The most common yeast is opportunistic in skin and ear infections to cause extreme pruritis.[96] *Malassezia pachydermatis* is the most common of seven species of the yeast and isolated especially from the dog and less so from the cat. *Note*: it is on the skin, in anal sacs and in mucus of healthy cats who also may have *M. sympodialis* and *M. globosa*. Dogs and cats can be companions in a household situation along with pet ferrets.

Malassezia species have been associated with ferrets in the UK.[97] In a colony of 50 ferrets, eight developed crusting and necrosis of the ear pinnae. The disease spread to another six ferrets with all ferrets having *Otodectes* sp. infection. It was considered that *M. pachydermatis* was acting as an opportunistic pathogen. An ear infection is liable to spread to the face. With the infected ferrets, treatment with topical betamethasone, neomycin and monosulfiram failed and the ear pinnae had to be ablated. Histologically the involved epidermis had inflammatory cells and yeast beneath the corneum but no acanthosis. However, large areas of necrosis and haemorrhage were seen.

Diagnosis: Again earwax material will show *Malassezia* yeast cells on microscope inspection. The cells measure 3–8 µm in diameter; they are round or oval and usually in clusters.

Treatment: With the UK ferrets, oral ketoconazole at 5–10 mg/kg b.i.d. and topical application of miconazole, polymyxin and prednisolone were used, giving an improvement in 5 days. All in-contact ferrets were treated. *Note*, it is again important to remove the ear mite infestation (Ch. 12).

Fox lists fungi causing systemic infections in the ferret: (1) *Blastomyces dermatidis*, (2) *Coccidioides immitis*, (3) *Histoplasma capsulatum* and (4) *Pneumocystis carinii*.[94] The first three organisms are widespread soil contaminants like *Cryptococcus bacillisporus* while the fourth was considered a protozoan but now is classified as a fungus. The difficulty in the treatment of these dangerous fungal infections can be considered.

Blastomycosis

This is a primary condition caused by *Blastomyces dermatidis*, with a chronic granulomatous invasion of the lung tissue and possible skin lesions. A clinical example of ferret infestation was seen in the 1980s along with cases in dogs and humans in that period.[94] The disease incidence is sporadic, from the soil and possibly by inhalation of conidia in dust. There is apparently no animal/ animal or animal/human transmission. It has not been recorded in Australia or NZ but in the USA, Canada, Africa and rarely in Central America. Ferrets housed outdoors may be at higher risk.

Clinical signs: Ferrets develop a chronic granulomatous mycosis in the lungs, giving signs of cough and sneezing. A cutaneous blastomycosis gives ulcerative swellings, which spread slowly over the skin. The footpads can have ulcerative swellings.

PM signs: In the US case, a reticulonodular interstitial pneumonia was seen. The lung had focal consolidation and pleural fluid. There was a bilateral diffuse granulomatous pneumonia and pleuritis, a meningoencephalitis and an enlarged spleen.

Diagnosis: It could be another cause of chronic respiratory disease in ferrets and the yeast organisms can be extracted from skin or lung aspirate. Tissue imprints will show budding yeasts. It is noted that as with the dog infection, characteristic 'snowstorm' interstitial changes can be seen. Circulating antibody titre to the organism can be shown by agar immunodiffusion test.

Treatment: In dogs is by amphotericin B (AB) and ketoconazole (KTZ). This can be more difficult in the ferret as the AB must be given i.v. The dosage of AB (0.5 mg in 1 mL 5% dextrose) for the US ferret was 0.8 mg AB/kg. In addition, 5 mg KTZ was given p.o. The BUN was monitored and fluids given s.c. However, the AB caused anorexia, pyrexia and azotaemia so the AB dose was reduced to 0.25 mL (0.4 mg/kg) and checked by the BUN levels. The ferret showed a resolution of the forepad ulcer and regression of primary lesions. It became difficult to give the AB by i.v. injection so that only the KTZ was continued s.c. every other day. Two weeks after the s.c. treatment began

the ferret relapsed and was euthanized. It is not easy to treat ferrets with some diseases and especially over long periods where the actual drugs used may have a cumulative toxicity factor.

Coccidioidomycosis

The fungal pathogen in this case is *Coccidioides immitis*, found particularly in low-lying sandy alkaline soils in the USA. Interestingly, it likes a high temperature environment.[94] The mycelium of the fungus produces arthrospores, which can become airborne and infective.

This disease has been recorded in ferrets in the USA. One ferret (18-month-old male) showed signs over 3 weeks of lethargy and weight loss. It had lost 36% of weight over 6 months. At presentation, it was said to have been coughing for 3 days and showed moderate pharyngeal hyperaemia. Blood check and temperature were normal.

Treatment: The ferret was given 25 mg tetracycline t.i.d. for 7 days but after 2 weeks, the cough had worsened and the submandibular glands were enlarged. Radiographs showed increased lung interstitial pattern in the cranial lobes. The treatment was changed to oral amoxicillin at 12.5 mg b.i.d. for 10 days. No improvement occurred after addition of 1.25 mg prednisolone daily for 16 days.

Coccidioidomycosis test was at first negative and then, 1 year later, when the ferret was seen with more weight loss, the test was positive. The ferret then was lethargic, weak was still losing weight and showed an abdominal mass plus lame right front leg. The scats were bloody. The WBC count was at a stress level of 24 000/µL. As coccidioidomycosis was diagnosed, the ferret was given 10 mg KTZ b.i.d. but with no improvement, so the ferret was euthanized 6 weeks after treatment began. No post mortem was possible.

Another US ferret became sick 2 days before presentation. It had been a pet shop ferret and when clinically examined was anorectic and lethargic with radiographs showing two radiodense areas of the mediastinum and caudal right lung lobe. A tracheal wash was attempted under G/A but the ferret died. However, a post mortem showed *Coccidioides* organisms in the lungs and lymph nodes.

Yet another US ferret was presented with a draining wound on the left stifle and showed symptoms of nasal discharge, weight loss and dehydration.

Treatment: 2 mg gentamycin was given to the ferret and the owner told to give oral amoxicillin plus oral vitamin B complex for 7 days. The wound was to be cleaned with peroxide daily. When checked 3 weeks later, the tibiotarsal region showed a swollen draining tract from which a smear was made revealing bacteria and neutrophils. Gentamycin was tried again for 4 days without success. Then amikacin sulphate was used at 6 mg/kg b.i.d. s.c. with an improvement shown so that the dosage was upped to 6 mg/lb once daily. After initial response, the draining swollen area recurred. Radiographs revealed a swollen radiodense area of the right radius. The ferret was euthanized 2 days later as there was no recovery progress. On examination of the draining tract, the area of the muscle and soft tissue of the right corpus and right and left tarsus were involved and from the right tarsus area. *Coccidioides* species were lifted for microscopy. No post mortem was possible.

It is noted that inhaled arthrospores of C. *immitis* can produce respiratory signs in 1–3 weeks in the dog and man.

Diagnosis: The diffuse interstitial pattern of infected lungs may be an indication of this disease on X-ray. Swelling of the mediastinal lymph nodes may be another clue. The disease can spread from the lungs to affect bone and joints, as seen in the last ferret case, and also any abdominal organs, the heart and CNS and even the male testicles. Osteomyelitis may be present on X-ray. Actual confirmation of C. *immitis* is by cytology or biopsy examination of tissues.

Treatment: This disease requires long-term treatment with ketoconazole (KTZ) being used in dogs and cat. The dose indicated for ferrets is 20 mg/kg b.i.d. In my opinion, as with cryptococcosis treatment, KTZ may be likely to be hepatotoxic to the ferret long before it has completely killed the pathogen it is aimed at. Having said that, prognosis of the disease in humans is good even without treatment, but guarded in dogs. There is not enough clinical data on ferret prognosis but it is possibly guarded too as it still is with cryptococcosis.

Histoplasmosis

This pathogenic organism is *Histoplasma capsulatum*, which is not contagious but is infectious.[94] This disease is said to infect by the respiratory route and a case was seen in a working ferret in the USA. Ferreting is not common now in the USA but the ferret involved was used to hunt rats and rabbits. It lived on dog food, table scraps and rabbit heads and this diet could be compared with the nutrition ideas in Chapter 4. The disease usually affects dogs, so that might be a connection with working ferrets. In the USA, it has been seen in the central continental area where *H. capsulatum* is found in the soil.

The symptoms were severe abdominal pain, enlarged spleen and subnormal temperature. In another ferret, subcutaneous nodules were noted in the skin. Again, this disease would have to be differentiated from cryptococcosis. In ferrets, the disease may run the same course as with dogs, showing pneumonia, ascites and

lymphadenopathy with a positive diagnosis being made from fungal culture and/or biopsy.

Pneumocystis carinii

This organism is interesting as it was considered to be a protozoan. It has been re-classified on the homology of the parasite's basic genes with those found in fungi. The parasite can infect ferrets, rats, mice and even man. The *P. carinii* from these hosts appear morphologically similar but there are antigenic and genetic differences.[94] It is considered that further study of *P. carinii* as a zoonotic organism is required. The parasite is said to inhabit the lungs as a commensal in laboratory and some domestic animals including ferrets. It apparently affects immunocompromised animals under drug treatment or with some disease.

Pneumocystis carinii pneumonia in ferrets

The ferret has been used as a laboratory study of the disease while being under long-term cortisone medication (cortisone acetate 10–20 mg/kg s.c. for 9–10 weeks). The organism was found in all 11 ferrets under trial and caused disease in six animals, and should be considered as a possible disease problem with ferrets under long-term steroid therapy.

Ferrets are resistant to losing body weight, as are humans, when under corticosteroid therapy. Pneumocystic pneumonia can occur with ferrets undergoing long-term steroid treatment Also, it should be noted that in adrenal gland neoplasm, where the blood cortisone levels will be high, *P. carinii* might be present in sick animals (Ch. 14). Diagnosis would be by finding trophozoites by a bronchoalveolar lavage. Treatment is by using oral trimethoprim–sulfamethoxazole, in any infected ferrets, as with rats and humans. Histology showed interstitial pneumonia, focal mononuclear cell infiltrates and many cysts and trophozoites under GMS and Giemsa stains.

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